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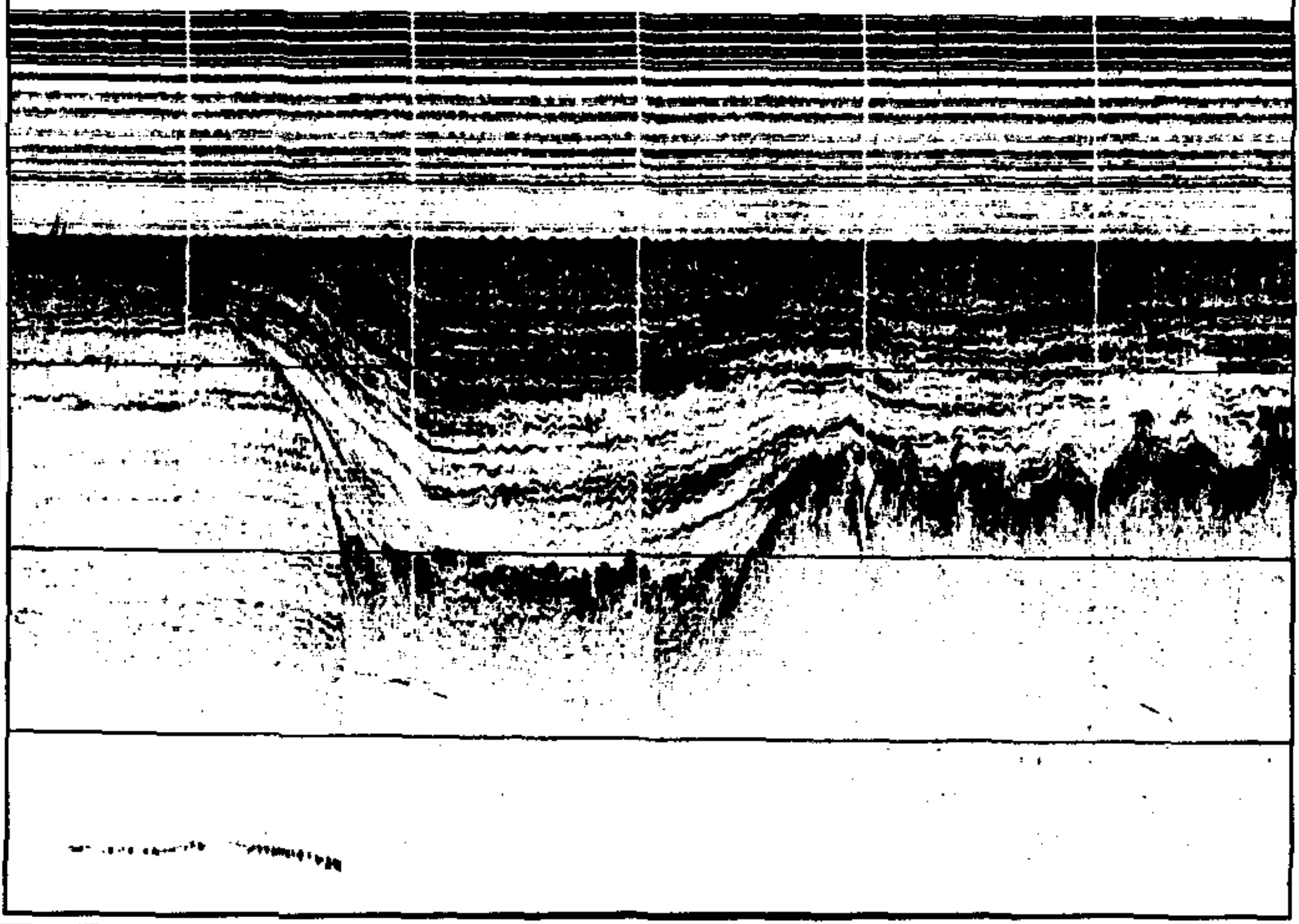
ARCHAEOLOGICAL INVESTIGATIONS ON THE OUTER CONTINENTAL SHELF:

A Study Within the Sabine River Valley, Offshore Louisiana and Texas



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U.S. DEPARTMENT OF THE INTERIOR

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ARCHAEOLOGICAL INVESTIGATIONS ON THE OUTER CONTINENTAL SHELF: A STUDY WITHIN THE SABINE RIVER VALLEY, OFFSHORE LOUISIANA AND TEXAS

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ABSTRACT

Coastal Environments, Inc. has undertaken a study for the Minerals Management Service, U.S. Department of the Interior, whose objective is to evaluate the potential for the preservation of archaeological sites on the Gulf of Mexico Outer Continental Shelf, and, if possible, to locate submerged prehistoric archaeological deposits. The project area selected for the study is the filled valley of the Sabine River in offshore Texas and Louisiana. The study is designed as a partial test of a predictive model of site occurrence and preservation developed in earlier studies of the archaeological potential of the Outer Continental Shelf (OCS). An additional purpose of the project is to provide information to the Minerals Management Service which will facilitate their future management and study of the archaeological resources of the OCS.

The project consists of two phases. The first phase involves the collection, evaluation, and synthesis of archaeological, geological, seismic, and bore-hole data from the study area. This information is used to establish the geologic setting and history of the area. Relying primarily on terrestrial analogs, models of archaeological site locations are projected for the study area and assessments of the potentials for site preservation are made. The second phase involves the collection and analysis of vibracore samples taken from target areas identified from seismic records as potential archaeological site locales. Examination of samples includes analyses for pollen, foraminifera, grain size, and particle and geochemical constituents. A series of radiocarbon determinations from vibracore samples provide chronological control to the interpretation of the most recent (Holocene) geologic events in the study area. Extensive areas of preserved, pretransgressive landforms are identified within the offshore Sabine River valley. Included are Deweyville floodplain features not before identified on the OCS.

About 10 mi offshore, vibracore samples from a Deweyville surface, adjacent to two streams tributary to the Holocene Sabine River valley, have produced evidence suggesting the presence of archaeological deposits. At this location, a Rangia cuneata shell deposit and a stratum containing large quantities of burned and unburned bone fragments have been encountered. In terms of their location, geometry and content, these two features are more similar to known coastal archaeological deposits than they are to known natural deposits in the region. Dating to between 8000 and 8500 B.P., the features were deposited when sea level was approximately 55 to 60 ft lower than at present and when the adjacent Sabine River valley probably exhibited a saline to brackish marsh environment.

Evaluations of the techniques employed in the study indicate variable success and utility. Data collected by high resolution seismic survey is entirely adequate to identify critical landform features, if interpretation of features is placed within the context of the known regional geology. The vibracore is capable of collecting the necessary samples for analysis and providing the data needed to refine stratigraphic interpretation.

The final assessment of a collected sample on the basis of its physical and chemical characteristics is the most difficult aspect of the study. Inundation and burial for several thousand years have altered the content of archaeological sites on the OCS to some, currently unknown, extent. The particle content of fine-screen samples seems to be the most useful approach for distinguishing archaeological deposits. However, all of the criteria used need refinement. Additional detailed information on the particle and geochemical content of known terrestrial sites, as well as offshore archaeological and natural deposits, would greatly enhance the approaches used in this study.

EXECUTIVE SUMMARY

For the past decade there has been an increasing interest in the prehistoric archaeological resources potential of the continental shelves of the world. Many would agree that, given certain conditions, prehistoric sites established on the continental shelf during periods of lower sea stand would have withstood the effects of rising seas and now remain preserved on the submerged portions of the shelf. One of the settings which provides that set of conditions conducive to site preservation is a filled stream valley, especially a larger valley, which, with sea level rise, develops into an estuary and slowly fills with sediments before being completely inundated. Archaeological deposits can become covered by, and encapsulated in, estuarine sediments and remain intact beneath the erosive impacts of transgressive seas. Developing statements concerning the occurrence and distribution of archaeological deposits in these offshore settings requires, first, the projection of a culture history for the area with its attendant settlement patterns; second, an assessment of the geological and ecological histories of the area; and third, the identification of the geomorphic processes which have occurred relative to their effect on archaeological site preservation.

Several studies relying on these types of data have produced what appear to be reasonable models of site occurrence and preservation in large stream valleys on the North American continental shelf. Testing these models, however, is another and more complicated problem. It requires a technology that permits the identification of submerged and buried landforms which have a high likelihood of containing archaeological remains and it requires also a method for collecting samples from these landforms. Fortunately, this technology is today available in the form of a variety of instruments that permit refined mapping of the shallow, subsurface geology and in a range of coring devices which can collect samples from a submerged target landform.

This report presents the results of a study sponsored by the United States Department of the Interior, Minerals Management Service (MMS), and undertaken by Coastal Environments, Inc. (CEI), to assess the potential of preserved archaeological sites on the Gulf of Mexico Outer Continental Shelf (OCS). The study was designed as a test of a predictive model of site occurrence and preservation developed in an earlier baseline study of the cultural resources potential of the OCS (Coastal Environments, Inc. 1977). An additional purpose of the study is to provide information to MMS which will facilitate its future management and study of the archaeological resources of the OCS.

The project was conducted in two phases. The first phase involved the collection, evaluation, and synthesis of archaeological, geological, seismic, and bore-hole data from the study area. The second involved the collection and analysis of vibracore samples taken from target areas which had been identified from the seismic records as potential archaeological locales.

The region selected for implementation of this study is an area of approximately 2580 mi^2 in the offshore Sabine-High Island region of eastern Texas and western Louisiana containing the relict, filled channels of the late Pleistocene to Holocene-age Sabine River valley. This late Pleistocene river system provided an ideal research universe for the study partly because a series of published works are available that offer rather detailed information on the present setting and geologic history of the valley area. Of particular importance is the published work of H. F. Nelson and E. E. Bray (1970). This work delineates the Pleistocene river system and the subsequent changes it underwent with sea level rise. In addition to the work of Nelson and Bray, an extensive body of seismic and bore-hole data, collected in the region relative to oil industry activities, are available.

Other factors which make the buried Sabine Valley conducive in the search for submerged sites are: (1) the river system was active and the region was subaerially exposed when prehistoric populations occupied the region; (2) the river system was active for at least 12,000 years, sufficient time to permit the accumulation of an extensive archaeological record, possibly including multicomponent, stratified sites; (3) relict features having a high probability for both site occurrence and preservation had been identified within the valley system; and (4), importantly, these landforms are often not deeply buried and many are within the range of vibracoring, the sampling technique used in this study.

The geologic model provided by Nelson and Bray was augmented and refined using previously collected seismic and bore-hole records. Relying on this geologic reconstruction, an assessment of prehistoric human settlement was developed for the area, and centered on identifying those types of landform settings most likely to contain archaeological deposits. Settlement within the area was considered over the time span from about 15,000 B.P. until ca. 6,000 B.P., by which time the study area had become inundated as a result of rising sea level. This period encompasses two archaeologically recognized culture periods in the region, Paleo-Indian and Archaic. Evaluation of settlement locational strategies used by prehistoric populations in the study area relied partly on an assessment of known archaeological site distributions in two Gulf coastal river valleys which, in terms of geology and modern environment, are similar to that projected for the study area during the period of interest. These two river valleys are the lower Pearl River and the present-day lower Sabine River. In addition to using these terrestrial analogs, identification of settlement choices in the study area incorporated present assumptions about adaptive strategies that may have been employed, and the impact of climatic conditions on settlement selection.

Using previously collected seismic data, eight locations that contained landform settings considered most likely to contain archaeological sites were identified in the study area. These areas were located in the following offshore lease blocks: Sabine Pass 3, 6, and 9; High Island 18, 38, 49, and 163; and Galveston 151. Preliminary assessments of these locations also suggested a reasonably high preservation potential. These eight areas were selected for additional, closely spaced, seismic surveys to enable accurate identification and mapping of the selected landform. Seismic data were collected by John E. Chance and Associates, Inc., of Lafayette, Louisiana, using the vessel Global Surveyor. The primary seismic instrument used was the ORE Subbottom Profiler operated at a frequency of 3.5 kHz. During portions of the survey, an ORE 5810A GeoPulse high-resolution subbottom profiler was used to collect supplemental seismic data. This latter instrument, operating at frequencies between 60 Hz and 2 kHz, proved of minimal utility in interpreting the upper 100 ft or so of sea floor sediments, which represented the section of interest in this study. Eight days were expended in the close-order survey of selected areas and an additional four days were spent running long seismic lines over portions of the study area to gather broad-scale information on its geology.

The additional seismic survey data suggested the elimination of one of the selected areas (High Island 38) from further consideration and the prioritizing of the other areas for vibracoring. In order of their presumed potential for containing preserved archaeological deposits, the areas were ranked from highest to lowest as follows: Sabine Pass 6, Sabine Pass 9, Sabine Pass 3, High Island 18, High Island 49, High Island 163, and Galveston 151.

Vibracoring was conducted by McClelland Engineers, Inc., of New Orleans, using the jack-up barge Harold Bradshaw. The vibracore could extract a 40-ft core. Given the water depths at which coring was undertaken (+30 ft) and the size of the vibracore used, a jack-up barge was a necessity to create a stable platform from which to work and to achieve the accurate positioning required. Seventy-six vibracores were taken from five of the selected areas. Two areas, High Island 163 and Galveston 151, were eliminated because of shortened field time due to bad weather. In every case, vibracores struck the target land surfaces within 1 to 3 ft of the suspected depth derived from the seismic records. This indicated accuracy in terms of positioning and a measure of reliability in terms of the interpretation of features from seismic records.

Samples were taken from these vibracores in an effort to further refine the local geology and to test for archaeological deposits. Analytical procedures conducted included grain-size, point-count, pollen, foraminifera and geochemical analyses. A number of radiocarbon dates were obtained from selected locations.

Results

Analyses of all of the collected seismic and core data provided abundant information on the geologic history of the study area and its archaeological potential. In most respects the geological findings correspond closely to those developed by Nelson and Bray relative to the configuration and age of the buried Sabine Valley. A major departure from Nelson and Bray is the identification of extensive areas of relict Deweyville floodplain features within the Sabine Valley area. The identified Deweyville channels are 900 to 1000 ft across, comparable in size to relict Deweyville channels seen today along the onshore Sabine River. It is recognized that Deweyville channels reflect much higher discharges than at present; however, there is disagreement over the nature and conditions responsible for the increased discharge. The dating of Deweyville is in contention also, with estimates ranging from greater than 30,000 B.P. to as late as 6000 B.P. Within the study area, several radiocarbon dates were obtained from in-place swamp deposits which cap Deweyville channel features. The earliest of these is 10,145 B.P., indicating that Deweyville channels in the study area are earlier than that date. How much earlier is not known.

On seismic records, Deweyville surfaces usually appear as an initial, hard reflector beneath which there is a void or little indication of variability in the sediments. This signal is distinctly different from that produced by the older, Pleistocene-age, Prairie/Beaumont Terrace formation through which the Sabine River has incised. The Prairie/Beaumont Terrace is characterized by distinctive, multiple, parallel reflectors through which the pinger general achieved considerable penetration, up to 100 ft. The identified Deweyville surfaces in the study area fringe both sides of the Sabine Valley and exist as a topographically level surface 10 to 15 ft lower than the Prairie/Beaumont surface. Deweyville surfaces can be identified with confidence for a distance of about 30 mi down the offshore Sabine Valley.

The interior portion of the offshore Sabine Valley, identified as Holocene floodplain, was only minimally examined because most of this area was characterized on seismic records by a flat to very uneven biogenic gas front which absorbed and attenuated the seismic signal. Vibracores which penetrated this gas front indicate that it represents the presence of extensive pretransgressive floodplain and early transgressive marsh/estuarine organic deposits. Floodplain landforms (levees, relict channels, etc.) certainly exist beneath this gas front but they were not identifiable on seismic records.

While considerable variability was noted in the specific sedimentary facies identified in each of the five areas cored, certain general areal trends are noted. Most importantly, in each area examined, pretransgressive Holocene deposits, which are intact or only minimally disturbed have been identified. These deposits consist of organic freshwater swamp or channel fill as well as fluvial sediments. Earlier Pleistocene or Deweyville surfaces were encountered beneath and/or adjacent to these Holocene deposits. Over much of the study area a thin stratum of sandy to silty clay blanketed the identified pretransgressive deposits. Some variability occurred in this facies but generally it was heavily burrowed, contained Rangia cuneata shell (often quite numerous) and, occasionally, other estuarine mollusk species, as well as localized organic or organic clay lenses. The Rangia shells found in this facies commonly exhibit minimal wear, suggesting disturbance has not been great. Foraminifera species identified in this deposit indicate moderate salinities. This widespread facies is interpreted as a low-energy, transgressive deposit formed with the initial expansion of estuarine systems into the area. This blanketing zone is critical in marking the boundary of transgression, and archaeological materials are expected to be found primarily within or beneath this deposit.

Above this initial transgressive facies is generally found a massive deposit of gray clay which represents bay/estuarine fill. The massiveness and homogeneity of this deposit suggests relatively rapid sedimentation. The uppermost stratum in the section consists of heavily burrowed clay containing varieties of marine shell. This facies represents modern, open Gulf, seafloor deposits.

An assessment of the preservation potential of pretransgressive landforms, and any associated archaeological sites, indicates that the critical factor in preservation is pretransgressive topography. Surfaces within deep stream valleys can become encapsulated and covered in estuarine muds during the early periods of transgression, which, with rising sea level, places them beneath the reach of wave activity when the shore front crosses the area. Land surfaces at higher elevations, such as the Prairie/Beaumont surface in the study area, are likely to be severely impacted by shore-front erosion. Archaeological deposits in these areas are unlikely to have survived transgression and inundation.

A series of radiocarbon dates obtained from the study area indicate a steady rise in sea level from about -75 to -45 ft between the period from 9000 to 7400 B.P. Rather significant compaction of pretransgressive, organic deposits was noted in some locales. Compaction was particularly obvious in identified marsh deposits found within the Holocene valley of the Sabine River. Radiocarbon-dated samples from these deposits could be displaced by many feet from their original point of deposition, seriously affecting their utility in measuring sea level rise. It is obvious that the effects of compaction and subsidence have to be carefully considered when evaluating radiocarbon dates in settings such as are found in the study area.

No distinctive man-made artifacts were encountered in any of the vibracore samples examined. Finding such artifacts was not considered likely in view of the small sample size and the nature of archaeological remains anticipated in the area. However, in one of the locales examined, the suite of analytical techniques employed in sample analysis suggests that archaeological deposits were encountered. This locale was in the Sabine Pass 6 lease block, situated about 10 mi offshore. This area is located on the eastern side of the former Sabine River valley and represents a point where two small stream channels draining the Deweyville surface meet at the edge of the Holocene floodplain. These two streams may be portions of relict, filled Deweyville channels.

Vibracores encountered two deposits in this area which exhibit characteristics of archaeological sites. Both of these potential archaeological deposits rest on the identified Deweyville surface adjacent to tributary streams, a setting considered optimum for prehistoric settlement. One of these deposits consisted of a concentration of *Rangia cuneata* shell at least 2.5 ft thick and 150 ft wide lying adjacent to, and possibly extending into or over, one the tributary streams. A matrix sample from the shell deposit contained a high percentage of well-preserved pollen, showing little damage related to water movement or redeposition. This suggests subaerial deposition of the pollen. Two key constituents of the pollen assemblage were juniper and disturbance (Cheno/Am) types. Fine screen (0 phi and -1 phi) samples from the shell deposit matrix contained fragments of bone. All of those which could be identified are fish and one is apparently burned. The size and configuration of the shell deposit, the condition and types of pollen represented, plus its particle content, are all consistent with expectations for an archaeological shell midden.

Chemical analysis of the deposit was less definitive as to the possibility of its being cultural. It did, however, exhibit moderately high concentrations of tightly-bound phosphates and zinc, both of which have been shown in other studies to be high in archaeological soils.

Approximately 150 ft south of the *Rangia* concentration, four vibracores encountered another deposit which has a high probability of being archaeological in origin. Samples taken from within, and just below, the initial transgressive zone yielded large quantities of bone, much of it burned. This bone concentration is estimated to cover an area about 125 by 175 ft in size and is located atop the Deweyville surface on the peninsula formed by the juncture of the two streams. The deposit containing the bone blankets the Deweyville surface and seems to spill over into one of the small stream channels.

Identified bone from fine-screen samples from this deposit consisted primarily of fish, but also included amphibian, reptile, small mammal, and possibly bird elements. As noted, much of the bone appears burned, some of it is definitely calcined. Preserved plant seeds from this deposit include fresh to brackish marsh types as well as upland species. This assemblage suggests deposition on an elevated landform adjacent to a marsh.

Chemical samples from this bone-concentration deposit indicated high total phosphate content and moderately high zinc concentrations. The distribution and occurrence of bone as indicated in the vibracore samples suggests that, at least, some of it has been disturbed and reworked, apparently during the initial transgression of marsh/estuary systems across the area. It was impossible to determine whether portions of the parent deposit, from which the bone was derived, is intact.

The particle content from this deposit, especially the bone fragments, indicates much greater similarity with known archaeological deposits than with natural deposits. Additionally, the location and confined nature of the bone distribution is consistent with expectations concerning prehistoric human settlement loci.

A radiocarbon date of 8055 ± 90 B.P. was obtained on the *Rangia* feature, while the deposit within which the bone concentration occurs is estimated to date about 8500 B.P. It appears that occupations of this locale first occurred during a period prior to transgression, possibly when marshes were near or first expanding into the area. The *Rangia* deposit suggests a later occupation, postdating the expansion of marshes into the area, and after extensive *Rangia* populations had become established. Shortly after 8000 B.P. all land surfaces suitable for habitation in the Sabine Pass 6 area would have been covered due to rising sea level. Despite the fact that both of these deposits have been impacted by transgression, buried by sediments, and inundated for over 8000 years, they maintain substantial characteristics of their original depositional environment.

Another aspect of the project was to evaluate the utility of the approaches used in this study. Additionally, their use and application by MMS in overseeing the offshore cultural resources program, was considered. It is obvious that the technological tools required in the search for archaeological sites on the OCS are available and viable. High resolution seismic survey is a useful and efficient means of collecting data needed to identify those locations and landforms most likely to contain archaeological remains. In terms of instrumentation used in this study, the 3.5 kHz "pinger" was most useful while the "boomer", operating at lower frequencies, was of lesser utility. The vibracore achieved the core recovery desired. Its use requires great precision in positioning and, to achieve the needed accuracy, a stable platform from which to operate. The jack-up barge used in this study proved satisfactory; however, it is an extremely weather-sensitive vessel and can be safely operated only in relatively calm seas.

The final assessment of a sample relied on its physical and chemical characteristics. Point-count analysis, using fine-screen samples, seems to be the most useful of the parameters employed in the study. This is primarily because it appears that the particle content of an archaeological deposit is less altered by the effects of inundation and burial than are other constituents. Chemical content, for example, varied widely among samples examined and differed from that known for terrestrial sites. However, trends in the chemical composition of samples were noted which suggests that this approach has promise.

While useful in combination, the criteria used in sample analysis need refinement. This can be achieved by the collection of more data on the variability in the particle and chemical content of known archaeological sites and of buried offshore sediments. In addition, the impacts of inundation to these parameters within archaeological contexts needs to be more carefully examined.

A brief series of recommendations, arising out of the results of this study, are provided. One is the recommendation that MMS needs to insure the accuracy of geological interpretations presented in lease-block survey reports. This study revealed consistent misinterpretations in these reports. This is extremely important for the management of archaeological resources on the OCS, since potentials for the occurrence of archaeological sites and recommendations for avoidance are based on the geologic interpretations.

The key to accurate interpretation is the placement of lease-block interpretations within a regional geologic framework. The present study provides the framework for one area of the OCS, others need to be developed. This can be done to some extent using already collected seismic and bore-hole data.

An additional need is a refinement, and possible expansion, of the analytical criteria used to examine core-size samples. As noted, this can be achieved through the examination and characterization of the chemical and particle content of a range of archaeological site deposits and natural sediments.

CHAPTER I: INTRODUCTION

For the past decade there has been an increasing interest in the prehistoric archaeological potential of the continental shelves of the world. Many would agree that, given certain conditions, prehistoric sites established on the continental shelves during periods of lower sea stand would have withstood the effects of rising seas and now remain preserved on the submerged portions of the shelves. One of the settings which provides that set of conditions conducive to site preservation is a filled stream valley, especially a large valley which, with sea level rise, developed into an estuary and slowly filled with sediments before being completely inundated. Archaeological deposits can become covered by, and encapsulated in, estuarine sediments and remain intact beneath the erosive impacts of transgressive seas. Developing statements concerning the occurrence and distribution of archaeological deposits in these offshore settings requires, first, the projection of a culture history for the area with its attendant settlement patterns (probably best drawn from onshore analogies); second, an assessment of the geologic and ecological histories of the area; and, third, the identification of the geomorphic processes which have occurred relative to their effect on archaeological site preservation.

To date, several studies relying on these types of data have produced what appear to be reasonable models of site occurrence and preservation in large stream valleys on the North American continental shelf (Belknap and Kraft 1981; Coastal Environments, Inc. 1977; Kraft et al. 1983; Masters and Fleming 1983). Testing these models, however, is another and more complicated problem. It requires a technology that permits the identification of submerged and buried landforms which have a high likelihood of containing archaeological remains, and it also requires a method for collecting samples from these landforms. In essence, it demands a practical geological/geophysical approach to an archaeological problem. Fortunately, this technology is today available in the form of a variety of instruments which permit refined mapping of the shallow subsurface geology, and in a range of coring devices which can collect an analyzable sample from a submerged target landform.

This report presents the results of a study sponsored by the United States Department of the Interior, Minerals Management Service (MMS), and undertaken by Coastal Environments, Inc. (CEI), to assess the potential of preserved archaeological sites on the Gulf of Mexico Outer Continental Shelf (OCS). Specifically, the present project was designed to test a predictive model of site occurrence and preservation developed in an earlier baseline study of the archaeological resources potential of the OCS (Coastal Environments, Inc. 1977). Relying on two key data sets, present knowledge and concepts of Quaternary geology and geomorphology and the nature and distribution of coastal archaeological sites, that study identified those landforms with which archaeological sites are most likely to be associated, and argued that many of these landforms (and their associated archaeological deposits) are preserved submerged on the continental shelf. The specific objectives of the present study were to test the validity of the proposed model, to determine whether modifications in the model are required, and to assess the reliability and utility of the current remote sensing technology as it is applied in offshore archaeological surveys. The wider purpose of the study is to provide information to MMS which will facilitate future management and study of the archaeological resources of the OCS.

This study required the evaluation and collection of remote sensing seismic data and the collection and analysis of physical samples from on and below the sea floor. The locale selected for implementation of the study is an area of approximately 2,580 mi^2 in the offshore Sabine-High Island region of eastern Texas and western Louisiana

(Figure 1-1). This area contains the relict, filled channels of the late Pleistocene-age Sabine River valley. The strength and reliability of the findings, conclusions, and recommendations resulting from the study are heavily dependent upon three factors: (1) the appropriateness and reliability of the geophysical techniques used in data collection, (2) the quality of the geophysical and geological interpretations employed throughout the study, and (3) the reliability and adequacy of the sedimentary and geochemical criteria used to distinguish archaeological deposits from natural sediments.

This project was conducted in two phases. The first phase involved review, synthesis, and evaluation of existing archaeological, geological, seismic, and bore hole data pertinent to the study; selection of locales having a possibility of containing archaeological sites; and collection of high-resolution seismic data from these selected locales. The second phase involved the collection and analysis of vibracore samples from the target areas in an effort to identify archaeological remains.

Project Background

Since 1973 the United States Department of the Interior has required remote sensing surveys of offshore oil and gas leases on the OCS prior to their development by industry. This survey requirement was initiated in recognition that increased mineral extraction activities may result in irreversible damage to, or loss of, the archaeological resources of the OCS. The purpose of these surveys has been to assess the archaeological potential of the lease areas and identify any significant archaeological resources that may exist.

In an effort to implement more effectively their responsibility to manage cultural resources, the Department of the Interior also initiated several study efforts to inventory and evaluate the archaeological setting and potential of the OCS. In 1977, CEI produced one of these studies, Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf. As noted, that study led to the development of a set of predictive models of the occurrence and preservation of prehistoric sites on the Gulf of Mexico OCS.

Seismic data collected as a result of the required archaeological surveys have recorded many examples of relict landforms identified in the CEI models as having a high probability for containing evidence of prehistoric occupation. Avoidance of these landforms has been, with very few exceptions, the course of action undertaken by industry as a means of compliance. As a result, no substantive data have been collected which could serve to evaluate the predictive model developed by CEI.

In a subsequent study (Gagliano et al. 1982), CEI examined the sedimentary characteristics of coastal prehistoric sites as analogs for submerged sites on the OCS. The study established criteria and a suite of analytical techniques and procedures which enable the identification of archaeological deposits from small, core-sized samples. Together these two studies provide much of the background and the analytical approaches and parameters needed for the implementation of the present research.

Concepts

Several fundamental concepts are incorporated in the CEI models which are critical to the present study. The following discussion presents these concepts and relates them to the present project. One of these is the basic recognition that great portions of the continental shelf were exposed as land areas during relatively recent geological time

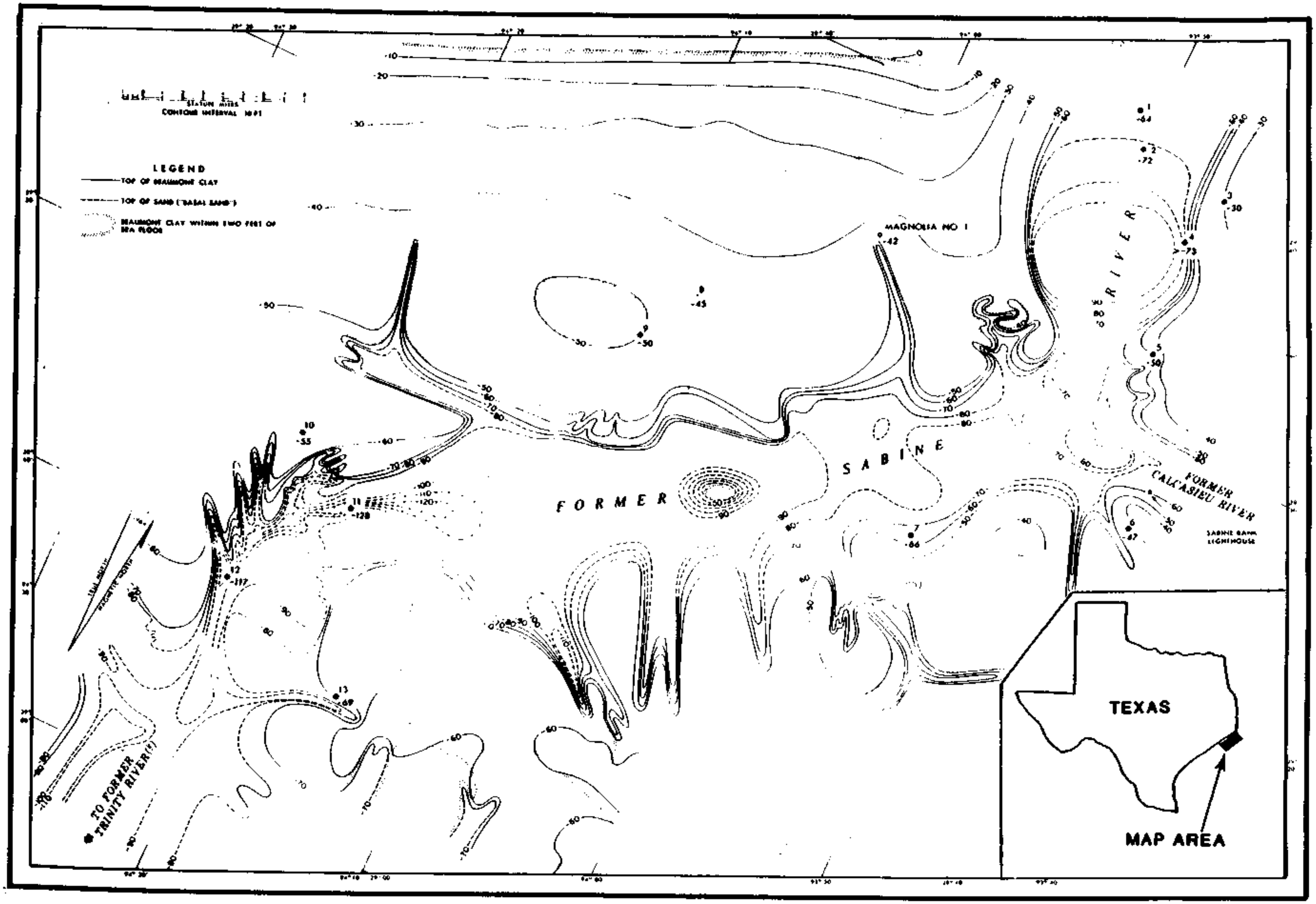

Figure 1-1. The study area (after Nelson and Bray 1970).

but have become submerged as a result of sea level change. While there is probably a general consensus among Quaternary geologists that most of the continental shelf areas of the world were exposed as a result of glacial episodes during the late Pleistocene, there is still disagreement as to the precise date and absolute depth below present level of this sea stand. Available evidence from the northern Gulf area suggests sea level was at least 90 m lower than present, possibly as much as 130 m, and that the low stand occurred during the period 20,000 to 17,000 years B.P. (Nelson and Bray 1970). Since that time sea level has risen, reaching its present stand about 3,500 years B.P. This means that all of that region selected as the study area for this project, the offshore Sabine-High Island area (fully discussed below), was subaerially exposed land surface during the period of the low stand.

A second fundamental consideration concerns the probability that human populations were present in the region, specifically in the study area, during periods of terrestrial exposure. There is today general agreement among archaeologists that human populations have been in the Gulf area for at least 12,000 years and some would argue for as long as 20,000 years. Therefore, much, if not all, of the continental shelf has been exposed and available for use and occupation since the period of human entry into the New World. Over the past 15,000 years or so the study area has contained many of those environments and landforms considered to have been particularly attractive to human utilization (Coastal Environments, Inc. 1977). Therefore, it is reasonable to assume that the area was occupied by man during periods of lowered sea level. Direct support for this assumption is provided by the occurrence of Paleo-Indian artifacts along McFaddin Beach between High Island and the Sabine River, along the northern edge of the designated study area. Clovis points, generally accepted to date prior to 11,000 years ago, have been discovered, as have numerous fossils of Pleistocene fauna, including mastodon, mammoth, saber-toothed tiger, horse, capybara, and camel (Long 1977). A radiocarbon determination from a piece of elephant tusk from McFaddin Beach provided a date of 11,100 ± 750 years B.P. (Long 1977:7). All of the cultural and faunal material from McFaddin Beach has been recovered from beach-lag where it is being deposited by wave action. The material is apparently derived from several eroding late Pleistocene and early Holocene deposits which are exposed immediately offshore (Pearson 1983). The McFaddin Beach material provides evidence that both man and the animals which he hunted were near the study area 11,000 years ago, a time period when most of the study area was exposed as dry land and contained the active Sabine River and river-mouth estuary.

An additional consideration is whether or not archaeological deposits would have survived the late Wisconsin sea level rise and transgression. The model developed in the 1977 CEI study presents evidence that, under certain conditions, archaeological sites on the Gulf of Mexico OCS will survive rising sea level. Others have presented discussions of the factors leading to site preservation for other areas (Belknap and Kraft 1981; Fleming 1983; Kraft et al. 1983; Masters and Fleming 1983). On the Gulf of Mexico OCS sites are most likely to be preserved when they are covered by, or encapsulated in, sediments as a result of subsidence or alluviation, a situation which provides protection from subsequent marine erosion during transgression. Many examples of completely and partially buried and drowned sites are known from the Mississippi Deltaic Plain and from the upper Texas coast. (See Ambler 1973 and Dillehay 1975 for examples from Texas and Gagliano et al. 1982 and McIntire 1958 for examples from the Mississippi Deltaic Plain area.)

A somewhat similar process of site preservation can occur in drowned river valleys, as is exemplified in the former Sabine River valley, the major relict geomorphic feature in the study area. Nelson and Bray (1970) have studied the Holocene deposits of the filled valley, interpreted the environments of deposition of the various strata and established their age through radiocarbon dates. Their study has indicated that features associated with the Sabine River and the Sabine River mouth estuary, deposited during periods of early human occupation (Paleo-Indian and Archaic times), are preserved in the shallow subsurface on the continental shelf. These features have been buried by subsequent deposits (primarily estuarine/lagoonal) sufficiently thick to remove and protect them from shoreface erosion. River systems and estuaries were favored habitation locales for prehistoric populations; therefore, it is reasonable to assume that archaeological sites may be associated with certain preserved landforms of the filled Sabine River valley.

A final element in the CEI models concerns the relationship between sites and landforms. Relying on known archaeological site data, primarily from coastal settings, the models indicate that the pattern of settlement and environmental use is closely related to natural systems and associated landforms. It has been demonstrated that these landforms exist on the OCS as drowned, relict features and that they can be identified with the geophysical instrumentation currently in use (Gagliano et al. 1982). Critical to the present study is the indication by Nelson and Bray (1970) that several types of these high probability landforms exist as buried and preserved relict features within and adjacent to the former Sabine River valley.

The Study Area

The region selected for implementation of this study is the area of the buried Sabine and Calcasieu River valleys located in the offshore Sabine-High Island area of eastern Texas and extreme western Louisiana (see Figure 1-1). This late Pleistocene/early Holocene river system provided an ideal research universe for the present study, in part because a series of published works is available which provide considerable information on the present setting and geologic history of the valley area. Of particular importance, as noted earlier, is the published work of Henry F. Nelson and Ellis E. Bray (1970) which delineates the Pleistocene river system and the subsequent changes it underwent with sea level rise. In addition to the work of Nelson and Bray, an extensive body of seismic and borehole data, collected relative to oil industry activities, is available from the area and the regional geology has been well studied (Aronow 1971; Aten 1983; Bernard 1950; Bernard and LeBlanc 1965; Bernard et al. 1962; Berryhill 1980; Curray 1960; Nelson 1968).

Other factors which make the buried Sabine Valley important in the search for submerged sites are: 1) the river system was active and the area was subaerially exposed when prehistoric populations occupied the region; 2) the river system was active for at least 12,000 years, sufficient time to permit the accumulation of an extensive archaeological record, possibly including multicomponent, stratified sites; 3) relict features having a high probability for both site occurrence and preservation have been identified within the valley system; and, 4) importantly, these landforms are often not deeply buried and many are within the range of vibracoring, the sampling technique used in this study.

Volume Organization

Chapters II and III present information on the geology and cultural history of the study area and serve as the background for comprehending the later portions of this volume. Chapter IV presents discussions on the specific sources of data used in the study and on the various field techniques and laboratory procedures employed. That chapter also discusses the locales selected for vibracore testing and provides the rationale for that selection. Chapter V presents the results and interpretation of data analyses for each of the selected locales. Conclusions and recommendations are presented in Chapter VI.

As will be seen throughout this report the English, rather than the metric, system will be the primary measure used for distances and depths. The reason for this is that survey work and geophysical and geological interpretations conducted relative to the vast majority of offshore studies in the Gulf of Mexico utilize the English system. It was decided to maintain this usage to permit ease in comparing all sets of data. Metric equivalents are given where appropriate.

CHAPTER II: GEOLOGICAL AND ENVIRONMENTAL SETTING

Introduction

The study area consists of the late Pleistocene/early Holocene river valley formed by two principal rivers, the Sabine and Calcasieu. In order to better assess the geological setting and research potential of the area, two levels of basic data review were conducted. One level focused on the Sabine/High Island area and examined available literature dealing with the study area and adjacent regions and with questions of archaeology and the OCS in general (e.g. Masters and Fleming 1983). The second level of review concentrated on the small-scale, detailed survey reports pertaining to lease block and pipeline surveys conducted for or by the various oil and gas exploration companies operating in the area. Because of the geological detail often contained in reports of this nature, they became the basis by which specific areas of close-spaced seismic data were selected. These latter reports will be discussed in Chapter IV. The regional overview is presented here.

Geological Overview

Geologic History

The late Quaternary stratigraphic sequence of the northern Gulf coast has been discussed in numerous works (Aronow 1971; Aten 1983; Bernard 1950; Bernard and LeBlanc 1965; Fisk 1944; Saucier 1974, 1977), and it is, in general, well understood. Questions remain concerning the dating of some of the stratigraphic units, and these have led to the two interpretations of the geologic history presented below. The earliest deposits of interest are those of the Beaumont Terrace, which form the margins of the Sabine River valley within the study area. What is called the Beaumont in Texas is equivalent to the well-studied Prairie Terrace formation in Louisiana. To avoid confusion, the formation hereafter is referred to as the Prairie/Beaumont. These deposits are of fluvial and deltaic origin and upper sections consist typically of highly oxidized stiff clays, although other facies are present as well (Aronow 1971:43). The entire formation was at one time considered to be of Mid-Wisconsinan age (ca. 30,000-25,000 B.P.) (Bernard and LeBlanc 1965; Fisk 1944), but recent interpretations suggest that deposition began during the Sangamon Interglacial (prior to 80,000 B.P.) and that only the uppermost deposits are associated with the Mid-Wisconsinan, Farmdalian Interstadial (Saucier 1977).

It is during the succeeding Woodfordian substage that the disagreement over the geologic history becomes pertinent to the present research (Figure 2-1). Aten (1983:Fig. 8.3) would extend the Prairie/Beaumont formation into this period on the basis of two terrace levels which he has identified along the Trinity River. These terraces are intermediate between what he terms the Deltaic Plain phase of the Prairie/Beaumont formation, which would include the five Trinity River meander belts identified by Aronow (1971), and the distinctive "Older" and "Younger" Deweyville terraces first described by Bernard (1950). Aten (1983:110) argues that the intermediate levels are strath terraces cut during stillstands in the falling sea level. No absolute dates are reported for these terraces, thus Aten's placement of them is based largely on his estimates of the ages of the Deltaic Plain phase of the Prairie/Beaumont formation and the Deweyville terraces.

The Deweyville terraces are fluvial features which exist as topographically level surfaces located intermediate between the Prairie/Beaumont Terrace and the Holocene floodplain (or, along the Trinity River, between the Holocene floodplain and

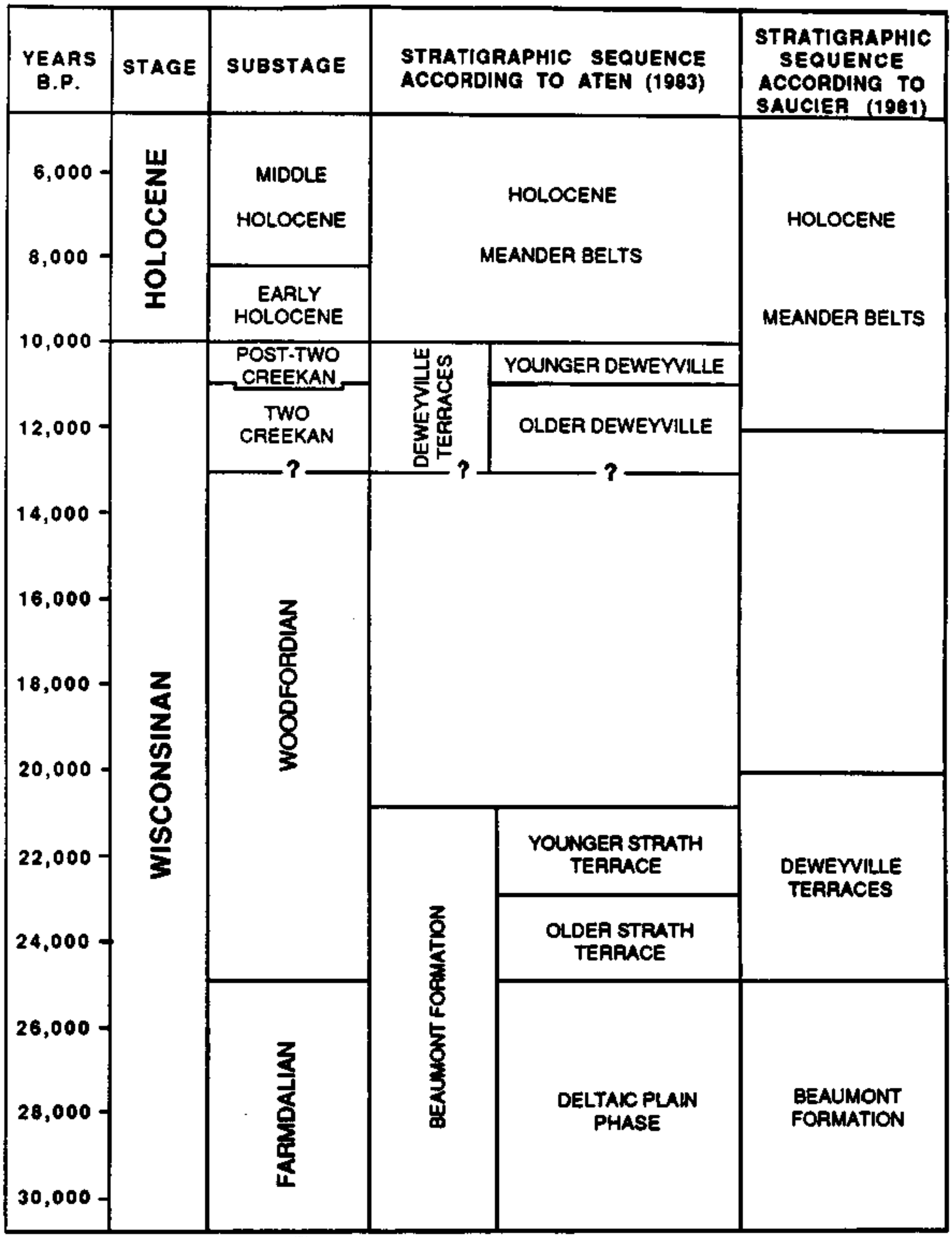

Figure 2-1. Geologic sequences of Aten and Saucier.

the strath terraces). The surfaces of the Deweyville are characterized by the presence of "giant" meander and channel scars three to six times larger than those of the modern Sabine River (Bernard 1950; Gagliano and Thom 1967; Saucier 1974). In the lower Sabine area, Deweyville scars average 960 ft across, a size suggesting that Deweyville rivers accommodated bank full discharge some four to seven times the capacity of the modern river (Alford and Holmes 1985; Gagliano and Thom 1967).

There presently is disagreement as to the forces responsible for the production of the distinctive Deweyville channels. As now known, Deweyville-like features are confined to coastal plain streams in the southern and southeastern United States. Because streams containing Deweyville features are ones which would not have been affected by glacial melt water, most researchers look to a much wetter climate as the causal factor. Alford and Holmes (1985:100-104) argue that large meanders of the Deweyville are associated with a warmer and wetter-than-present post-Pleistocene climate, specifically a climate characterized by warm season precipitation resulting from tropical storms. Others, while arguing for increased precipitation, and/or lower evapotranspiration, suggest that Deweyville features formed during a cooler-than-present climate.

The age of the Deweyville is also in contention. Radiocarbon assays on wood from Deweyville channels in the Sabine Valley and elsewhere indicate an age ranging from 17,000 to greater than 30,000 years B.P. (Bernard and LeBlanc 1965). Gagliano and Thom (1967) argue that the conditions responsible for Deweyville alluviation continued through the Two Creekan Interstadial up to 6,000 or 7,000 years ago. Aten (1983:114) associates the Older Deweyville Terrace with the rising sea level during the Two Creekan Interstadial (ca. 13,000-11,000 B.P.) and the Younger Deweyville Terrace with the reversal brought on by the Valders (or Greatlakean substage) Glaciation (ca. 11,000-10,000 B.P.). He identifies no stratigraphic units intermediate in age between the early Woodfordian strath terraces and the much later Deweyville terraces. Recently, Alford and Holmes (1985:401-402) have argued for a "mid-Holocene" date for the Deweyville of ca. 7500-4000 B.P.

Saucier, on the other hand, associates the Deweyville terraces with the end of the Farmdalian Interstadial and the onset of the Woodfordian Glaciation (ca. 25,000-20,000 B.P.) (Saucier and Fleetwood 1970:885-886; Saucier 1981:12). Sometime prior to the glacial maximum (ca. 18,000 B.P.) deposition apparently halted and a cycle of entrenchment began. The next stratigraphic units identified in Saucier's sequence are braided stream deposits which date between 18,000 and 9000 B.P. along the Mississippi and Arkansas Rivers (Saucier 1981:14-15).

The current state of knowledge is, then, that Deweyville features date anywhere between 30,000 and 4000 B.P. During the course of the present study, relict Deweyville floodplain features were identified in the offshore study area. Radiocarbon dates from organic fill in relict Deweyville channels indicate a minimum age of at least 10,000 B.P. for the features. Our assessment of the Deweyville phenomenon is discussed more fully later in this volume.

It is important that we refine our knowledge of the Deweyville terraces since they were in existence throughout much, if not all, of the period of human occupation in the Gulf coastal region, and, on the basis of present archaeological data, were extensively inhabited. As Saucier (1981:12) notes this is probably because Deweyville is everywhere "the first terrace (and hence closest high ground) bordering long stretches of the Holocene floodplains of the rivers."

Late Quaternary Environments

The environmental setting of the study area provides a backdrop against which we can begin to comprehend human use and settlement of the study area. Aten (1983) has presented a detailed discussion of the probable post-glacial environmental settings for the southeast Texas area which are applicable to the present study. Here a brief synthesis of the proposed environmental setting for the region is presented. A more detailed assessment of the environmental settings and changes within the study area is offered in the final chapter of this report. For now, the following discussion is organized around three periods which are thought to mark significant environmental changes in the region of the study area during the time of potential human occupation: late Pleistocene (13,000-10,000 B.P.), early Holocene (10,000-8500 B.P.), and middle Holocene (8500-6000 B.P.).

The dating of the Deweyville terraces has an important impact on the development of paleoenvironmental models for the Sabine River valley during the 13,000-10,000 B.P. period. Aten's placement of the terraces in this interval carries with it the implications of very high rates of discharge and pluvial climatic conditions which have generally been associated with the Deweyville (Bernard 1950; Gagliano and Thom 1967; Saucier and Fleetwood 1970; but see Saucier 1981:12). In addition to the inferred higher annual precipitation, Aten (1983:135) cites vertebrate and invertebrate faunal studies which support a model of deciduous forest cover in the region. The resulting picture of the present study area is one of a forested river valley traversed by a stream possibly several times the size of the present Sabine River. During this period the mouth of the stream shifted as sea level rose and then fell slightly, but at no time was the area of interest closer than 25 mi to the estuary into which the stream emptied (Nelson and Bray 1970:67-68).

Saucier's placement of the Deweyville terraces in a much earlier time period suggests that by 13,000 B.P. discharge levels on the Sabine River already had fallen to something approaching present levels. Climatic conditions and biotic patterns during this time also may have been closer to those of the early Holocene than Aten's model suggests. The implications of these changes for the immediate study area are that the Deweyville surfaces had been abandoned by this time, and that the Sabine River was already occupying a smaller, entrenched floodplain.

The controversy over the dating of the Deweyville terraces has only a minor effect on environmental reconstruction during the succeeding early Holocene period. Aten (1983:135-136) places the shift to present hydrologic conditions within this interval and infers from this a reduction in precipitation and the establishment of more divergent seasonal temperatures. He further suggests that the decreased precipitation led to an expansion of grasslands. As noted previously, Saucier's dating of the Deweyville terraces would presumably place the transition to interglacial climatic and hydrologic conditions somewhat earlier.

The major event occurring in the immediate study area during this period was the inundation of this portion of the Sabine River valley by a brackish-water estuary or lagoon (Nelson and Bray 1970:67-69). The Prairie/Beaumont Terrace and at least portions of the Deweyville terraces were still exposed and probably continued to support a deciduous forest during this time.

The final period of interest is the middle Holocene, a time interval closely associated with the Altithermal or thermal optimum. Aten (1983:136) states that discharge levels on streams fell to a point approximately 40% below current rates during this period.

This, coupled with the formation of caliche deposits, led him to suggest that precipitation decreased further during this time, resulting in the continued expansion of grasslands. He also cites evidence of increased mean annual temperatures for this period.

Within the immediate study area there may have been a drop in sea level of roughly 10 ft early in this period, followed by a stillstand and then the resumption of the general Holocene rise (Nelson and Bray 1970:66, 69). This possible short-term regression and stillstand may be related to the climatic changes discussed above. Estuary or lagoon systems continued to occupy the former river valley extending up to approximately the present shoreline, but salinity levels may have been somewhat higher than previously due to decreased freshwater inflow. Deciduous forest was probably being replaced by prairie on the Prairie/Beaumont formation, but it may have continued to cover much of the Deweyville terraces still exposed. By 6000 B.P. marine transgression had inundated all but a few high points in the immediate study area.

Geology and Paleoenvironment of the Study Area

While the foregoing studies provide important and useful information, it is the work of Nelson and Bray (1970) which has been most detailed, has most influenced subsequent research, and, in effect, is the basis for selecting the Sabine-High Island area for study. Nelson and Bray's interpretation of the geologic history of the study area served as the base on which the present study was built. Data collected in the present study have expanded upon, and resulted in some alteration to, the model developed by those two authors, and these alterations are discussed later. For now, however, we will examine Nelson and Bray's conceptualization of the study area at the time the present project was initiated.

Nelson and Bray identified, through a series of marine sonoprobe profiles, the filled late Pleistocene-age Sabine River valley as the major subseafloor feature in the region. This filled valley runs across the study area from the northeast to the southwest (see Figure 1-1). The filled Pleistocene-age valley of the Calcasieu River joins the Sabine Valley in the eastern part of the study area and the Sabine Valley itself extends southwestward out of the study area, eventually joining the former Trinity River valley.

The Sabine River valley is incised across the earlier Pleistocene-age Prairie/Beaumont formation. The specific date of the Sabine entrenchment is not known, but available information on sea level change derived from radiocarbon determinations collected by Nelson and Bray (1970) suggests that much of the entrenchment occurred during a period of falling sea and low sea stand probably between 25,000 and 18,000 years B.P. (Curray 1960; Gagliano and Pearson 1982; Parker 1960).

Augmenting their marine sonoprobe data with approximately 7000 dredge samples and several cores, Nelson and Bray developed a reconstruction of the geological and environmental history for the Sabine Valley over the past 10,000 years or so. Their reconstruction is critical to the present study since it was used to initiate the interpretation and chronological placement of features identified on the seismic records examined and collected. Their sequence of events is presented in Figures 2-2 and 2-3, and is briefly summarized below.

Prior to about 10,200 years B.P. the study area consisted of the exposed Prairie/Beaumont formation, a fairly flat, weathered surface, probably similar to the present-day land surfaces seen just inland of the study area on the Texas coast. The

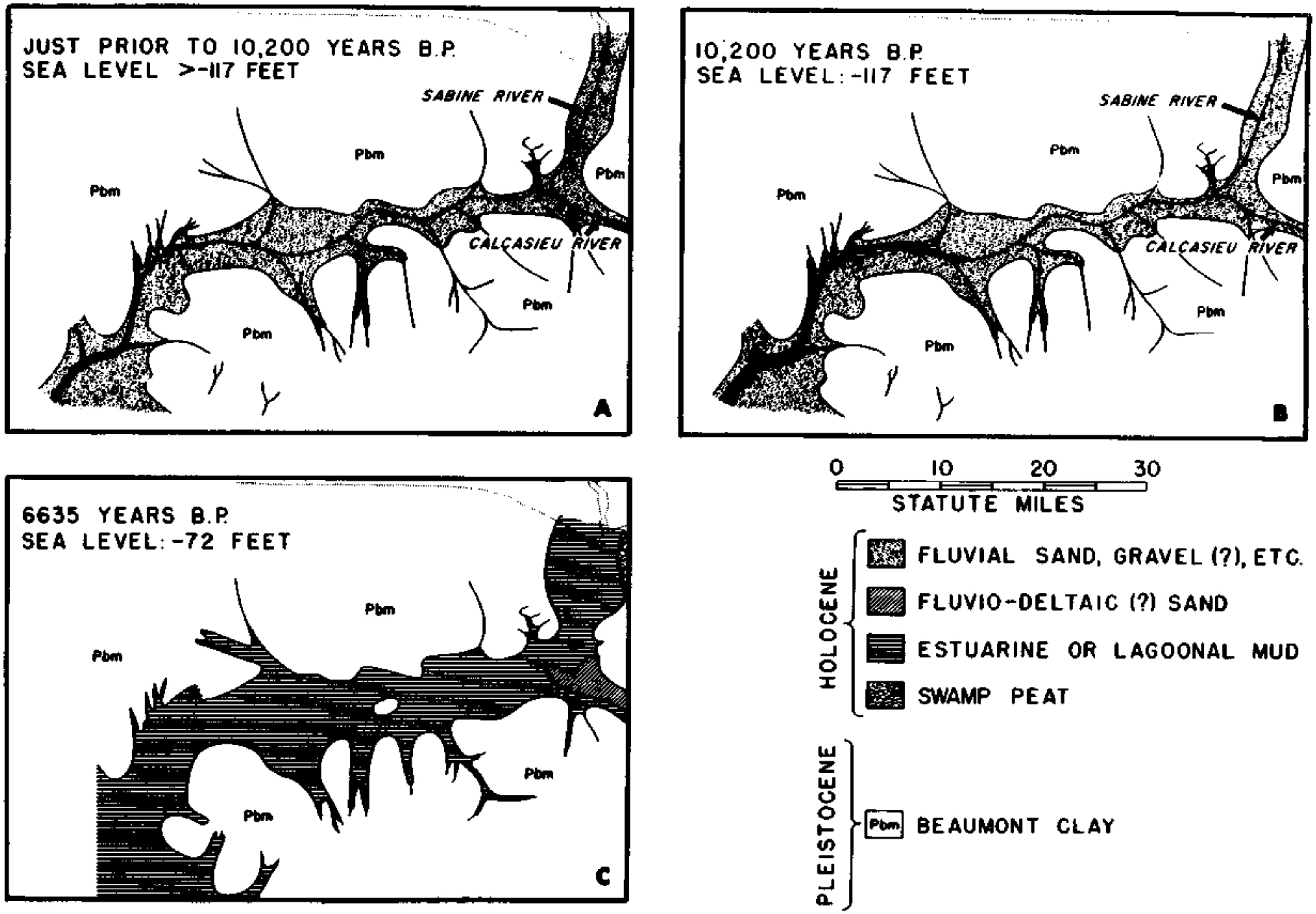

Figure 2-2. Sequence of Holocene events in study area from 10,200 years B.P. to 6635 years B.P. (after Nelson and Bray 1970).

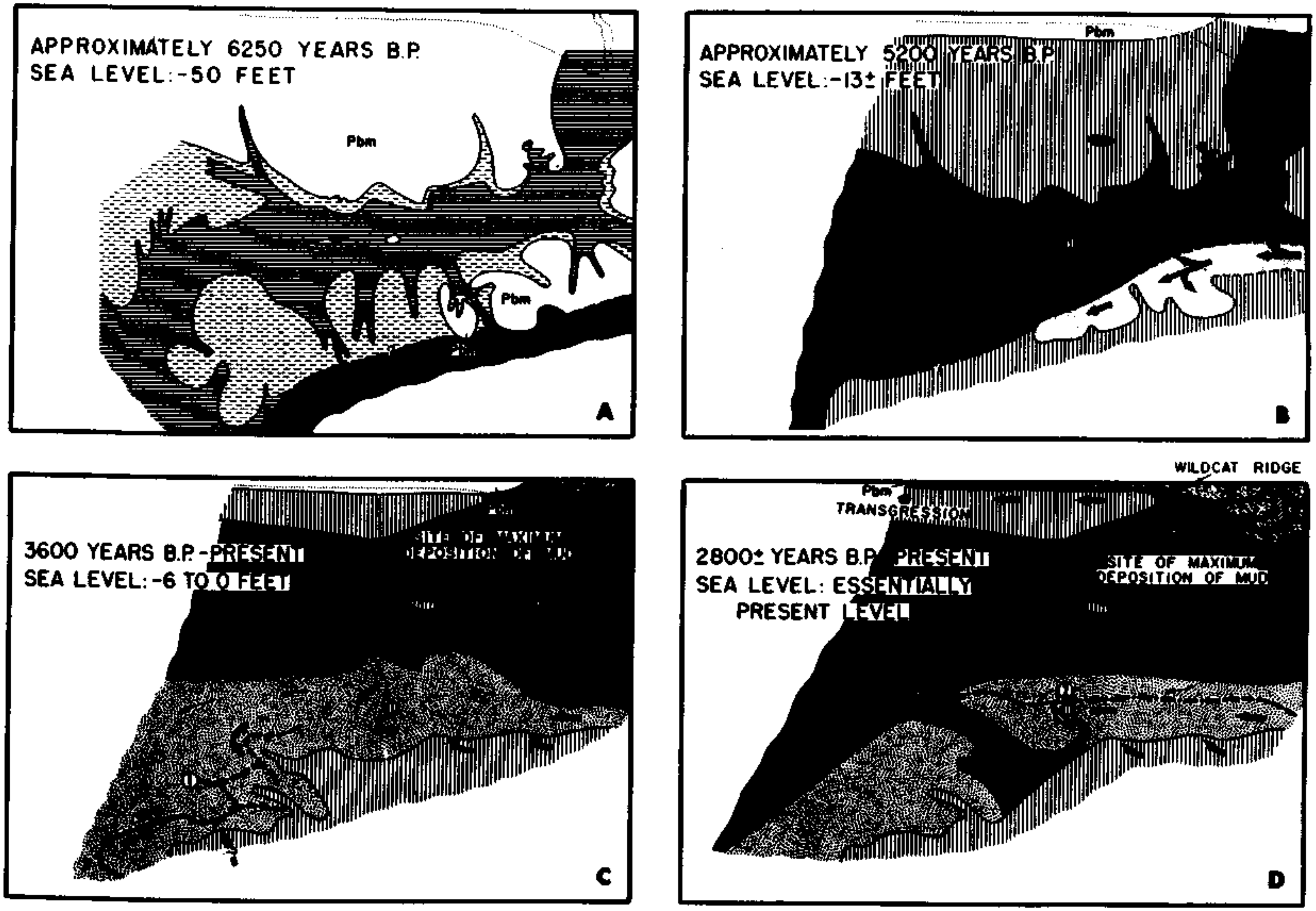

Figure 2-3a. Sequence of Holocene events in study area from 6250 years B.P. to 2800 years B.P. (after Nelson and Bray 1970).

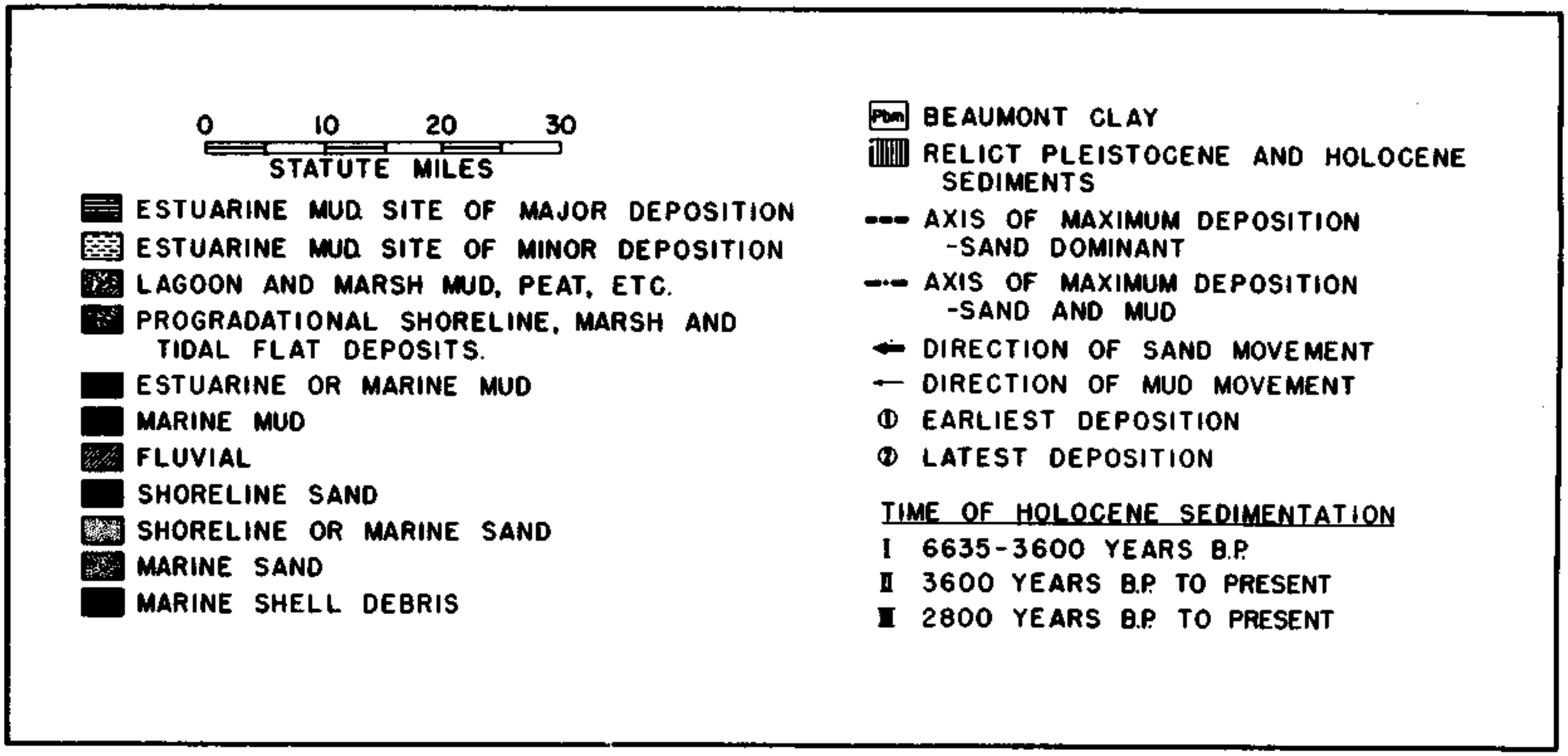

Figure 2-3b. **Key to Figure 2-3a.**

flowing Sabine River and its wide valley were incised across the surface and, according to Nelson and Bray (1970:48):

> At 10,200 years B.P. the rising sea began to flood the Sabine valley and convert it into a lagoon or estuary. A swamp formed ahead of the rising water. At this time sea level was at -117 feet. The sea continued to rise rapidly until it reached a level of -73 feet at 9,400 years B.P. when the rate of rise decreased. For the next 2,800 years, until 6,600 years B.P., sea level fluctuated between -62 and -72 feet. Sand began to accumulate along a shoreline just south of the study area during this time. At 6,600 years B.P. sea level again began to rise rapidly; this continued until 5,650 years B.P. when the rate of rise decreased. Sea level reached its present elevation approximately 2,800 years ago. Important geologic events during this period were: (1) inundation of the upland, (2) the change from a brackish water to a marine environment in the vicinity of the banks (5,200± years B.P.), (3) accumulation of sand in the marine environment to form present-day Heald and Sabine Banks, and (4) establishment of the shoreline on the coastal plain and migration of part of this shoreline seaward as the Sabine estuary filled with sediments.

The data provided by Nelson and Bray allow us to bracket that time period when the study area offered the optimum sets of environments suitable for human exploitation and also to identify the areas where occupation and preserved sites are most likely to occur.

For simplicity, the study area can be viewed relative to the existence of two major environmental systems associated with the former Sabine River.

1. The earliest of these systems is essentially riverine in nature and was characteristic of the study area when the Sabine was a flowing river. Riverine environments were dominant in the area during the period prior to about 10,200 years B.P. when sea level was at -117 feet and lower (see Figure 2-2).

2. During the period between about 10,200 and 6,200 years B.P. the Sabine Valley became an estuarine system, eventually becoming completely inundated by rising sea level (see Figure 2-2). During this interval estuarine-lagoonal systems became dominant. Sea level rose from about -117 feet to -62 feet and, apparently during much of this period, fluctuated between -62 feet and -72 feet (Nelson and Bray 1970:48).

The post-6,200 years B.P. period is of little concern in this study. After that date the critical portion of the study area, the buried the Sabine Valley, became entirely flooded eliminating the possibility of habitation (see Figure 2-3).

The Modern Sabine River as an Analog

It is important to emphasize that during the period from 25,000 to 6,000 years ago the Sabine River in the study area was a complex and dynamic riverine and then coastal estuarine ecosystem. We must assume that at any one point in time the area within the boundaries of the Sabine Valley defined by Nelson and Bray exhibited the range and variety of polygenic biotic and abiotic features and systems found in present-day riverine and estuarine settings. The modern Sabine River serves as an analog with which to model the setting of the study area prior to marine inundation. This analog represents the geologic history and setting of the river valley as a riverine system prior to conversion into an estuary. As such it presents only a segment of the full developmental sequence postulated for the Sabine Valley in the study area. As will be noted later, the utility of this model is enhanced since, in the study area, features which are preserved and which can be identified on seismic records tend to be those associated with the fluvial history of the Sabine River. It has proven to be more difficult to identify and verify features which may be associated with the estuarine history of the valley. Figure 2-4 presents the surface and near-surface geology of a 14-mi-long section of the lower Sabine River between Orange, Texas, and Starks, Louisiana. Within this area the Sabine River has incised an alluvial valley, ranging from 3 to 7 mi in width, into late Pleistocene terrace deposits identified as part of the Prairie/Beaumont formation or terrace. The Prairie/Beaumont Terrace in this area is relatively flat and minimally dissected and slopes gently to the south. Relict fluvial features are still preserved on its surface.

Deweyville terrace deposits fringe both sides of the Sabine Valley (see Figure 2-4). These exist as a topographically level surface located intermediately between the Prairie/Beaumont Terrace and the Holocene floodplain. As noted earlier, the surface of the Deweyville is characterized by the presence of "giant" meander channel scars which average 960 ft across.

The modern or Holocene floodplain of the Sabine River is confined to the central portion of the valley, commonly bounded on either side by Deweyville terraces. In some areas the Holocene floodplain impinges upon the Prairie/Beaumont Terrace edge. The modern floodplain is characterized by the present Sabine channel as well as relict meander belts and channel segments of earlier courses of the river. Associated with these channels are natural levee landforms that rise only 3 to 6 ft above the poorly drained backswamps which dominate the floodplain. Several tributary streams draining the Prairie/Beaumont Terrace and/or the Deweyville surfaces flow into the modern Sabine channel.

Borings conducted by the Louisiana Department of Highways and presented in Bernard (1950) provide cross sectional information on the subsurface geology of the Sabine River in this area. Figure 2-5 presents bore hole data taken along transect X-X', the location of which is illustrated in Figure 2-4. This profile shows the gross lithology and relationship of the three major formations in the valley, the late Pleistocene Prairie/Beaumont Terrace, the late Pleistocene/early Holocene (?) Deweyville terraces, and the Holocene floodplain. The Prairie/Beaumont Terrace is characteristically composed of reddish brown clays or silty clays, the Deweyville terraces are primarily a gray silty to sandy clay or gray sand, and the modern floodplain consists of gray clays overlying sands. In addition, the Prairie/Beaumont is generally stiffer and more highly oxidized than the other two deposits.

Comparison of the general size and configuration of Nelson and Bray's interpretation of the submerged Sabine Valley and the modern valley demonstrates close correspondence (see Figures 2-4 and 2-6). Figure 2-6 shows the locations of two transects of some of the bore hole data examined from the study area. Two schematic geological cross sections from these bore hole data are presented in Figures 2-7 and 2-8. Core data were derived from Nelson and Bray (1970) and various oil company borings. The structure, configuration and lithology shown in these cross sections closely correspond to that noted in the cross section of the modern Sabine Valley, as shown in Figure 2-5. The river valley is incised into Pleistocene Prairie/Beaumont Terrace deposits to a depth of about 120 ft below sea level, a depth matching that provided by Kane (1959) for the Pleistocene Sabine channel under present-day Sabine Lake. In Figure 2-7, interpreted Deweyville deposits, consisting primarily of gray

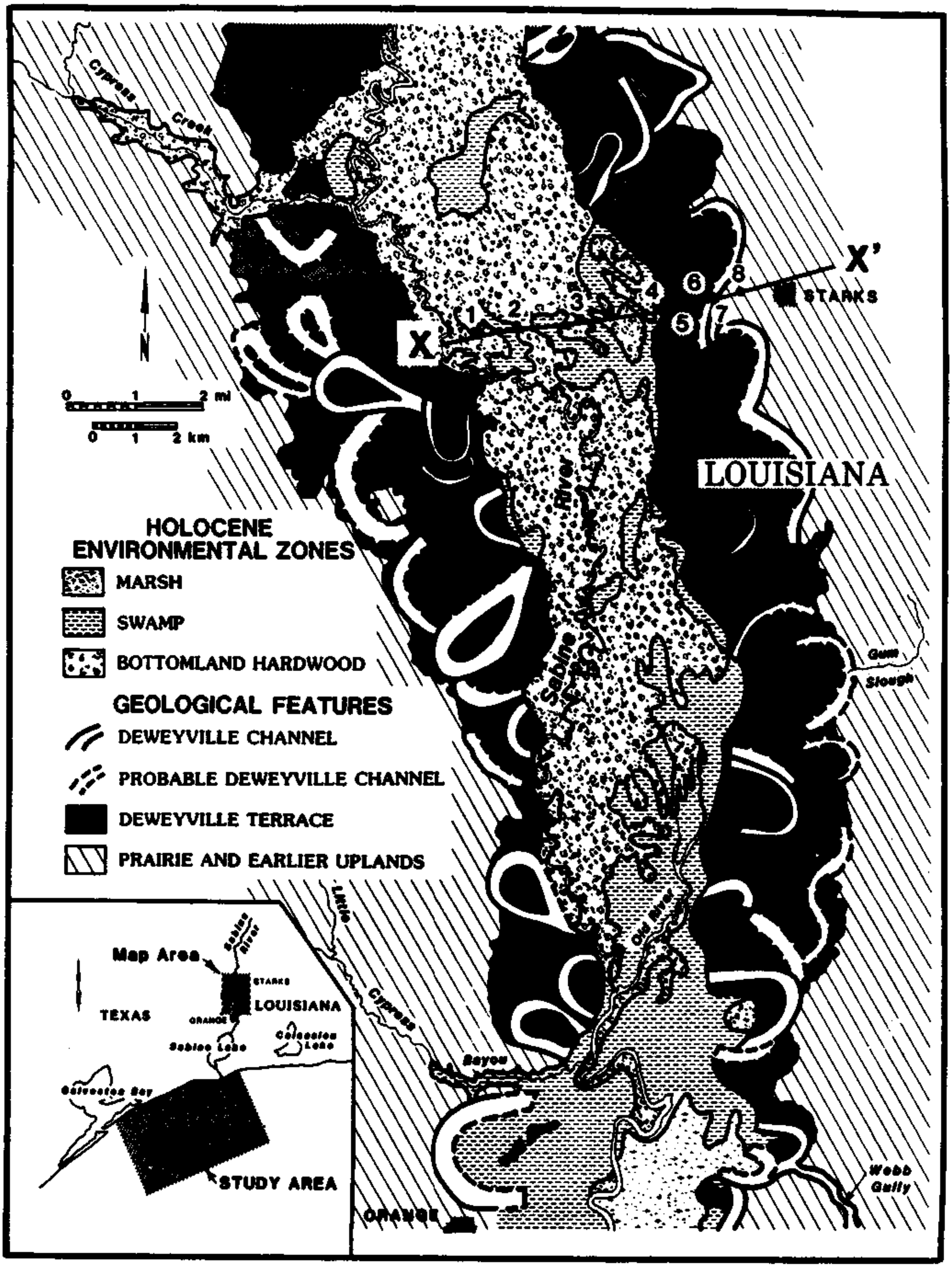

Figure 2-4. Surface geology of the lower Sabine River showing bore hole transect.

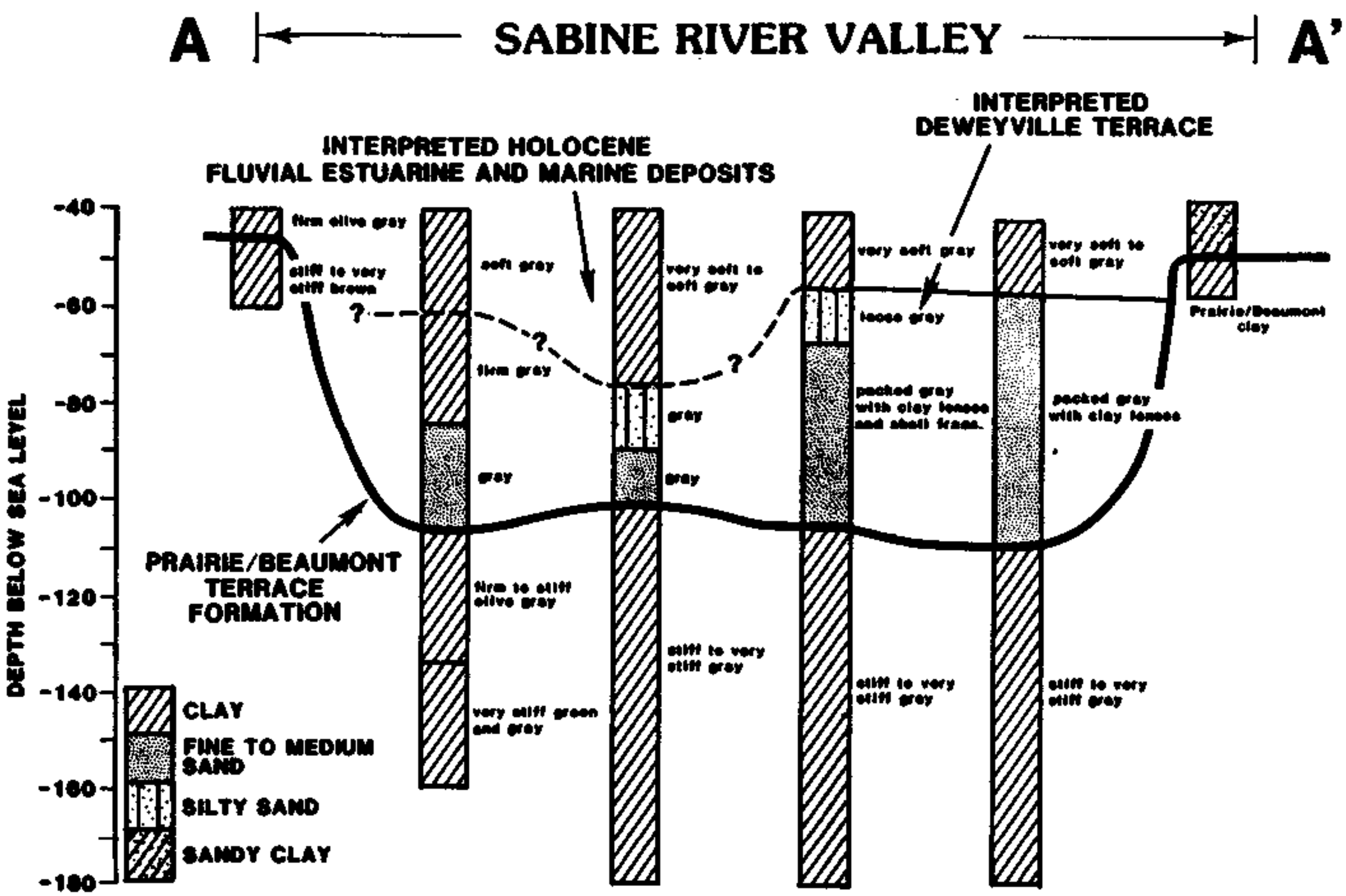

Figure 2-7. Schematic geological profile across the buried Sabine River valley in the study area. Location of profile shown in Figure 2-6. Bore hole data derived from Nelson and Bray (1970) and oil company borings.

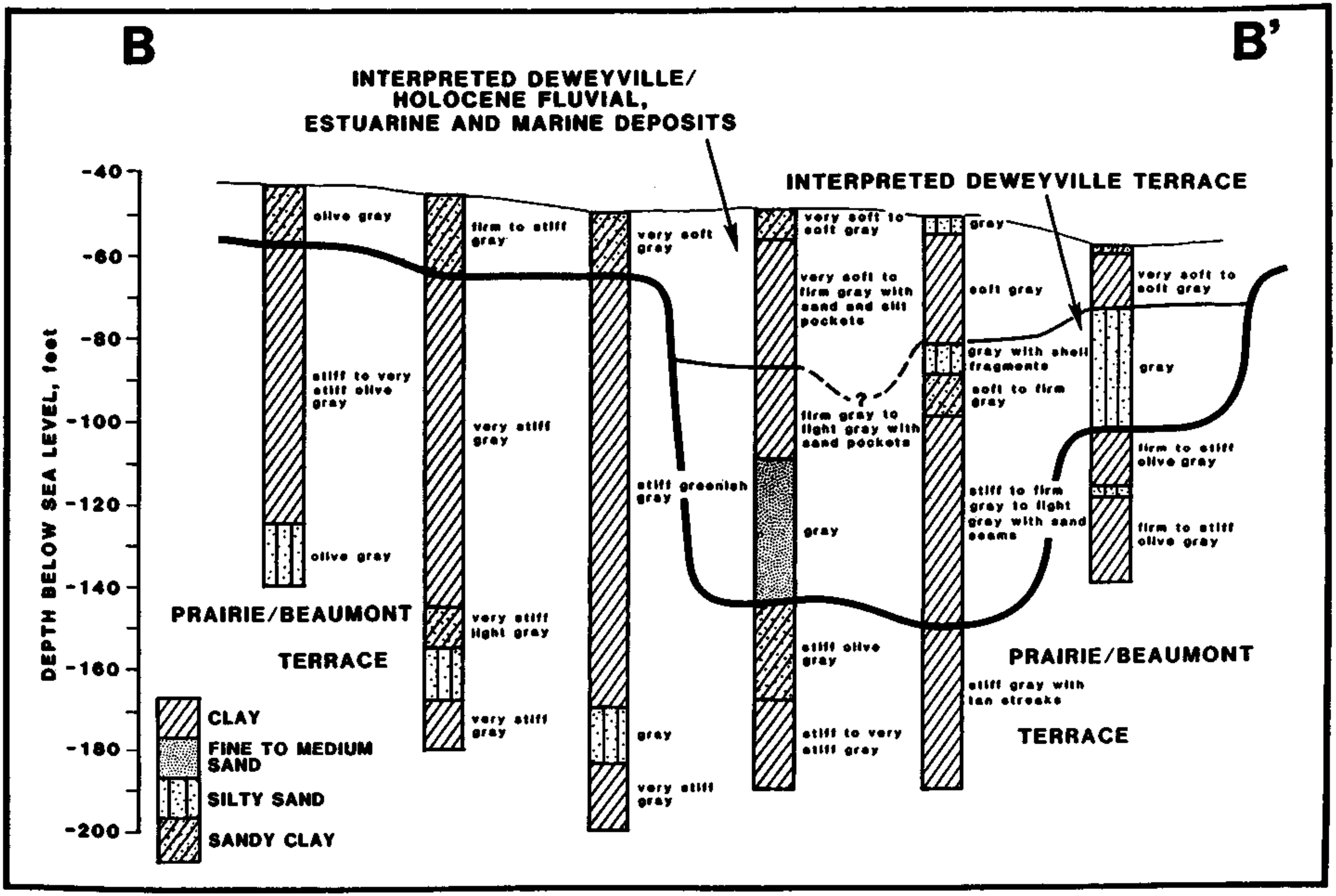

Figure 2-8. Schematic geological cross section through the lower portion of the buried Sabine Valley in the study area. See Figure 2-6 for location. Bore hole data from various oil company borings.

sands, are shown adjacent to the eastern valley wall. The elevation of this identified Deweyville surface relative to the Prairie/Beaumont Terrace matches that found along the modern Sabine. In Figure 2-8, the interpreted Deweyville deposits are most easily identified along the southern part of the valley. The surface of these deposits are silty sands, contrasting with the fine clay estuarine or marine sediments resting above them. Deweyville deposits are less confidently distinguished on the north (landward) side of the valley; however, a shift to firmer clay sediment indicated in the third core from the right in Figure 2-8 is tentatively identified as the Deweyville surface.

The geophysical data examined and collected in this study (fully discussed later) confirms the existence of extensive Deweyville deposits within the buried Sabine Valley. These deposits generally appear as a hard reflective (sand?) surface underlain by an acoustical void or transparent zone which can generally be distinguished from the multiple reflector character of Prairie/Beaumont deposits. Additionally, large, well-preserved, filled channel segments are commonly observed on these Deweyville surfaces. These channels average 900 to over 1000 ft across, corresponding in size to the Deweyville channels identified on shore. The seismic records indicate that in many cases the Deweyville surface and associated features are complete and well preserved. It appears that they have not been seriously damaged or truncated by shoreface erosion during transgression. Furthermore, Holocene fluvial or estuarine deposits may exist intact over Deweyville terrace features.

As noted earlier, landforms associated with relict Deweyville channels provided ideal habitats for human use and exploitation. Their levees were high and well drained and, prior to complete filling, the relict channels themselves provided open water or swamp habitats which supported a variety of aquatic and land animals and plants. Several areas with Deweyville features were selected for intensive study and are discussed individually in later sections of this report.

The Holocene deposits shown in Figures 2-7 and 2-8 consist of clays which sometimes overlie sands. Presently it is difficult to distinguish between Holocene fluvial and estuarine deposits in all cases. It is apparent, however, that these deposits are preserved within the confines of the trench.

The seismic records of the modern floodplain are most commonly truncated by biogenic gases, obscuring any buried features. As a result, it is difficult, if not impossible, to identify modern floodplain and estuarine formations. Marine deposits of varying depths, overly all of the buried trench area. It is often impossible with the available data to differentiate marine sediment from underlying estuarine deposits.

CHAPTER III: CULTURAL SETTING

In addition to changes in the environment, as discussed in Chapter II, it is assumed that patterns of settlement shifted in the study area over time. These shifts are presumed to have resulted, in part, from internal changes in the cultural systems themselves and from accommodations made to a changing environment. These assumptions about settlement on the continental shelf are derived from direct knowledge of onshore site data or from conceptions about cultural adaptation and change in the past. The quality of the information from these two sources influence the reliability of models of settlement patterning developed for the OCS.

Landforms and Human Utilization

In dynamic riverine and coastal situations, where changes in the positions of shorelines and streams are accompanied by shifts in the prehistoric settlement pattern and land use, the occupation pattern is dictated by active and relict landforms, such as stream banks, beaches, and margins of estuaries. The Sabine Valley area is a case in point. A model depicting site locations in a valley similar to that of the Sabine is illustrated in Figure 3-1. Sites can be anticipated along the banks of the stream itself (most likely after the stream became relict or cut off from the main channel), along the margins of the floodplain or valley wall, in the deltaic area of the stream system, and along the margin of the estuary near the mouth of the stream (see Gagliano 1984).

The morphology of such systems may be complicated by fluctuations in the base level of the stream, resulting in the formation of alluvial and coastal terraces. Relict stream courses are associated with the alluvial terraces, while relict beaches and other shoreline features are found on the coastal terrace. In many instances, sites can be found associated with these features, although the features themselves may predate the sites by many thousands of years (e.g. relict Deweyville channels). The recent study by CEI (Gagliano et al. 1982) examined sites associated with several of the landforms expected within the Sabine Valley. These include sites on both major and minor natural levees, a site on the edge of a Pleistocene terrace overlooking a small stream, and two sites on a terrace adjacent to an estuary. In fact, the latter two sites, Cedarland Plantation and Jackson Landing, indicate the diversity of site types expected along an estuarine margin not unlike that believed to have existed adjacent to, and at times within, the Sabine Valley.

Settlement in the Study Area

Efforts to study the archaeology of the North American OCS requires an understanding of several specific aspects of the natural and human history of any given area. One of these is the pattern of settlement which would have been practiced by the various populations occupying the shelf area over the period of time when it was exposed as dry land. A well-developed conception of the placement and distribution of sites across the landscape through time is particularly important if research is directed at actually locating sites, as was done in the present study. The development of a settlement model requires either a usable sample of sites from a particular area which is adequate and sufficient to permit the development of a comprehensive model, or a set of settlement data from another area which can serve as an analog for model development. There are no site data from the OCS, such that any proposals of settlement must be derived through the use of onshore analogs. In those few cases where settlement patterns have been discussed for shelf areas, it has normally been achieved by extending the onshore patterns of settlement into offshore areas (e.g. Coastal Environments, Inc. 1977; Kraft et al. 1983).

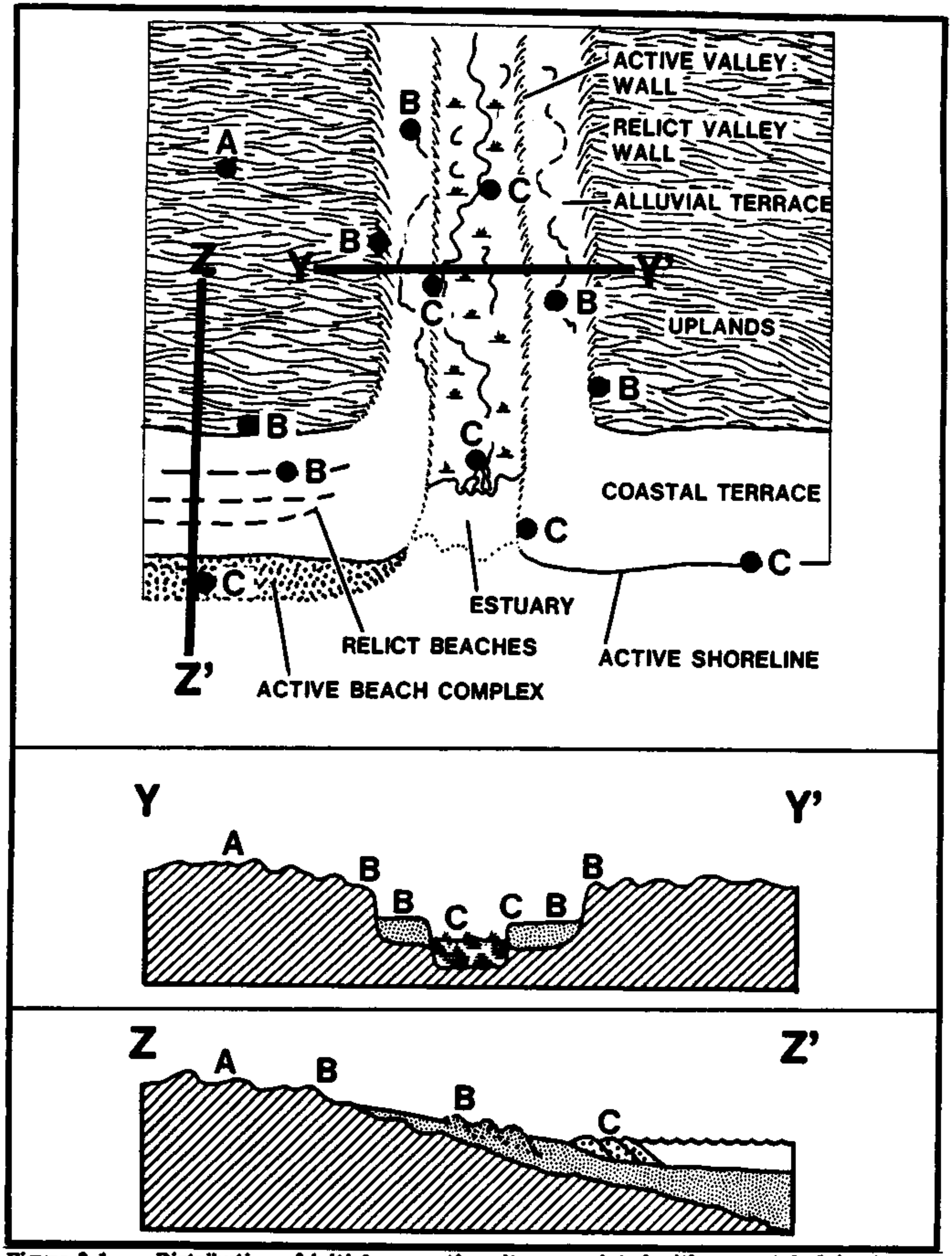

Figure 3-1. Distribution of initial occupation sites associated with a coastal plain stream system. A - oldest; B - intermediate; C - youngest (after Coastal Environments, Inc. 1977:1:183).

The lack of offshore data dictates that onshore evidence be used in the development of any settlement pattern models for the submerged shelf area. The nature of what is here termed "onshore" data can range from specific examples of archaeological settlement systems, to more general models of site-landform relationships (e.g. Coastal Environments, Inc. 1977), to assumptions about prehistoric cultural systems and their presumed modes of settlement. In the present study, and probably in most studies of similar offshore areas, the development of reasonable models of settlement requires the use of this full range of data types and sources. Two previously published sources were extensively drawn upon in this effort. One of these was the 1977 CEI baseline study which provided a basic model of site-to-landform relationships for the Gulf of Mexico region. That portion of the model which deals with coastal riverine systems and their history through inundation is applicable in the present study.

The other published data source which was used extensively is that of Aten (1983). This study provides basic environmental and cultural data from the east Texas area which has direct application in assessing prehistoric settlement in the study area. In addition to these published works, onshore site data from two Gulf coast riverine systems, the Sabine and Pearl Rivers, are used as "best-case" analogs for deriving specific information on site locations as they may have existed within the study area.

Data Biases

Some consideration must be given to the shortcomings and biases which exist in the data used to develop models of settlement for the OCS. Although discussed in terms of direct reference to the present study, these problems exist for any similar study. A major difficulty in the direct use and extension of onshore settlement data into an offshore area is the lack of sufficient onshore site data which can serve as a reference point for developing applicable offshore models. For example, as Aten (1983:140) has noted, there are minimal site data from the upper Texas coastal zone dating to earlier than 3500 years ago. Some additional site data are available from slightly further inland, but even with these there is a relatively small quantity of settlement information with which to work.

Another difficulty with a simple extension of onshore site distributions into the offshore area, is that sites found in the coastal zone today may not have been coastal sites when occupied. This is particularly true for the earlier sites which were occupied when sea level was much lower, and are likely to be reflective of an inland pattern of settlement. In the east Texas area (as in much of the Gulf coast region), the location of early sites (e.g. Paleo-Indian through initial Middle Archaic) which would reflect true coastal settlement and adaptive systems, today would be located well offshore where coastal environments formerly existed. Farther east, in Louisiana, the Salt Mine Valley site on Avery Island may provide our only example of an early littoral site. There, artifacts co-occur with the brackish water clam Rangia cuneata and extinct fauna, suggesting a nearby coastal estuary during the period of use of the locale (Aten 1983:144-145, Coastal Environments, Inc. 1977:222). Dates for the strata containing these materials range from 10,900 B.P. to 11,950 B.P. (Coastal Environments, Inc. 1977:222). With this one exception then, in the region of interest we have no good examples of early settlement patterning in the littoral zone. The majority of these early habitats and sites which may have been associated with them, are now submerged or buried.

Additionally, there is the question as to whether past climatic conditions and coastal habitats, both of which influenced human settlement, were like those of the present. Aten (1983:131-139), for example, suggests that the much greater freshwater outflow of Deweyville times plus hypothesized changes in the patterns of precipitation resulted in coastal climates quite different from those seen today. He (1983:135) suggests that prior to 10,030 B.P. forested conditions existed for the upper Texas coast with climate characterized by milder winters, cooler summers and overall higher precipitation. The period from 10,030 to 8,490 B.P. was characterized by a drastic reduction in precipitation and a greater divergence in mean annual temperatures and an expansion of grasslands. The period from 8,490-5,060 B.P., the thermal optimum, was a period of increasing reductions in river discharge and a warmer and drier climate resulting in a continued expansion of grasslands. Synthesis of pollen data from the Southeast provide conflicting evidence on this period. Delcourt and Delcourt (1981) suggested vegetation changes in the Southeast during the period from 8,000 to 4,000 years B.P., reflecting an increase in warmth and aridity resulting from increased strength of prevailing westerly winds. More recently, Delcourt (1985) has argued an increase in summer precipitation after about 8,000 B.P. from greater influence of the Maritime Tropical Airmass. This establishment of a distinctive seasonal rainfall pattern is earlier than that projected by Aten. He suggests that after 5,060 B.P. modern seasonal patterns of precipitation and temperature became established, river discharges increased and precipitation probably increased.

Aten's scenarios of post-Pleistocene climatic and environmental change on the Texas coast are the most detailed and relevant to the study area. They are, however, of necessity, broadly drawn. There are simply insufficient data available at present to be more precise. There is, however, some question as to the nature and degree of impact these possible changes had on the prehistoric populations of concern in this study. We are dealing with populations inhabiting river valley and coastal marsh/estuary biomes, habitats which would be buffered to some extent from climatic changes.

The changing amounts of water in fluvial systems and as precipitation would certainly have influenced the extent and configuration of riverine and estuarine biomes but it is unlikely that these would have been entirely eliminated over the course of the climatic changes proposed by Aten. Some evidence for the continued existence of marsh/estuary habitats similar to those known today is evidenced in the preserved plant seeds collected in this study. These seeds imply that at least for the period from about 7,500 to 10,000 B.P., there existed in the offshore study area saline, brackish, and freshwater plant communities almost identical to those known today.

At the broader, regional scale, Delcourt and Delcourt have argued that the vegetation of the Gulf Coastal Plain of the Deep South "has remained relatively stable during the last 40,000 years in that an already widespread mosaic of oaks, hickories, and Southern Diploxylan pines has persisted in sandy upland sites" (Delcourt and Delcourt 1981:153). This regional stability has been due largely to the overriding climatic influence of the Maritime Tropical Airmass (Delcourt 1985).

In viewing the impact of climatic change on the prehistoric settlement patterns of the study area it is probably reasonable to assume that populations had to adjust to spatial shifts in plant and animal communities rather than to absolute elimination of, or additions to, these communities. Additionally, it has become apparent in this study that changes in sea level had a more profound effect on the occurrence and distribution of habitats in the study area than did climate.

The meagerness of site data from the early periods influences the precision with which settlement can be modeled in the study area. Consequently, the authors are most confident in projecting settlement patterns for those locales and time periods associated with riverine habitats. This is primarily because onshore site data which have utility in assessing early prehistoric settlement in the study area are largely associated with riverine settings. The almost total lack of early sites in the east Texas/western Louisiana area which, when occupied, were associated with the pre-6,000 B.P. strand, estuarine or marsh habitats of the coastal zone, weakens the direct use of onshore analogies in the development of offshore settlement models for these habitats.

The settlement choices made by a population are dictated by a multitude of cultural phenomena such as the technology, level of social organization, economic orientation, and relationships with neighboring groups. These factors are important in any effort to characterize prehistoric settlement and, dependent upon the nature of available site data, may be the critical parameters used. The general lack of site data from the east Texas area useful for modeling early prehistoric settlement in a coastal habitat, emphasizes the need for using these cultural variables. As Aten (1983:149) notes, however, any effort to characterize how early cultures may have used the coastal zone requires deductive considerations.

Conceptual Settlement Patterns

As discussed earlier, the study area includes only a portion of the landforms and environmental settings presented in the 1977 model by CEI. These settings are those associated with a drowned riverine system. The two major habitats extant in the study area would have been: (1) the coastal zone with strand, estuaries and marshes, and (2) the deciduous, riparian woodlands of the river valley proper and the area immediately bordering the river system. Aten (1983:148) identifies an additional habitat for the upper Texas coast, a coastal prairie or parkland positioned between the coastal zone and the deciduous woodland. This habitat is of less concern here since it existed away from the valley proper, in an area considered to have a low potential for site preservation.

It is expected that adaptation to each of these major habitats varied such that settlement distribution and site types would have differed in each. In addition, adaptive patterns (and resultant settlement distributions) would show changes over time. Thus, within the framework provided by natural habitat on one hand and adaptation (primarily in terms of economic orientation and resource exploitation) on the other, it is possible to characterize prehistoric settlement in the study area during the period of interest.

The study area was submerged by about 6,000 years ago limiting the present concern to populations occupying the region earlier than that date. The cultural periods of concern are Paleo-Indian and the Early Archaic. Several workers have discussed or synthesized available information on the archaeology of these periods for the Texas Coastal Plain (Aten 1983, Hester 1976a, 1976b; Story 1980; Suhm et al. 1954). Aten (1983:141) suggests dates for the Paleo-Indian of about 12,000 to 9,000 B.P. in the east Texas coastal area. Most researchers in Texas would terminate the Early Archaic at about 5000 or 5500 B.P. (Aten 1983:143; Story 1980).

The general conception for the entire southeastern United States is that Paleo-Indian refers to cultures adapted to the late, full glacial period, while Archaic cultures are associated with the changing environments of the post-Pleistocene period. While this is broadly true, variability in climatic conditions certainly affected patterns of human adaptation and settlement at the subregional level. In the study area, for instance, if Aten's geologic model is accepted, Paleo-Indian populations would have confronted Deweyville conditions which he equates with the late full-glacial period. Deweyville floodplain and deltaic settings would certainly have provided environmental conditions quite distinctive from non-Deweyville settings elsewhere in the eastern and southeastern United States regardless of the regional climatic conditions. On the other hand, under Saucier's geologic model, the Paleo-Indian time period would postdate the Deweyville interval and these populations would have faced environmental conditions which were, or were becoming, more similar to those generally associated with succeeding Archaic populations.

Paleo-Indian Settlement

The authors' conception of Paleo-Indian settlement in the study area is based upon the minimal amount of archaeological data from the upper Texas coast, correlation with the archaeological record elsewhere, assumptions about Paleo-Indian economy, and assessments of the nature of environmental and climatic conditions.

Evidence of Paleo-Indian occupations in southeast Texas is rare and aspects of early settlement and subsistence are not well defined. The general assumption is that Paleo-Indian economy centered on big game hunting. However, Bryant and Shafer (1977) argue that the woodland and parkland habitats, assumed to have existed in eastern Texas, would have forced dispersal of certain herding species and forced a diversified hunting and collecting economy on the area's early inhabitants. For the woodland habitats outside of the riverine setting, then, Paleo-Indian sites were probably small, widely dispersed and represented short periods of occupation (Aten 1983:149). The nature of these sites makes them difficult to locate archaeologically.

Patterson (1985) has recently synthesized the data on prehistoric settlement and subsistence in southeast Texas. He argues for very long-term occupation of some sites suggesting "a stable settlement pattern lasting for as long as 10,000 years may be indicated for some of the sites" (Patterson 1985:258). However, he presents little information on riverine settlement during the Paleo-Indian period. One of the difficulties in dealing with these latter settings is that alluvial sediments have buried earlier floodplain landforms such that few Paleo-Indian artifacts have been recovered. It is assumed, however, that Paleo-Indian settlement did occur in the floodplains, almost certainly on the elevated, well drained and dry levee and fluvial terrace features just as occurs in the later prehistoric periods for which settlement data are available. Floodplains certainly supported an abundance of Pleistocene megafauna during the late glacial period as evidenced by data from the Central Mississippi Valley (Morse and Morse 1983:51-53). There is no reason to believe that the Sabine River valley would not also have supported varieties of megafauna as well as an abundance of smaller animals and aquatic species. Given the available evidence, it is probable that Paleo-Indian populations would have concentrated in riverine environments and established settlement on escarpments, terrace edges, natural levees or other similar, elevated settings. Presumably, an effort would be made to establish sites near a water source such as a relict channel or active tributary stream.

If, as Aten suggests, Deweyville regime channels were active during the Paleo-Indian period, they would certainly have influenced settlement. We can assume much greater quantities of water in the valley, possibly restricting settlement to only the very highest elevations within the valley or to the escarpments bordering the valley. Whether these restrictions would have been seasonal or year-round is unknown.

Also difficult to assess is Paleo-Indian adaptation to, and settlement in, the strand, estuary, and marsh habitats that existed in the study area. Aten (1983:149) suggests that early adaptation to these habitats may have involved "strandlooping" or a relatively diversified economy based on exploitation of plant and animal species of the coast and estuary margins. This seems reasonable in light of the biological productivity, diversity and relative ease of exploitation of food resources of these habitats. This is particularly true in terms of fish and shellfish. Smith (1986) has recently synthesized the data on the utilization of shellfish in the Southeast which, by the middle Holocene, had become a major component in the diet of some populations. The earliest dates on shell midden sites in coastal estuary ecosystems are about 4200 to 3800 B.P. This correlates closely with the date at which sea stand reached its present level. While Smith (1986:22) seems to imply that the stabilization of sea level at circa 4500 B.P. was causative to the emergence of coastal shellfish exploitation, it seems as, or more, acceptable to suggest that earlier exploitation took place but the sites evidencing this have been buried or destroyed by transgression. It is evident that shellfish exploitation on interior Southeastern rivers was occurring in an intensive manner as early as 6000 B.P. (Smith 1986:22). While not direct evidence for the earlier exploitation of coastal shellfish, this does suggest that populations in the Southeast were knowledgeable of shellfish as a dietary item at a period much earlier than the dates now available for coastal sites.

Within the Galveston Bay estuary, just west of the study area, a number of shell middens of Rangia cuneata dating from ca 2000 B.P. to as early as 3700 B.P. are known (Aten 1983: Table 14:1). These sites provide evidence that shellfish have been exploited essentially as long as shellfish producing environments have existed in this area. There is currently no reason to believe that shellfish beds associated with lower sea-level stands were not similarly exploited. Some evidence for exploitation of Rangia cuneata at a very early date is its occurrence in the 11,000 to 12,000 year-old bone bed of the Salt Mine Valley site on Avery Island, Louisiana, some distance east of the study area (Gagliano 1970). Similarly, the concentrations of Paleo-Indian artifacts in what are assumed to have been coastal habitats in the Choctawhatchee Bay area of northwest Florida may be indicative of the use of coastal zone resources (Coastal Environments, Inc. 1977:1:289-292). It is noted that the Florida materials consist of lithic artifacts which occur as individual finds or in very small concentrations; no evidence of Paleo-Indian shell middens have been recorded. If Paleo-Indian populations were exploiting coastal and estuarine resources in a manner similar to later populations, then it seems reasonable to assume that many similarities in settlement would exist. These types of settlement locales are fully described in the 1977 CEI model and, as they are applicable to the study area, are summarized in Table 3-1. The nature and content of these sites (e.g. containing shell) would make them much more visible and archaeologically detectable than contemporary sites in the uplands and inland river floodplains.

Table 3-1 also presents information on our assumptions about Archaic settlement, potential for landform preservation, potential for identification of a specific landform with the subbottom profiler, and the potential for sampling a landform with the vibracore. The data presented are based on an assessment of seismic records and analysis of vibracores collected. The information in the table is considered applicable only to the study area or similar drowned valley settings.

Archaic Settlement

Characterizing settlement during the Early Archaic is hampered by the same problems found when dealing with the Paleo-Indian period, i.e., lack of onshore site analogs and a limited understanding of Early Archaic adaptation. Archaeological data indicate that Early Archaic sites on the coastal plain of Texas are fewer and more widely dispersed than those of either the Paleo-Indian or Middle Archaic periods (Story

Table 3-1. Projections on Site Occurrence, Preservation, and Locatability for the Study Area.

Settlement Location	Probability of Site Occurrence		Preservation Potential	Seismic Detectibility	Vibracore Accessibility
	Paleo-Indian	Archaic			
Coastal Beach/Accretion Ridge	1	1	1	2	2
Coastal Barrier Island	2	2	1	2	2
Bay Margin	1	2	2	1	2
Estuary Margin	2	3	2	1	2
Holocene Natural Levees	2	3	3	1	1
Other Holocene Floodplain Features	2	1	3	1	1
Deweyville Natural Levees	2	3	3	2	2
Deweyville Terrace Margins	2	3	3	3	2
Pleistocene Terrace Margins	3	2	2	3	3
Interior Pleistocene and Earlier Uplands	3	1	1	2	3
Pleistocene Erosional Remnants within Floodplain	3	3	2	2	3

Key: 3 - high
2 - moderate
1 - low

1980:13). In this region, Early Archaic sites appear to be more concentrated inland and well away from the present coast.

Aten (1983:152-155) has suggested that the apparent decrease in Early Archaic utilization of the coastal plain may be related to environmental factors. The Early Archaic in Texas generally corresponds to the Altithermal or Atlantic climatic episode, the period of the thermal maximum characterized by periods of hot, dry conditions which resulted in decreased stream flow and expansion of prairie habitat. The implications are that human populations abandoned the prairie habitat and were concentrated farther inland in the area of the deciduous forests or in coastal riverine valleys and estuaries. The latter seems likely, though little archaeological proof of this is available because the record is now buried under transgressive coastal marshes or submerged on the shelf.

Early Archaic settlement and use of the floodplain forests and coastal strand and estuary habitats of the study area are likely to have been similar to those known for the later Middle Archaic period. The overall economic strategy is seen as one which exploited a range of animal and plant species. Pleistocene megafauna had disappeared, and, so too, the settlement types and choices associated with their hunting. The fish and shellfish resources of the estuary systems are presumed to have constituted important, if not primary, food sources. Sites associated with estuarine exploitation should contain quantities of shell refuse that would be archaeologically detectable. The specific locations of Early Archaic sites in coastal, estuarine habitats would have been similar to those projected for the Paleo-Indian period, as shown in Table 3-1 and as discussed by CEI (1977). The number and density of Early Archaic sites in the estuarine habitat relative to Paleo-Indian sites is open to conjecture. Aten (1983:154) seems to suggest that there is an overall decrease in coastal populations during the Early Archaic as a result of dry Altithermal conditions. The data for this are derived primarily from nonriparian upland areas, and it is possible that Early Archaic populations were larger than those of the Paleo-Indian period but were concentrated in the floodplain and coastal estuarine habitats. This would argue for an increase in the number and density of sites in the study area throughout the Paleo-Indian and Early Archaic periods. Thus, the onset of the Altithermal may be marked by a significant increase in the number of sites in the coastal estuarine habitat. There is less certainty concerning Early Archaic settlement in the riverine floodplain habitat of the study area. The settlement locations provided in the 1977 CEI model are seen as applicable (see Table 3-1). It is tentatively postulated, however, that settlement densities in the inland floodplains were lower than those in the river mouth-estuary area.

Terrestrial Model of Riverine Site Locations

Although the present study has drawn heavily from the literature, particularly CEI (1977), Gagliano et al. (1982), and Aten (1983), as reviewed above, it became necessary to look more closely at specific prehistoric riverine settlements along rivers comparable to the drowned Sabine Valley in order to formalize settlement models. Terrestrial analogs of the offshore Sabine Valley study area offered an opportunity to gain a more precise understanding of high site probability areas, environments conducive to site establishment, and, most importantly, the positions of sites relative to the landforms upon which they occur.

Portions of two river valleys were selected as sources of data in model development; the Sabine River itself, and the Pearl River in southeastern Louisiana and southwestern Mississippi (Figure 3-2). Data from other southeastern rivers are of

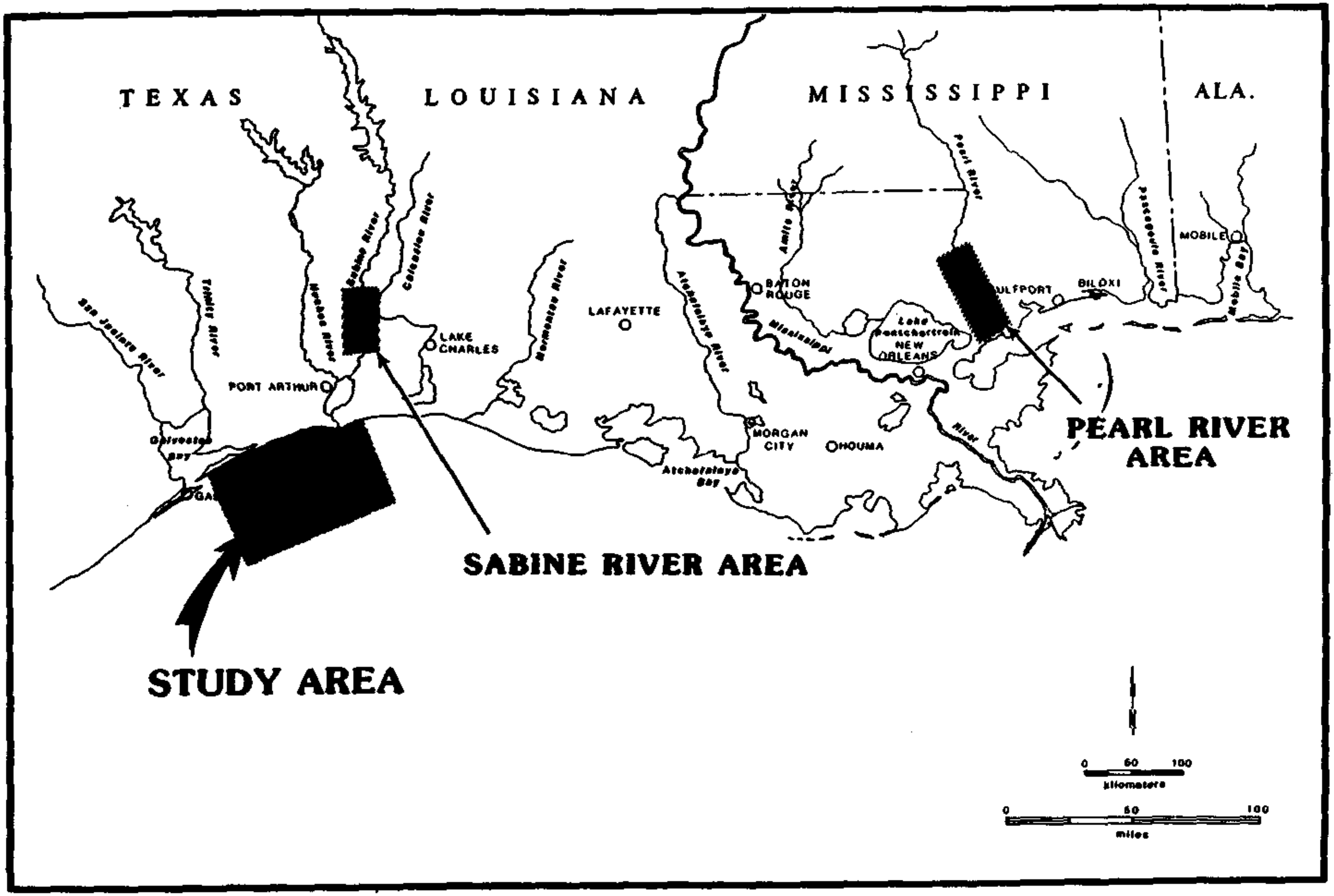

Figure 3-2. The study area shown in relation to the two selected analog areas.

course available, such as the Savannah River, for which a considerable amount of geoarchaeological information has been recently sythesized (Anderson and Schuldenrein 1985; Brooks et al. 1986). However, the geological setting and history of most of these rivers (particularly in the lack of identified Deweyville features) is sufficiently different from that of the study area to make them less useful as analogs. Both the onshore Sabine and the Pearl Rivers possessed several criteria considered necessary to provide a usable comparison with the submerged Sabine. Both contain relatively well-defined Prairie/Beaumont surfaces fringing the valleys and serving as the margins of the two systems. Within the valleys of both river systems are found Deweyville terraces and Holocene floodplains similar in extent and configuration to those identified on the seismic records in the offshore study area. Additionally, it is assumed that past environmental settings found in these onshore river systems in many respects mirrored those projected for the study area. The one environmental setting anticipated for the study area and not found in the two analog systems is a coastal strand setting. For the present, we have few good archaeological analogs for modeling early settlement in this sector and can only assume that certain features of this environment were utilized, as is indicated in Table 3-1. Lastly, sites dating to several early periods of human occupation are known from both river valleys, and are believed to represent settlements not unlike those which, prior to inundation, existed in and along the offshore Sabine River valley.

For both river valleys, the geological features and environmental zones were mapped upon U.S.G.S. 15- and 7 1/2-minute quadrangle maps. In the case of the Sabine Valley, some data were obtained from Bernard (1950), Fisher et at. (1973), and Gibson (1978), while the interpretation of the Pearl utilized information supplied by Gagliano and Thom (1967), Gagliano (1980), Gagliano et al. (1982), Snead and McCulloh (1984), and mid-1950s black and white aerial photography (Ammann International Corporation 1955).

Site information was derived from several published sources (see Tables 3-2 and 3-3, below), and from site forms on file at both the Texas Archeological Research Laboratory at the University of Texas and the Balcones Research Laboratory in Austin; the Division of Archaeology, Louisiana Department of Culture, Recreation and Tourism in Baton Rouge; and the Mississippi Department of Archives and History in Jackson. Sites dating to the Paleo-Indian and Early Archaic periods are of primary importance; however, they are very few in number. Because of this, all known prehistoric sites have been included on the maps. These sites depict the accumulated patterns of settlement practiced by prehistoric populations in the two river valleys. As such there are shortcomings in the data. It is certainly true that the subsistence strategies, technology, and social organizations of Paleo-Indian and Archaic populations differed dramatically from those of later populations and that these differences will at some level be reflected in settlement patterns. It is also true, however, that within floodplain and coastal settings, such as are being dealt with in this study, there are certain physical constraints in the environment of sufficient importance to impart similarities in the process of settlement selection through all of the prehistoric period. Essentially, settlement within the floodplain and along the coast is primarily resticted to elevated, well-drained landforms. We assume that selections for these specific landforms as settlement locales would have occurred throughout prehistory. This does not mean that site size or function or settlement densities were similar over time, simply that suitable places for settlement were restricted numerically and spatially such that similar locales were selected over a long period of time.

There is some supportive data for the idea of selection of similar settlement locales over time in the region. As noted earlier, Patterson (1985) in a review of aspects of the prehistory of the upper Texas coast notes the existence of a "stable settlement pattern" over 10,000 years of prehistory with some sites showing very long occupation sequences. In the Galveston Bay estuary area are numerous examples of preceramic and ceramic period shell middens, in several instances the two periods are represented at the same site (Aten 1983). Despite significant technological changes, similarities in exploitation and settlement selections continue.

It is recognized that there are shortcomings in the data base, but systematic surveys have been few, and there are minimal data on most of the sites. Similarly, many sites probably have been destroyed by riverine erosion and/or buried by alluvium. Despite this, the site data provide the best source for developing settlement models, and are considered sufficient for the generalizations presented below.

Sabine River Valley

The area of in-depth study chosen for the Sabine Valley extends from just north of Orange, Texas, to a point approximately seven miles north of the Calcasieu-Beauregard Parish line in Louisiana (Figure 3-3). The valley is incised into and is bounded by Pleistocene-age deposits, primarily identified as the Prairie/Beaumont formation. A well-preserved complex of Deweyville channel remnants and oxbow lakes is present along both sides of the valley. These remnants, for the most part, occur on a surface or terrace elevated several feet above the Holocene floodplain. The difference between the floodplain and terrace is only a few feet in the southern portion of the region but about 10 feet in the northern portion. This elevated terrace most likely can be equated with the "Upper" or "Older" Deweyville Terrace recognized previously (Aten 1983; Gagliano and Thom 1967).

Within the area under review, only two segments of "Lower" or "Younger" Deweyville channels have been recognized, apparently because the Holocene floodplain has eroded away much of the Younger Deweyville Terrace or deposited sediment atop the surface masking the features. Sedimentation is particularly noticeable in the southern end of the region where even portions of the Older Deweyville have been covered by Holocene deposits. The Younger Deweyville relict channel segments occur as two separate cuts into the Older Deweyville along the west side of the valley north of Cypress Creek (Figure 3-3b). Slightly farther north, however, and off the map illustrated in the figure, the Older and Younger Deweyville surfaces become more pronounced and both are raised above the Holocene floodplain. Site locations relative to these three major geologic units (i.e. Prairie/Beaumont Terrace, Deweyville terraces, Holocene floodplain) is an important aspect of the settlement model, primarily because these three major features can be identified with some reliability in the study area using seismic records.

Three basic environmental zones are identified within the Holocene floodplain: saline-to-fresh marsh, swamp, and bottomland hardwood. Marshes occur only in a small area at the extreme southern end of the region, while swamp exists in more dispersed pockets up and down the valley. The bottomland hardwood zone makes up the vast majority of the remainder of the Holocene valley. While it is recognized that these zones are not necessarily reflective of environmental conditions during prehistoric times in terms of their present spatial distribution, they do depict the types of major environmental habitats available. The occurrence of these habitats within the modern Sabine River valley (as well as the Pearl River valley) duplicates the general setting for one frame of time in the offshore study area. That time can be equated to the period when the Sabine River valley contained a riverine setting with marshes just beginning to encroach at its lower end. It probably closely resembled the setting depicted in Figure 3-3a. For most of the study area, and in particular for those locales where intensive seismic survey was conducted (generally the upper end of the drowned valley), the setting in Figure 3-3 portrays that envisioned for the study area around 10,000 years B.P. and slightly earlier. One difference which may have existed is that Deweyville features were more extensive, having not been removed by Holocene channel meandering. Similarly, the relict Deweyville channel segments may have contained more open water than today.

Table 3-2 lists those sites identified along the Sabine River in the area under review. (Site numbers used are the trinomial designations assigned by the appropriate state office.) Their locations relative to the geological and environmental features can be seen in Figure 3-3. Twenty-nine sites are illustrated, ranging in age of initial occupation from the Late Archaic through possible Mississippi periods. These represent all of the sites presently known along this stretch of the valley and reflect the limited amount of work conducted in the area. Although the sample of sites is small, two basic site locational zones can be identified, terrace edges and Holocene natural levees. Eleven of the sites (16 BE 37, 38, 39, 40, 41, 42, 16 CU 144, 41 NW 56, and 41 OR 16, 40, and 81) are situated atop the Prairie/Beaumont or earlier terrace edges overlooking either the Holocene floodplain or relict Deweyville channels. These latter features were attractive to prehistoric populations since, as noted, many retained a significant amount of water, representing lakes suitable for fish and aquatic birds and reptiles, or were reoccupied by Holocene backswamp streams or the Sabine River itself. High, well-drained land adjacent to such features would have been particularly favorable for settlement. Seven sites (16 CU 16, 154, 155, 156, 165, 190 and 41 OR 7) are located atop the Older Deweyville surface edge, again adjacent to lower land, in this instance, the Holocene floodplain. One of the two identified Archaic sites in the region (16 CU 156) is included in this group (see Figure 3-3a). In addition to their location in these ecotonal settings, these "overlook" sites also tend to be in proximity to streams draining into the river valley.

Nine sites (16 CU 158, 159, 160, 161, 162, 163, 164, 166, and 41 OR 80), all located in the southern portion of the region, are associated with the natural levees of the modern Sabine River. These sites are grouped near the marsh zone and all are either Woodland or undifferentiated in age. Two sites are located in slightly different settings. One, 16 CU 157, an Archaic locale, is situated atop the Older Deweyville Terrace adjacent to a relict Deweyville channel, while the other (16 BE 43) rests atop a low rise in the Holocene floodplain. This rise may be the remains of a natural levee.

Pearl River Valley

That section of the Pearl River valley examined covers the area between about 3 mi south of Pearlington, Mississippi, at the southern end, to around the latitude of Henleyfield, Mississippi, at the northern end (Figure 3-4). As with the Sabine Valley, the Pearl River valley is bordered by Prairie/Beaumont and earlier Pleistocene formations. Both Deweyville and Holocene floodplains are situated between the valley walls. Because this portion of the Pearl River valley is closer to the Gulf of Mexico than is that segment of the Sabine Valley examined, a greater percentage of it is filled with marsh and swamp zones. Due to that fact, much of the Deweyville surfaces in the southern portion of the valley are masked by recent alluvium and the exposed Deweyville terraces in the Pearl River valley are less extensive than that identified along the Sabine.

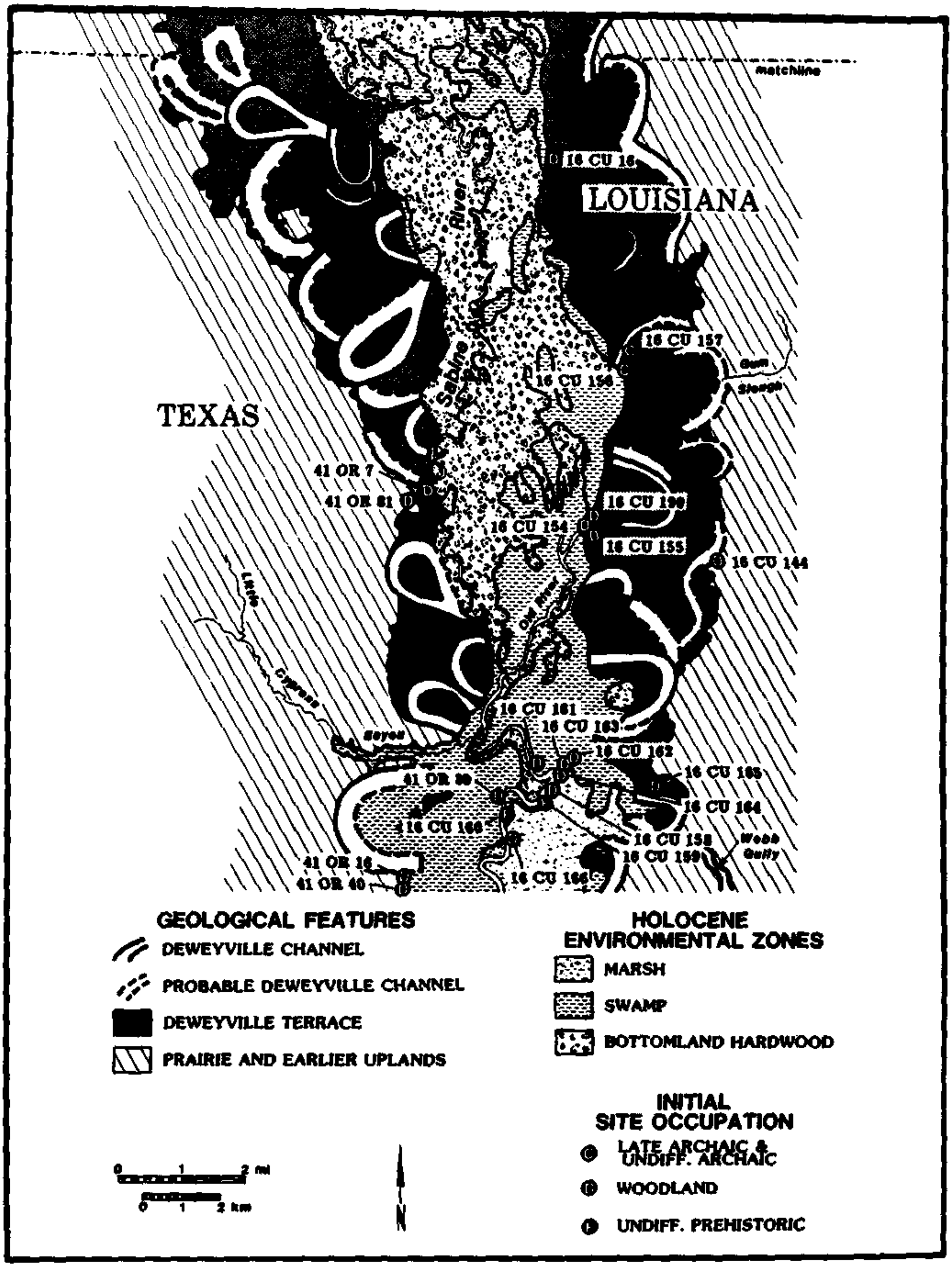

Figure 3-3a. Lower portion of Sabine River settlement analog area.

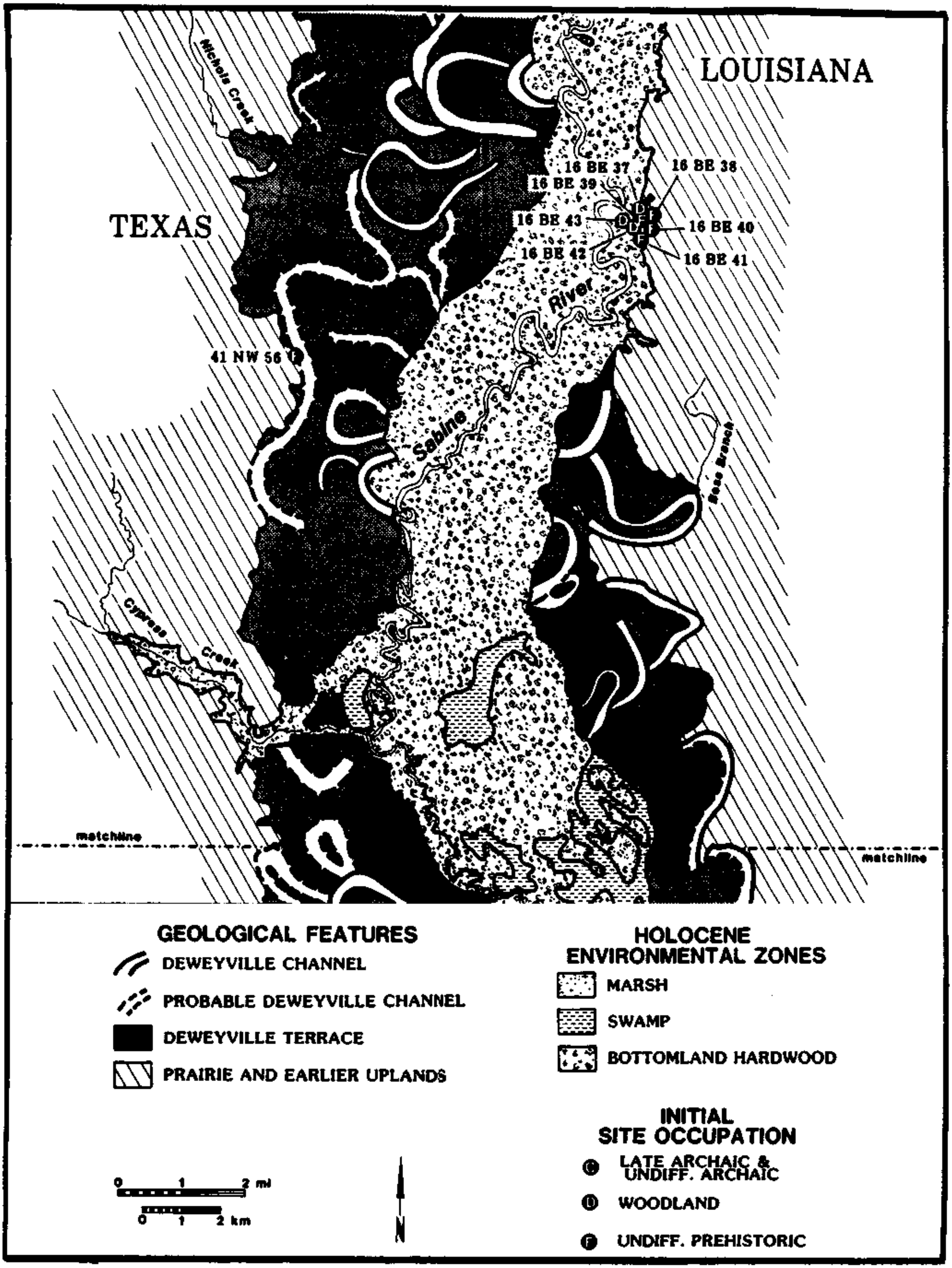

Figure 3-3b. Upper portion of Sabine River settlement analog area.

Table 3-2. Sites in the Lower Sabine River Valley Used in Settlement Model Definition.

Number	Name	Components	References
16 BE 37	Desperation	Woodland	Gibson 1978
16 BE 38	Dead Oak	Undifferentiated Prehistoric	Gibson 1978
16 BE 39	Road Cut	Undifferentiated Prehistoric	Gibson 1978
16 BE 40	Many Oak	Undifferentiated Prehistoric	Gibson 1978
16 BE 41	Primary Flake	Undifferentiated Prehistoric	Gibson 1978
16 BE 42	Step Up	Woodland	Gibson 1978
16 BE 43	Bottom	Woodland Mississippi (?)	Gibson 1978
16 CU 16	Hampton	Woodland	DCRT* site form
16 CU 144	Gum Slough	Woodland	DCRT site form
16 CU 154	State Park	Woodland	Gibson 1978
16 CU 155	Camp Ground	Woodland	Gibson 1978
16 CU 156	Dynamite Slough	Late Archaic Woodland	Gibson 1978
16 CU 157	Jowers Old River	Late Archaic Woodland	Gibson 1978
16 CU 158	Marsh Drain	Woodland	Gibson 1978
16 CU 159	Cut Bank	Undifferentiated Prehistoric	Gibson 1978
16 CU 160	Willow Bar	Undifferentiated Prehistoric	Gibson 1978
16 CU 161	Turner Island	Woodland	Gibson 1978
16 CU 162	Big Bayou North	Woodland	Gibson 1978
16 CU 163	Big Bayou South	Woodland	Gibson 1978
16 CU 164	Big Eddy	Woodland	Gibson 1978
16 CU 165	Cormier Cemetery	Woodland	Gibson 1978
16 CU 166	Sand Pile	Woodland	Gibson 1978
16 CU 190	Main Ramp	Woodland	DCRT site form
41 NW 56	No Name	Undifferentiated Prehistoric	TARL* site form
41 OR 7	No Name	Woodland	TARL site form
41 OR 16	No Name	Woodland	TARL site form
41 OR 40	No Name	Woodland	TARL site form
41 OR 80	Pipeline Canal	Woodland	Gibson 1978
41 OR 81	Morgan Bluff	Woodland	Gibson 1978

*DCRT - Louisiana Department of Culture, Recreation and Tourism
TARL - Texas Archeological Research Laboratory

Despite the smaller area of exposed Deweyville surface, both the Older and Younger Deweyville sequences are represented. As with the Sabine Valley, the Older Deweyville is a true fluvial terrace exhibiting numerous channel remnants and loops. It has been greatly reduced in size by subsequent river activity, much of which is likely to have been the result of Younger Deweyville meandering. This is particularly evident along the eastern valley wall where numerous arcuate cuts into the Prairie/Beaumont mark the former position of Younger Deweyville channels.

Forty-eight sites are known from the area of the Pearl River valley under discussion (Table 3-3). Twenty-four of these are situated atop the edge of the Prairie/Beaumont or earlier terraces, overlooking the valley proper. Four of these (16 ST 52, 16 WA 103, 22 HA 501, and 22 PR 583) have initial occupations dating to the Early Archaic, while another two (16 ST 121 and 22 HA 506) date at least as early as Late Archaic.

There are seven sites located atop the Older Deweyville surface overlooking either Younger Deweyville channel cuts or the Holocene floodplain. One (22 PR 563) dates as early as Middle Archaic (in this case, estimated to date between 7000 and 5000 B.P.), while another (22 PR 594) can be assigned to the Late Archaic. As along the Sabine River, sites located on these ecotones also tend to be near small streams draining into the river valley. The combination of small stream juncture and the point of abutment of any of the three major geologic features represents a high probability area relative to site occurrence.

Twelve sites are located in the Holocene floodplain, and of these only two (16 ST 119 and 120) date to the Archaic. Most of these sites appear to be resting on natural levee deposits, although a few, such as sites 16 ST 119 and 120, may actually be situated on the lowest slope of earlier terrace edges. Five other sites (16 ST 89, 22 PR 521, 540, 589, and 592) are atop the Prairie/Beaumont or earlier surfaces in the region, adjacent to minor streams tributary to the Pearl Valley. One of these (22 PR 521) has a Late Archaic initial occupation.

Summary of the Riverine Model

Seventy-seven sites were reviewed in regard to their landform associations within or immediately adjacent to the Sabine and Pearl River valleys. Table 3-4 summarizes the relationship of these sites to the geological features in the regions. Clearly, the edge of the various terraces, particularly in places which overlook some form of water body and near a juncture stream, is the preferred habitation locale throughout the prehistoric period. This observation may be biased to some extent since the terraces have been cleared for agriculture and modern settlement to a greater extent than the Holocene floodplain, making archaeological sites easier to find. In addition, many sites in the floodplain may be buried by alluviation. Nevertheless, the data at hand suggest that sites should be found along terrace margins, in this instance, either the Prairie/Beaumont or the Deweyville. The relationship of sites to the various environmental zones is not particularly clear (Table 3-5). Sites are situated both within each zone and overlooking each zone. Only in the Sabine Valley is there seen a tendency for sites to be associated with one zone, in this case, the swamp. As this zone is not the most extensive in the region (the hardwood bottomland zone exceeds it in areal coverage), this relationship may have some validity. When the sites associated with the swamp zones in both the Sabine and Pearl Valleys are examined, however, their overall percentage is not significantly greater than the other zonal relationships. These relationships must be viewed with caution because of the minimal amount of archaeological data available.

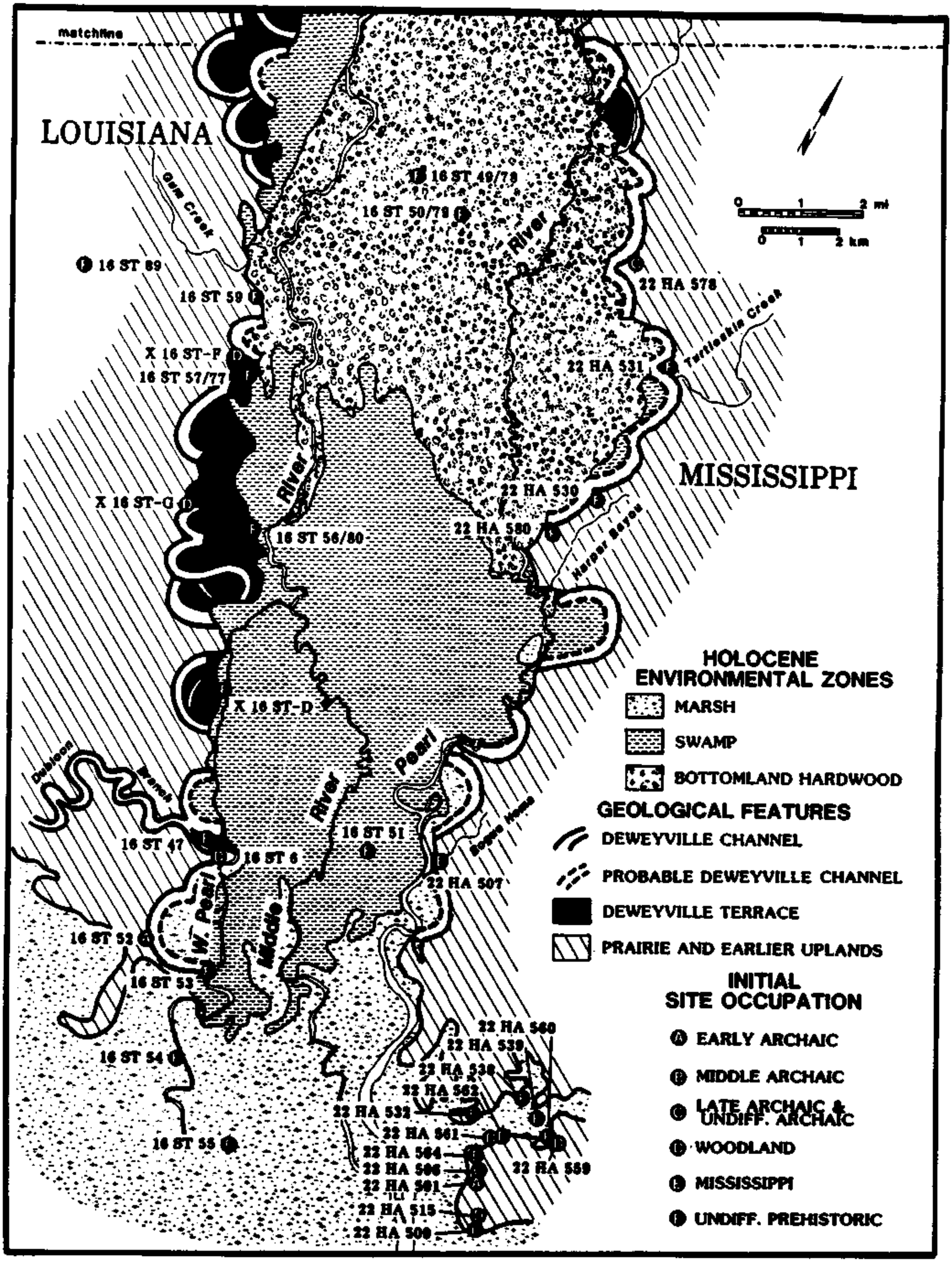

Figure 3-4a. Lower Portion of Pearl River settlement analog area.

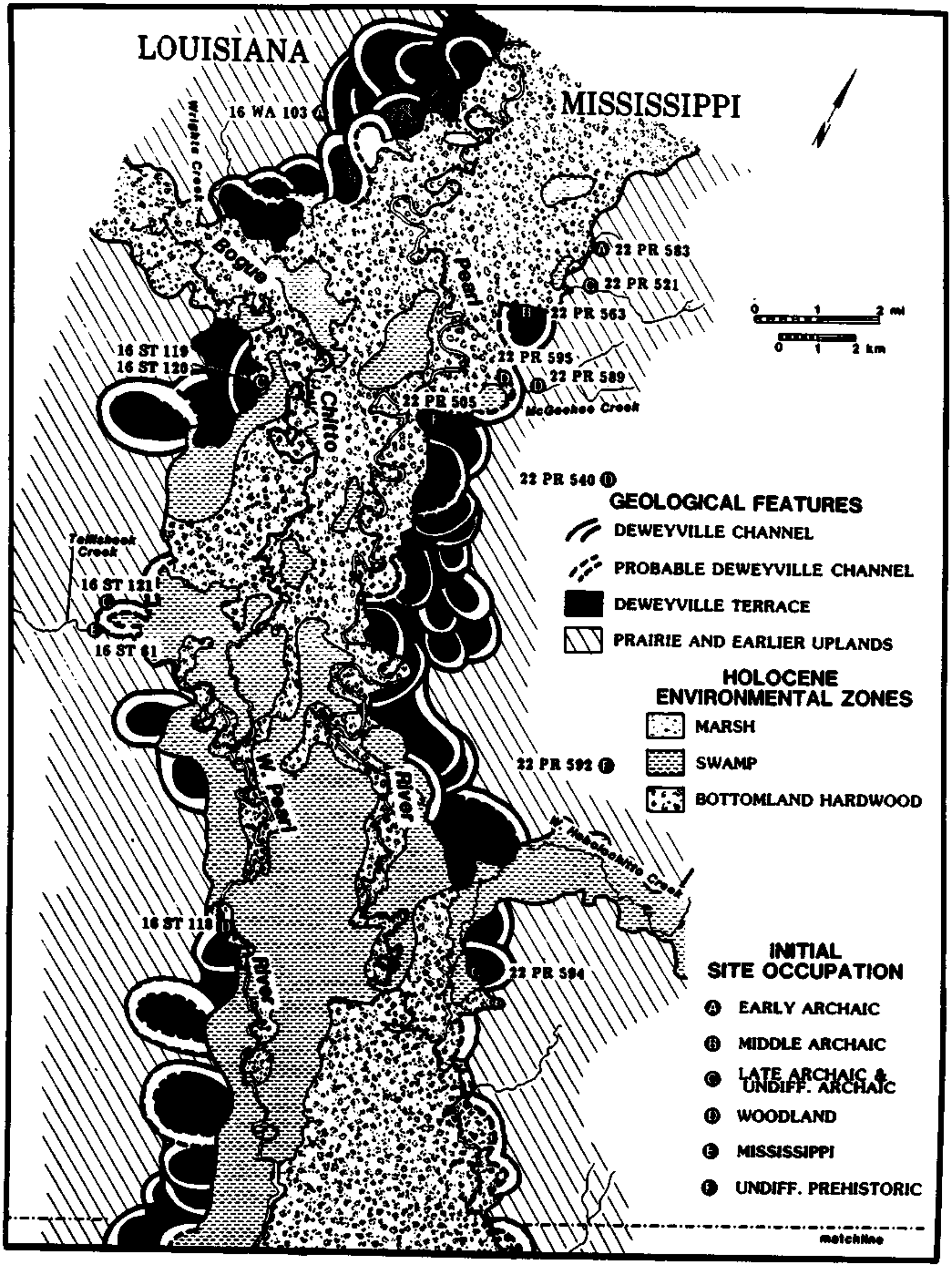

Figure 3-4b. Upper portion of Pearl River settlement analog area.

Table 3-3. Sites in the Lower Pearl River Valley Used in Settlement Model Definition.

Number	Name	Components	References
16 ST 6	Indian Village	Woodland	Saucier 1963 Gagliano 1980 Webb 1982
16 ST 47	No Name	Undifferentiated Prehistoric	DCRT* site form
16 ST 49/78	Honey Island	Undifferentiated Prehistoric	Gagliano 1980
16 ST 50/79	Indian Bayou	Undifferentiated Prehistoric	Gagliano 1980
16 ST 51	Morgan's Bayou	Undifferentiated Prehistoric	Gagliano 1980 (mislabeled as 16 ST 40)
16 ST 52	McKean	Early Archaic Middle Archaic Woodland	Gagliano 1963, 1980
16 ST 53	West Pearl River Bridge	Undifferentiated Prehistoric	Gagliano 1980 Beavers et al. 1984
16 ST 54	West Pearl River	Undifferentiated Prehistoric	Gagliano 1980
16 ST 55	Mill Bayou	Undifferentiated Prehistoric	Gagliano 1980
16 ST 56/80	Morgan's Bluff	Undifferentiated Prehistoric	Gagliano 1980
16 ST 57/77	Porter's River	Undifferentiated Prehistoric	Gagliano 1980
16 ST 59	Pump Slough	Undifferentiated Prehistoric	DCRT site form Gagliano, Pers. Communication
16 ST 61	Herget Place	Mississippi (Historic aboriginal village)	Gagliano, Pers. Communication
16 ST 89	S. Nutty	Undifferentiated Prehistoric	DCRT site form
16 ST 118	No Name	Woodland	Beavers et al. 1984
16 ST 119	No Name	Archaic	Beavers et al. 1984
16 ST 120	No Name	Archaic	Beavers et al. 1984

Table 3-3. Continued.

16 ST 121	No Name	Late Archaic Woodland	Beavers et al. 1984
X16 ST-D	Babs	Undifferentiated Prehistoric	DCRT site form
X16 ST-F	John Stevens	Woodland	DCRT site form
X16 ST-G	Magnolia Forest Entrance	Woodland	DCRT site form
16 WA 103	North of the Sun	Early Archaic Middle Archaic Late Archaic Woodland	DCRT site form
22 HA 500	Jackson Landing (Mulatto Bayou)	Woodland Mississippi	Gagliano 1963, 1980 McIntire 1958 Phillips 1970 Gagliano et al. 1982
22 HA 501	Claiborne	Early Archaic Middle Archaic Late Archaic Woodland	Gagliano and Webb 1970 Phillips 1970 CEI* 1977 Webb 1977 Gagliano 1980 Gagliano et al. 1982
22 HA 506	Cedarland Plantation	Late Archaic	Gagliano 1963, 1980 Gagliano and Webb 1970 CEI 1977 Webb 1977 Gagliano et al. 1982
22 HA 507	Weston Midden	Mississippi	Gagliano 1980
22 HA 515	Ancient Earthworks	Woodland	Williams 1974, n.d. Gagliano et al. 1982
22 HA 530	Hall	Undifferentiated Prehistoric	Gagliano 1980
22 HA 531	Turtleskin	Undifferentiated Prehistoric	Gagliano 1980
22 HA 532	Ford #8	Undifferentiated Prehistoric	Gagliano 1980

Table 3-3. Concluded.

22 HA 538	Ford #3	Undifferentiated Prehistoric	Gagliano 1980
22 HA 539	Ford #6	Undifferentiated Prehistoric	Gagliano 1980
22 HA 559	Gonzales Marine	Woodland	Heisler 1982
22 HA 560	Lot 7	Undifferentiated Prehistoric	Heisler 1982
22 HA 561	Garcia	Woodland	Heisler 1983
22 HA 562	Louis	Woodland Mississippi	Heisler 1983
22 HA 564	Lot 1	Mississippi	Heisler 1983
22 HA 578	No Name	Late Archaic Woodland	MDAH* site card
22 HA 580	No Name	Undifferentiated Prehistoric	MDAH site card
22 PR 505	Stewart	Undifferentiated Prehistoric	MDAH site card
22 PR 521	Burge Place	Late Archaic Woodland	MDAH site card
22 PR 540	Davis Lake "E"	Woodland	MDAH site card
22 PR 563	Wise-Middle Creek	Middle Archaic Late Archaic Woodland	MDAH site card
22 PR 583	Old River Field	Early Archaic Mississippi	MDAH site card
22 PR 589	Wise-McGehee Cemetery Road	Woodland	MDAH site card
22 PR 592	Westbrook Garden	Undifferentiated Prehistoric	MDAH site card
22 PR 594	Tiger Hammock	Late Archaic Woodland	MDAH site card
22 PR 595	Wise-McGehee Mound	Woodland	MDAH site card

*DCRT - Louisiana Department of Culture, Recreation and Tourism
CEI - Coastal Environments, Inc.
MDAH - Mississippi Department of Archives and History

Table 3-4. Site-Landform Relationships in the Sabine and Pearl River Valleys.

Prairie/Beaumont or Earlier Terrace Edge		Older Deweyville Terrace Edge		Holocene Floodplain Natural Levee		Other Landform Locations	
Sabine N = 11[a] % = 37.9	Pearl N = 24[b] % = 50.0	Sabine N = 7[c] % = 24.1	Pearl N = 7[d] % = 14.6	Sabine N = 9[e] % = 31.0	Pearl N = 12[f] % = 25.0	Sabine N = 2[g] % = 6.9	Pearl N = 5[h] % = 10.4
Totals N= 35 % = 45.5		Totals N = 14 % = 18.2		Totals N = 21 % = 27.3		Totals N = 7 % = 9.1	
[a] 16 BE 37	[b] 16 ST 6	[c] 16 CU 16	[d] 16 ST 47	[e] 16 CU 158	[f] 16 ST 49/78	[g] 16 BE 43	[h] 16 ST 89
16 BE 38	16 ST 52	16 CU 154	16 ST 56/80	16 CU 159	16 ST 50/79	16 CU 157	22 PR 521
16 BE 39	16 ST 59	16 CU 155	16 ST 57/77	16 CU 160	16 ST 51		22 PR 540
16 BE 40	16 ST 61	16 ST 156	X16ST-F	16 CU 161	16 ST 53		22 PR 589
16 BE 41	16 ST 121	16 CU 165	22 PR 505	16 CU 162	16 ST 54		22 PR 592
16 BE 42	X16ST-G	16 CU 190	22 PR 563	16 CU 163	16 ST 55		
16 CU 144	16 WA 103	41 OR 7	22 PR 594	16 CU 164	16 ST 118		
41 NW 56	22 HA 500			16 CU 166	16 ST 119		
41 OR 16	22 HA 501			41 OR 80	16 ST 120		
41 OR 40	22 HA 506				X16ST-D		
41 OR 81	22 HA 507				22 HA 539		
	22 HA 515				22 PR 595		
	22 HA 530						
	22 HA 531						
	22 HA 532						
	22 HA 538						
	22 HA 559						
	22 HA 560						
	22 HA 561						
	22 HA 562						
	22 HA 564						
	22 HA 578						
	22 HA 580						
	22 PR 583						

Table 3-5. Site-Environmental Relationships in the Sabine and Pearl River Valleys.

Marsh-Related Sites		Swamp-Related Sites		Bottomland Hardwood-Related Sites	
Sabine N = 3[a] % = 12.0	Pearl N = 16[b] % = 39.0	Sabine N = 14[c] % = 56.0	Pearl N = 11[d] % = 26.8	Sabine N = 8[e] % = 32.0	Pearl N = 14[f] % = 34.1
Totals N = 19 % = 28.8		Totals N = 25 % = 37.9		Totals N = 22 % = 33.3	
[a] 16 CU 158	[b] 16 ST 6	[c] 16 CU 16	[d] 16 ST 47	[e] 16 BE 37	[f] 16 ST 49/78
16 CU 159	16 ST 52	16 CU 154	16 ST 51	16 BE 38	16 ST 50/79
16 CU 166	16 ST 54	16 CU 155	16 ST 53	16 BE 39	16 ST 59
	16 ST 55	16 CU 156	16 ST 56/80	16 BE 40	16 ST 118
	22 HA 500	16 CU 160	16 ST 57/77	16 BE 41	16 ST 119
	22 HA 501	16 CU 161	16 ST 61	16 BE 42	16 ST 120
	22 HA 506	16 CU 162	16 ST 121	16 BE 43	X16ST-F
	22 HA 515	16 CU 163	X16ST-D	41 OR 47	22 HA 531
	22 HA 532	16 CU 164	22 HA 507		22 HA 578
	22 HA 538	16 CU 165	22 HA 531		22 HA 580
	22 HA 539	16 CU 190	22 PR 594		22 PR 505
	22 HA 559	41 OR 16			22 PR 563
	22 HA 560	41 OR 40			22 PR 583
	22 HA 561	41 OR 80			22 PR 595
	22 HA 562				
	22 HA 564				

The settlement data from the two onshore "analog" areas suggest a correlation in site locations to landforms, and have application to developing settlement models in the study area. Particularly obvious is the selection for settlement at a terrace edge and on a natural levee.

The terrace-edge setting includes the Pleistocene-age, Prairie/Beaumont Terrace and the more recent Deweyville terraces. The selection of these locales seems obvious; they provide an ecotonal setting allowing access to the biotic and abiotic resources found on each landform. Another feature of the terrace-edge settings is that they generally overlook water bodies, either lakes or streams. In addition, sites are commonly near a stream draining into the river valley.

The natural levee setting is also a reasonable one for settlement. Natural levees offer high, well-drained landforms in the floodplain. Although the data are minimal, it is probable that Deweyville natural levees were selected for settlement in the same manner as were the Holocene natural levees. Deweyville levees provided the added feature of adjacency to a relict stream segment which could be an open lake or freshwater swamp.

The onshore archaeological data show less definitive correlation between site locations and broad environmental zones. This may, in part, be due to lack of data, though it is suspected that topography (i.e., landform) may have been an overriding consideration in site selection.

Assumptions about site locations have been summarized in Table 3-1. The site locational information presented in the table has been derived from a synthesis of the known onshore archaeological record and assumptions about prehistoric economy and settlement as discussed earlier. The seismic survey and vibracoring strategy employed in this study has been guided by this information, coupled with assessments of the preservation potential of landforms. A review of this preservation potential is presented in the following section.

Models of Site Preservation Potential

Systematic research efforts to locate archaeological sites on the OCS require a consideration of the potential for site preservation. A series of works has appeared in recent years that argues for the preservation of submerged archaeological remains in the continental shelves of the world (see Masters and Flemming 1983). For the Gulf of Mexico, Coastal Environments, Inc. (1977), Gagliano (1984), Gagliano et al. (1982) and Ruppe (1983) have presented recent arguments for site preservation. These studies have relied on assessments of the geologic setting and history of the Gulf coastal area plus knowledge of specific coastal site situations, and have extended this concept, in a generalized form, to the OCS. Basic to these models is the idea that, in certain situations, archaeological sites can become buried sufficiently deep to place them beneath the impacts of shorefront erosion when transgression occurs. Specific settings in which this model is applicable are larger river valleys and delta systems. Sites within river valleys can become covered by fluvial and estuarine sediments and are protected from transgression. For deltaic sites, subsidence is an added factor which removes sites below the impacts of transgression. Over the years, numerous intact subsided and buried archaeological sites have been found in the Mississippi alluvial valley and delta area which lend credence to these preservation arguments (Gagliano 1984).

Examples of buried, preserved sites in the lower Mississippi River area of Louisiana include the Bayou Jasmine site, at the western end of Lake Pontchartrain, which contains extensive, intact midden deposits at least 18 ft below the present-day surface of surrounding swamp and marsh. The earliest deposits of this site are Poverty Point in age, dating ca 3500 to 3000 B.P. (Coastal Environments, Inc. 1977:261). The Linsley site, a Poverty Point period site located in Orleans Parish, is buried by over 3 ft of modern deltaic and marsh sediments (Gagliano and Saucier 1963). A dragline disturbed the site and removed large hunks of intact midden deposits consisting mainly of *Rangia cuneata* shell and containing ash, charcoal, bone, artifacts, and large quantities of well-preserved faunal remains (Gagliano and Saucier 1963:322). A soil boring indicated the site is resting on the levee ridge of a subsided Mississippi River distributary. Three radiocarbon dates on charcoal from the site provided an average date of 3690 B.P.

The Garcia site, located at the eastern end of Lake Pontchartrain, has produced late Paleo-Indian and Archaic material as well as Poverty Point-like microliths (Gagliano and Saucier 1963). The early artifacts include Dalton and lanceolate projectile points. This site is located on a beach ridge which has been covered by deltaic marsh deposits which are now being eroded by expansion of the lake. The site consists of a wave-washed beach accumulation "plus a possibly undisturbed shell deposit lying in 3 to 4 feet of water" (Gagliano and Saucier 1963:327).

Many other buried or partially buried later prehistoric sites are known from the lower Mississippi River delta area. Some of these sites demonstrate the rapidity with which sites can subside and became buried in this environment. The Buras Mounds in Plaquemines Parish, Louisiana, exist today as a cluster of four tree and shrub-covered knolls in an otherwise featureless marsh terrain. The site is located on the subsided levee ridge of a distributary of the Pomme d'Or subdelta complex of the Mississippi River (Gagliano 1979:A2). Only the tops of the mounds are above the marsh today; the site having subsided approximately 6 ft since it was occupied at circa 500 B.P. (Gagliano 1979:A-32). For the Buras mounds it was noted: "another importance of the gradual subsidence and sediment blanketing of this site is the preservation of the entire site within the sedimentary section" (Gagliano 1979:A2).

The largest subsided site known in the Mississippi River delta area is the Magnolia Mound site in St. Bernard Parish, Louisiana (Gagliano et al. 19832 Consisting of at least eleven earthen and shell (Rangia cuneata) mounds or midden heaps, the site rests on the subsided levees of a crevasse off a former Mississippi River distributary, the LaLutre-Mississippi, which was active circa 3400 to 1800 B.P. Initial occupation at the site probably occurred circa 2000-1600 B.P. and continued for almost 1000 years. Only the tops of the mounds project above the marsh today and 7 to 10 ft of post-occupational marsh deposits cover the site (Gagliano et al. 1982:20-21).

The forces which affect site preservation in the Mississippi River delta, while mechanically similar to those we can project for delta settings in the Sabine River study area, are quantitatively different. The key factors to preservation, subsidence and sedimentation, certainly occurred in the Sabine River delta but not on the scale or possibly with the rapidity seen on the Mississippi River.

A more explicit model of site preservation on the continental shelf is that developed by Kraft and Belknap, aspects of which have appeared in a series of articles (e.g., Belknap and Kraft 1981; Kraft 1971; Kraft et al. 1983). Their model is developed for the U.S. Atlantic continental shelf, specifically the Delaware-Maryland area, but it is generally applicable to the northern Gulf of Mexico. The basic assumptions of the Kraft-Belknap model are essentially the same as those projected for the Gulf area; however, they have attempted a more careful formulation and identified the influence of various factors on site preservation. They note that, "Variable fractions of the transgressive sequence may be preserved, depending on pre-existing topography, depth of erosion, wave energy, sediment supply, erosion resistance, tidal range and rate of relative sea-level change" (Belknap and Kraft 1981:429). They further argue that many of these factors are dependent upon sets of exceedingly complex actions, such that it is now impossible to evaluate the relative importance of each, especially over time. They do suggest, however, that the rate of relative sea-level rise is an important factor in determining site preservation potential (Belknap and Kraft 1981:440). The rationale for this concept rests in the Bruun theory and, more specifically, the Fischer concept of shoreface response to rising sea level (Bruun 1962, Fisher 1961). The Bruun model indicates that landward erosion produced by sea-level rise results in sediment deposition offshore approximately equivalent to the rise in sea. The Fischer concept is simply that the degree of preservation of transgressive stratigraphy is dependent on the depth of shoreface erosion.

When these two concepts are considered in combination with Kraft and Belknap's model, they indicate that the higher rate of shoreface erosion produced by rapid sea-level rise results in a faster build-up of offshore sediments, a quicker placement of the stratigraphic column beneath the wave base, and an increase in potential for facies preservation.

More recently, Kraft and Belknap have expanded their model to include the "concepts of a deeply eroding oceanic shoreface and a shallowly eroding estuarine shoreface" (Kraft et al. 1983:96-97). The former is characteristic of oceanic wavefront conditions and is likely to be totally destructive to archaeological sites encountered on a flat plain. The shallowly eroding estuarine shoreface, on the other hand, is less destructive primarily because it impacts to a shallower depth. Kraft and his associates also note that a location "such as a valley floor or wall site which has subsequently been inundated by marsh or lagoonal mud, may allow preservation as the shoreface passes above it. The zone of erosion passes above the site because sea level has risen in the interim" (Kraft et al. 1983:97). In their most recent work, Belknap and Kraft (1985) stress that "antecedent topography" is the critical factor in the preservation of Holocene deposits during transgression. For the Delaware coast they note: "Deeper portions of the Holocene stratigraphic column, especially in antecedent valleys, provide the only chance for preservation in the shoreface under prevailing conditions of slow relative sea-level rise and 10 m deep shoreface scour," (Belknap and Kraft 1985:235).

These latter elements in the mid-Atlantic model plus those earlier formulations by Coastal Environments, Inc. (1977) and Gagliano et al. (1982), are most applicable in the present study. With the Sabine River valley we are dealing with a deep stream channel where the factors of pretransgressive topography (Belknap and Kraft's "antecedent topography") and sedimentation, and to a lesser extent subsidence, are the dominant factors influencing site preservation. These factors, in combination, can place archaeological remains beneath the destructive impact of oceanic wavefront erosion. The evidence available from the study area (from Nelson and Bray 1970 and oil company borings) indicates the presence of preserved, Holocene, transgressive facies plus, at the base of the former Sabine Valley, preserved, early Holocene and pre-Holocene, pre-transgressive deltaic and fluvial deposits.

A generalized model of preservation potential relying on the concepts presented above is developed for the study area. This model incorporates knowledge and assumptions about site positions relative to landforms with the present information on the sequence of geologic events. The model identifies three areas or zones within the river valley, each with varying potential for site occurrence, preservation and accessibility for study.

Zone 1. This is the basal portion of the valley where progradational fluvial and deltaic deposits are preserved. Site densities in this zone range from low to high dependent upon the local landform and setting. Fluvial and deltaic sediments have covered, encapsulated and preserved some sites in this zone. Site destruction has been variable and, generally, localized dependent upon the position, as well as spatial and temporal extent, of fluvial erosive processes. Site preservation potential in this zone as a whole is moderate to high, but because this zone is deeply buried and specific high-probability landforms are difficult to identify from seismic records, because of biogenic gas disturbance of acoustic signals, probability of discovery and accessibility of sites is low.

Zone 2. Zone 2 consists of the preserved transgressive deposits within the valley.

These are composed primarily of estuarine and lagoon sediments and, based on the work of Nelson and Bray (1970), represent a significant portion of the valley fill. Spatially these deposits overlie intact fluvial-deltaic deposits where they exist or, at higher elevations in the valley, rest directly upon Pleistocene or early Holocene valley-wall and terrace features. The base of this zone represents the leading edge of Holocene transgression which represents initial expansion of brackish and saline environments up the valley. This basal segment essentially corresponds to the "shallowly-eroding estuarine shoreface" identified by Kraft et al. (1983:96) on the Middle Atlantic coast. It is believed that this initial transgressive zone represents a point of relative low-energy erosion such as exists along lake and lagoon edges. Even so, this transgression has the potential to damage and destroy archaeological deposits. Importantly, however, the disturbance extends to relatively shallow depths such that deeply buried or subsided deposits will not be impacted. Site probabilities are high at this basal segment of the zone where it contacts high-probability landforms. Preservation potential in and at this zonal base is low to moderate. Relatively rapid estuarine and lagoonal sedimentation and sea-level rise after initial transgression would have covered archaeological sites or disturbed deposits. Within the body of estuarine-lagoon fill of the valley, site probabilities are extremely low simply because appropriate landforms are few.

In Zone 2 the optimum location for finding archaeological remains is at the base of the estuarine deposits on high-probability, pretransgressive landforms. There, site potential ranges from low to high, while preservation potential also ranges from low to high. These deposits are accessible, in that they are buried at moderate depths and often can be worked by coring. Equally important, pretransgressive features at the base of Zone 2 are commonly identifiable on seismic records (at least in the study area), permitting a directed search for high-probability landforms.

Zone 3. Zone 3 represents the uppermost of the three zones in our model. This represents that portion of the stratigraphic column impacted directly by oceanic wavefront and wavebase erosion. As a result, it is severely disturbed and site preservation is minimal to nonexistent. Within the study area, this zone includes the upper elevations of the Prairie/Beaumont surfaces that fringe the Sabine River valley, as well as the upper portions of the valley fill itself. Site potential in Zone 3 ranges from low to high with the highest being on the Prairie/Beaumont surfaces adjacent to streams leading into the valley. Preservation potential, however, is, as noted, extremely low because of wavebase erosion. These locales are at or near the seafloor and accessibility is high.

This zonal model of site potential and preservation served as a conceptual guide for directing the search for sites in the study area. In light of the model, our effort was concentrated on examination of the base of Zone 2, a location where accessibility was reasonable, site occurrence potential ranged from low to high dependent upon landform, and where site preservation potential was considered moderate. In the final analysis this model formulation proved to be reasonably correct. Data were collected that allowed us to refine elements of the model and these are discussed in the concluding sections of this report.

CHAPTER IV: DATA REVIEW, SEISMIC SURVEY, CORE COLLECTION, AND ANALYTICAL PROCEDURES

Data Sources

Since 1973, marine archaeological surveys of oil and gas lease blocks and pipeline rights-of-way on the continental shelves of the United States have been required. The purpose of these surveys has been to locate prehistoric or historic archaeological resources and to evaluate the potential impact to these resources from the proposed oil- or gas-related development. The cultural resources requirements first were contained in the "Notice to Lessees" (NTL) for the MAFLA Lease Sale 32, dated December 20, 1973. Since that time several NTLs have been issued with revisions and additions to these requirements. The instruments required in the surveys are the magnetometer, side-scan sonar, seismic profiler(s), and depth sounder. Each of these provides a distinctive type of information on the conditions found on the sea floor surface and subsurface. Critical to the present study is that these surveys also collect substantial information on shallow subsurface geology, and, in fact, these data also are used in the assessment of bottom hazards, a requirement in offshore development since 1975.

These archaeological resources and hazard survey reports, and the collected data, represent a significant pool of information on the geology of the OCS. For a variety of reasons, however, these data have been little used by researchers. One of the reasons is that the raw data produced by the surveys are maintained by the oil or pipeline company funding the survey. Only the report of findings is submitted to the MMS for review. Thus, the data are stored at scattered locations and available only at the discretion of the various owners.

Compounding this problem is the fact that the reports produced from these data are of greatly varying quality and utility in geological (or archaeological) interpretation, a point recently emphasized by Ruppe (n.d.) in his assessment of the status of the OCS archaeological resources program. The problem with the reports results largely from inexperience or inadequate training of the archaeologist in interpreting the records, inadequate knowledge of the area's geologic and geomorphic history or the use of poor quality records in developing interpretations. As a result, it is normally imperative that the original seismic data be examined in addition to using the archaeological resources or hazard survey report.

Another reason for the lack of use of the offshore surveys is that they are relatively unknown. Most archaeologists and many geologists simply do not know that these data are available. Despite their shortcomings, the data and the reports resulting from hazard and cultural resources surveys served as a primary source of information in the present study. They were used for developing an interpretation of the geology of the project area as well as for selecting specific locales for intensive study. An effort was made to examine the original seismic data only for the 10 areas selected as high probability areas suitable for more intensive examination. This effort was only partially successful in that some of the records, either in whole or in part, could not be relocated by the firm that had collected them. In the discussions of the selected areas presented below, notation is made as to the availability of the original seismic data.

Survey reports prepared for lease block and pipeline surveys in and immediately adjacent to the study area were examined through the month of March 1985. Of the 119 lease blocks for which either a geophysical or archaeological survey report is presently available (Figure 4-1), 96 of them have had geophysical surveys while 115

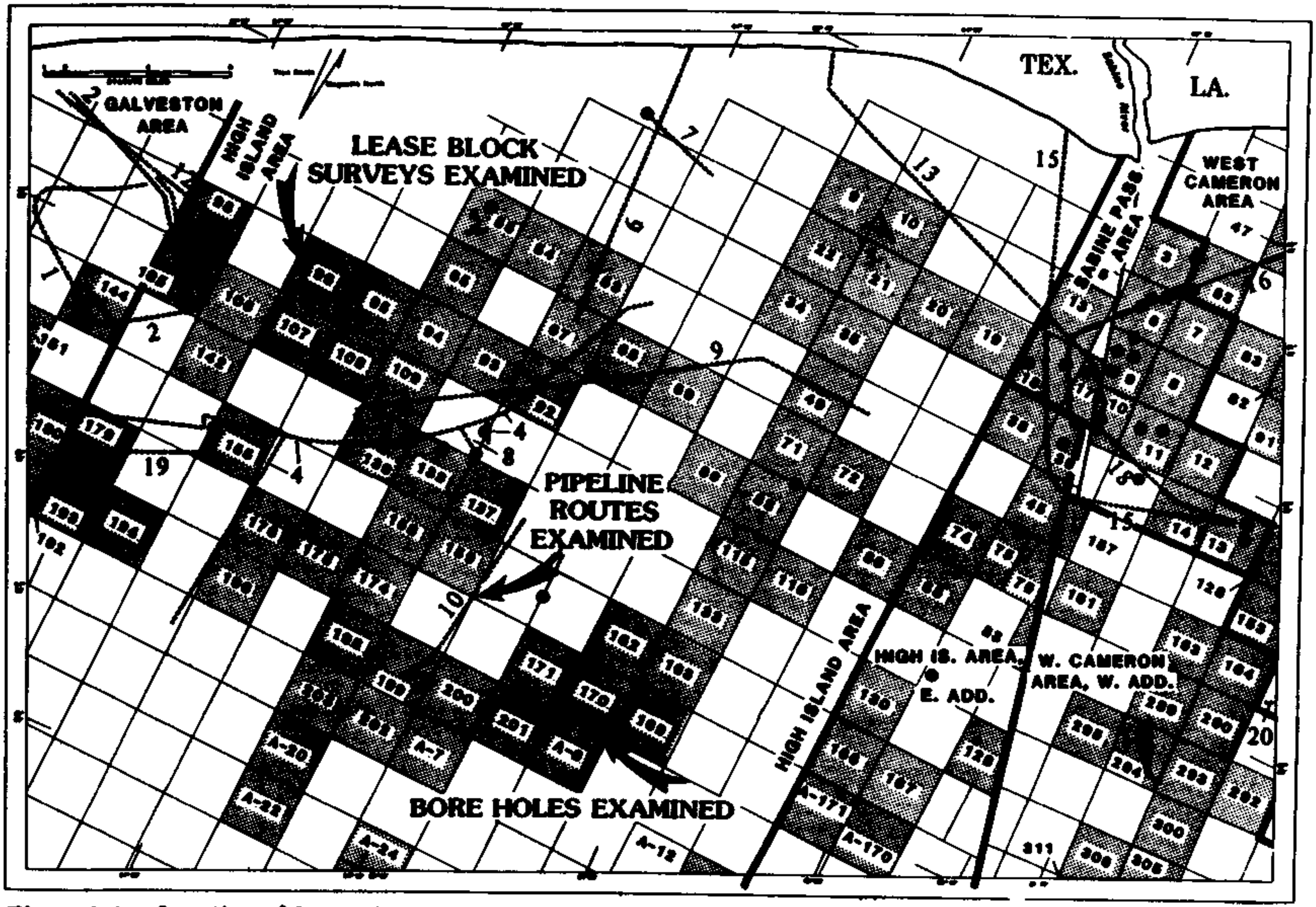

Figure 4-1. Location of lease blocks, pipeline routes, and bore holes whose survey reports and data were examined during the present study.

have had associated archaeological evaluations (Table 4-1). The vast majority of these survey reports were obtained from the MMS Regional Office in Metairie, Louisiana. A few already were available in-house or were obtained directly from the survey company that conducted the work. In some cases only archaeological surveys were available for review since, prior to 1975, a geophysical survey was not required and therefore was not conducted or was never submitted. Furthermore, in a few instances involving lease blocks in state waters where Federal archaeological resources survey requirements do not apply, only geophysical surveys are available. These reports were obtained directly from the survey company.

In addition to the reports cited in Table 4-1, eight reports were reviewed for lease blocks adjacent to, but not within, the study area. These included studies by Floyd (1981c), Gardline (1983), Hole (1974), Hudson (1981a, 1983d), Odom Offshore Surveys, Inc. (1981), Racal-Decca Survey, Inc. (1981a), and Savarino et al. (1984). The data in these were used to verify and help interpret that supplied in nearby lease blocks within the study area.

Twenty-three pipeline rights-of-way (ROW) were reviewed within the study area and reports on the geophysical and archaeological surveys are available for most (Table 4-2 and Figure 4-1). One additional pipeline ROW was examined although its path fell just to the east of the study area (Odom Offshore Surveys, Inc. 1976a; Saltus 1976e).

To complement the lease block and pipeline data, a review of the logs of foundation bore holes placed in the vicinity of proposed well and pipeline locations was conducted. The review concentrated on those cores which were in or adjacent to the Sabine Valley and which could be used to help interpret the subbottom records of the region. Thirty-five core logs was examined, and locations of the borings are shown on Figure 4-1.

Selection of the Survey Locales

Once all of the lease block and pipeline survey reports were reviewed, a preliminary group of potential survey areas was selected. Several steps were involved in the selection process. First, the types of relict landforms which represent high probability locations for prehistoric sites and which occur in the study area were determined, as per Chapter III. Next, examples of each type of landform were sought in the geological data obtained from the hazards surveys and other sources. For some landforms, numerous examples were present, but in other cases only one or a few occurred. The examples of high probability locations were then ranked to arrive at a maximum of ten areas for additional survey. The criteria involved in this ranking included: (1) the apparent preservation of the landform or its inferred potential for preservation, (2) the age of the feature and its date of final inundation, (3) the depth of the feature below the seafloor or its accessibility to vibracoring (a maximum of 40 ft), (4) the presence of potential limiting factors to seismic survey or vibracoring such as sand banks, shell reefs, or biogenic gas concentrations, and (5) the variety of landforms selected. Eight lease blocks was selected and the actual seismic records and/or bore hole data reviewed. Each block is discussed below and block locations are shown in Figure 4-2. In addition, examples of original survey maps, showing anomalies and shallow isopach contours, are included.

Sabine Pass 3

This block was chosen initially on data supplied by Decca Survey Systems, Inc. (1979c) in their geophysical survey (Figure 4-3). A prominent valley wall escarpment was mapped along the eastern edge of the block running roughly north-south. At the

Table 4-1. Geophysical and Archaeological Reports Examined for Individual Lease Blocks Within the Study Area.

GALVESTON AREA

Lease Block	Geophysical and Hazard Report	Archaeological Report
144L	OOSI* (1977b)	Gagliano (1977)
151	Lenzer and Robertson (1983)	Hudson (1983c)
180	Not available	Floyd (1975a)
192	Not available	Saltus (1976a)

HIGH ISLAND AREA (Including the East Addition)

Lease Block	Geophysical and Hazard Report	Archaeological Report
9L	OOSI (1978b, 1979)	None
10L	OOSI (1978b, 1979)	None
19	OOSI (1979e) and RDSI (1981b)	Hudson (1981b)
20L	Stuckey and Floyd (1984)	Stuckey and Floyd (1984)
21	IRC (1984a)	None
22	OOSI (1982b)	Spencer (1982a)
34	IRC (1984a)	Hudson (1976c)
35	DSSI (1979a)	Hudson (1979a)
38	Chowdhury et al. (1979)	Hole (1979a) and Rhodes (1980)
39	DSSI (1979b)	Hudson (1979b)
45	Behrens and Floyd (1983)	Behrens and Floyd (1983)
49	Taylor and Robertson (1981)	Hudson (1981c)
53L	Behrens et al. (1984)	Behrens et al. (1984)
54	Giles (1984a)	Landry and Giles (1984)
55	Giles (1984a)	Landry and Giles (1984)
65	Not available	Floyd (1983a)
67	Care and Aweeka (1984)	Hudson (1984a)
68	Williams (1983a)	Crow (1983a)
69	Roberts and Pettus (1985)	Roberts and Pettus (1985)

Table 4-1. Continued.

High Island Area (Continued)

Lease Block	Geophysical and Hazard Report	Archaeological Report
71	Trahan et al. (1984)	Hudson (1978a) and Trahan et al. (1984)
72	Peterson et al. (1981)	Hudson (1981d)
74	Shepherd and Care (1984)	Hole (1975) and Hudson (1984b)
75	Shepherd and Care(1984)	Floyd (1978a) and Hudson (1984b)
76	DSSI (1978a) and Shepherd and Care (1984)	Hudson (1978b) and Hudson (1984b)
83	RDSI (1982a)	Hudson (1982a)
85	Willrodt et al. (1985)	Hudson (1985b)
86	Trabant and Everding (1983)	Hudson (1983b)
88	Johnson et al. (1985)	Hudson (1985c)
89	Shepherd et al. (1985)	Hudson (1985d)
92	IRC (1983a)	IRC (1983a)
93	Not available	Hudson (1976b)
94	Behrens and Floyd (1981)	Behrens and Floyd (1981)
95	IRC (1983b)	Pettus (1983)
96	IRC (1983b)	Pettus (1983)
98L	OOSI (1978a)	None
105	Hampton and Floyd (1980) and Eldarragi and Floyd (1984)	Hampton and Floyd (1980) and Eldarragi and Floyd (1984)
106	Sea Tales (1984)	Landry (1984c)
107	Not available	Hughston (1980)
108	Williams (1981a)	Hughston (1981)
109	Not available	Hudson (1978c)
115	Hannah and Taylor (1984)	Hannah and Taylor (1984)
116	Hannah and Taylor (1984)	Hannah and Taylor (1984)
128	RDSI (1982b)	Hudson (1982b)
130	Stier et al. (1984)	Hudson (1984c)
133	IRC (1984b)	Pettus (1984)
137	Johnson (1980)	Hudson (1980a)
138	Adams (1980) and DuVal and Floyd (1984)	Hole (1979b) and DuVal and Floyd (1984)

Table 4-1. Continued.

High Island Area (Continued)

Lease Block	Geophysical and Hazard Report	Archaeological Report
139	DSSI (1975)	Hudson (1975)
142	Sea Tales (1984)	Sea Tales (1984)
155	Not available	Floyd (1975b)
158	Aguilar et al. (1984)	Aguilar et al. (1984)
159	Aguilar et al. (1984)	Aguilar et al. (1984)
162	Williams (1982b)	Williams and Crow (1982a)
163	Williams (1982c)	Williams and Crow (1982a)
166	Care (1984)	Hudson (1984d) and Price (1984)
167	Giles (1984b)	Landry (1984a)
169	Williams (1982d)	Crow (1982b)
170	RDSI (1981c)	Hudson (1981e)
171	Not available	Floyd (1983b)
174	Antoine (1984)	Landry (1984b)
175	Antoine (1984)	Landry (1984b)
176	Willrodt and Price (1984)	Hudson (1984e)
179	Not available	Floyd (1975c)
193	Not available	Saltus (1976b)
194	Williams (1983c)	Crow (1984)
196	Willrodt and Price (1984)	Willrodt and Price (1984)
198	Not available	Hudson (1976a)
199	DSSI (1978b)	Hudson (1978d)
200	DuVal and Floyd (1981)	DuVal and Floyd (1981)
201	Not available	Floyd (1981b)
202	Williams (1984)	Williams (1984)
203	Aweeka et al. (1985)	Hudson (1985a)
A-6	Not available	Floyd (1981a)
A-7	Thomas and Floyd (1983)	Thomas and Floyd (1983)
A-12	Phelps (1983)	Hudson (1983a)
A-20	Williams (1983b)	Crow (1983b)
A-22	Lenzer and Taylor (1983)	Spencer and Lenzer (1983)
A-24	Williams (1982a)	Crow (1982a)

Table 4-1. Continued.

High Island Area (Concluded)

Lease Block	Geophysical and Hazard Report	Archaeological Report
A-170	Williams (1982e)	Crow (1982c)
A-171	Williams (1981b)	Williams and Crow (1982b)

SABINE PASS AREA

Lease Block	Geophysical and Hazard Report	Archaeological Report
3	DSSI (1979c)	Hudson (1979c)
5	DSSI (1978c, 1981)	Hudson (1981h)
6	DSSI (1978c, 1981) and OOSI (1979b, 1979d)	Spencer (1979a) and Hudson (1978e, 1981h)
7	DSSI (1978d)	Hudson (1978f)
8	DSSI (1979d)	Hudson (1979d)
9	DSSI (1978e) and OOSI (1979d, 1979e)	Hudson (1978g) and Spencer (1979b)
10	Not available	Floyd (1979b)
11	OOSI (1979f)	Spencer (1979e)
12	Not available	Floyd (1980)
13	DSSI (1979e)	Hudson (1979e)
13L	OOSI (1976b)	None
14	Not available	Floyd (1980)
17	OOSI (1979e)	Floyd (1979c)
18	OOSI (1979c, 1979e)	Spencer (1979c, 1979d)

WEST CAMERON AREA (Including the West Addition)

Lease Block	Geophysical and Hazard Report	Archaeological Report
47	Sides and Floyd (1978)	Sides and Floyd (1978)
53	RDSI (1981d)	Hudson (1981f)
82	Not available	Floyd (1975d)
83	Not available	Hudson (1978h)
91	RDSI (1980a)	Hudson (1980b)

Table 4-1. Concluded.

West Cameron Area (Including the West Addition) (Concluded)

Lease Block	Geophysical and Hazard Report	Archaeological Report
92	Not available	Floyd (1979d)
128	Callian (1982)	Chaffin-Lohse (1982)
153	RDSI (1982c)	Hudson (1982c)
157	RDSI (1980b)	Hudson (1980c)
161	DSSI (1979f)	Hudson (1979f)
163	Hampton and Floyd (1983) and Thomas and Floyd (1985)	Hampton and Floyd (1983) and Thomas and Floyd (1985)
164	DSSI (1979g)	Hudson (1979g)
289	DuVal and Floyd (1983)	DuVal and Floyd (1983)
290	SGII (1982)	Hudson (1982d)
292	Nagel and Pettus (1984)	Nagel and Pettus (1984)
293	Lauderdale and Villar (1980)	Hudson (1980d)
294	Not available	Hudson (1979h)
295	DSSI (1980b)	Hudson (1980e)
300	SGII (1981)	Hudson (1981g)
305	Callian (1981a)	Chaffin-Lohse (1981a)
306	Thomas and Floyd (1984)	Thomas and Floyd (1984)
311	Callian (1981b)	Chaffin-Lohse ((1981b)

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*OOSI - Odom Offshore Surveys, Inc.
DSSI - Decca Survey Systems, Inc.
RDSI - Racal-Decca Survey, Inc.
IRC - Intersea Research Corporation
SGII - Summit Geophysical International, Inc.

northern edge of the escarpment a channel was identified, and it was possible this channel represented a relict Sabine River course which abutted the escarpment. No other features were noted within the Sabine Valley to the west of the escarpment as the entire seismic record was obscured by gas.

Although no evidence of archaeological sites or potential site areas were noted by Hudson (1979c) in his archaeological report of the block, the escarpment edge is considered a high probability area for site occurrence. According to the sequence of sea-level rise postulated by Nelson and Bray (1970), five environmental periods can be identified for this locale: 1) Prior to 9400 B.P. the area consisted of the

Table 4-2. Geophysical and Archaeological Reports Examined for Proposed Pipeline Routes Within the Study Area.

Route Location	Reference Number on Figure 4-1	Geophysical and Hazard Report	Archaeological Report
Galveston Block 144L to Galveston Block 99	1	Behrens and Savarino (1979)	Floyd (1979a)
Galveston Block 182S to Galveston Block 144L	2	OOSI* (1978c)	Gagliano (1978)
Galveston Block 182S to High Island Block 98L	12	OOSI (1977c)	None
Galveston Block 182S to Shore Point in High Island Block 66S	None	OOSI (1976c)	Saltus and Spencer (1976)
Galveston Block 255 to High Island Block 4	4	DSSI (1976)	Hole (1976)
High Island Blocks 9L and 10L	3	OOSI (1979a)	None
High Island Block 48 to High Island Block 139	9	DSSI (1980)	Hudson (1980h)
High Island Block 55L	5	OOSI (1982c)	None
High Island Block 67L to Shore	6	OOSI (1982d)	Gagliano and Pearson (1982)
High Island Block 87S	None	OOSI (1982e)	None
High Island Block 87S to High Island Block 24L	7	OOSI (1982a)	None
High Island Block 110	8	Behrens and Savarino (1978)	Floyd (1978b)
High Island Block 136 to High Island Block 199	10	Giles (1983)	Gagliano and Pearson (1983)
High Island Block 143 to Galveston Block 99	11	OOSI (1980b)	Saltus (1980)
High Island Block 179 to High Island Block 154	19	Behrens et al. (1978)	Floyd (1978c)

Table 4-2. Concluded.

Route Location	Reference Number on Figure 4-1	Geophysical and Hazard Report	Archaeological Report
High Island Block 193 to High Island Block 197	17	Behrens et al. (1978)	Floyd (1978c)
Sabine Pass Block 10 to Shore	13	OOSI (1980a)	Spencer (1980)
Sabine Pass Block 10 to West Cameron Block 19	16	Oceanonics, Inc. (1980a, 1980d)	Rhodes (1980b)
Sabine Pass Block 13 to Sabine Pass Block 10	18	Oceanonics, Inc. (1980b)	Hudson (1980i)
Sabine Pass Block 13 to Shore	15	Oceanonics, Inc. (1980c, 1980e)	Hudson (1980g)
West Cameron Block 165	20	OOSI (1977a)	Saltus (1977)
West Cameron Block 289 to West Cameron Block 294	14	OOSI (1982f)	Spencer (1982b)
Offshore to the Sabine River Mouth (Overview of 25 Lease Blocks)	None	Not available	Gagliano et al. (1976)

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*OOSI - Odom Offshore Surveys, Inc.
DSSI - Decca Survey Systems, Inc.

Prairie/Beaumont Terrace escarpment and uplands adjacent to the river valley. 2) Between 9400 and 8600 B.P. the valley changed from a riverine environment to an area characterized by an estuary or lagoon. 3) Between 8660 and 6600 B.P. the valley became a swamp. 4) Between 6600 and 6050 the ancient valley reverted back to an estuary, and (5) by 6050 B.P. sea level had risen to the point where the escarpment was inundated. Thus, the area would have been favorable for habitation from Paleo-Indian times through the Middle Archaic.

One of the questions concerning the area was whether sites situated atop the escarpment could have survived sea transgression since they may not have been protected by overlying estuarine or swamp deposits. It was postulated that sites could have existed along the slope of the escarpment and on any slightly lower terrace within the valley and thus would have been protected. It was also hoped that additional seismic data could clarify the exact nature of the river channel identified by Decca.

A review of the actual seismic records confirmed the existence of the escarpment and the adjacent valley. A shallow depression also was noted in the gas in the location of the possible channel. Whether this depression represented a true river channel or simply an uneven gas surface was undetermined.

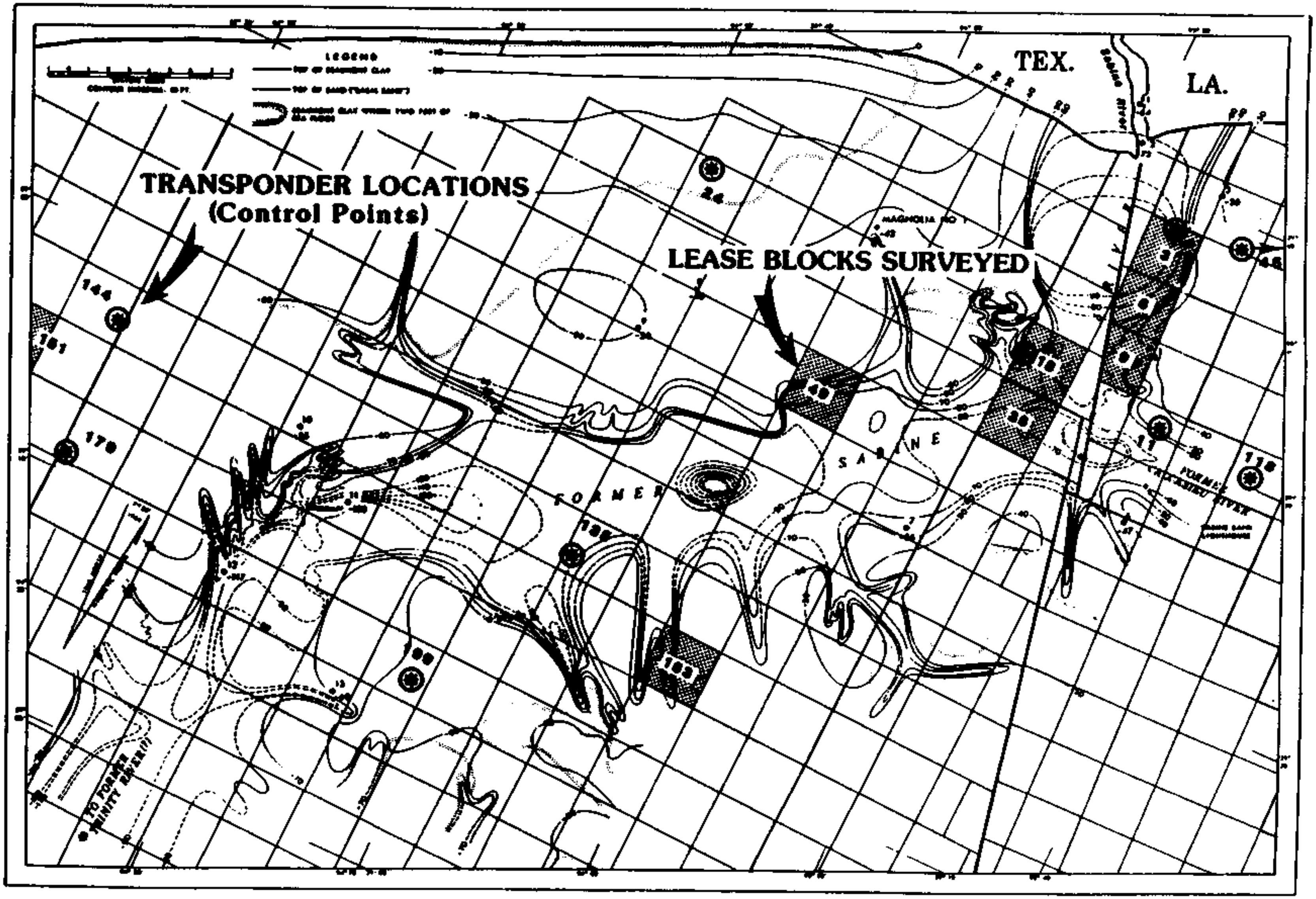


Figure 4-2. Lease blocks selected for survey during the present study. Transponder locations used in positioning during the actual seismic surveys are shown as well.

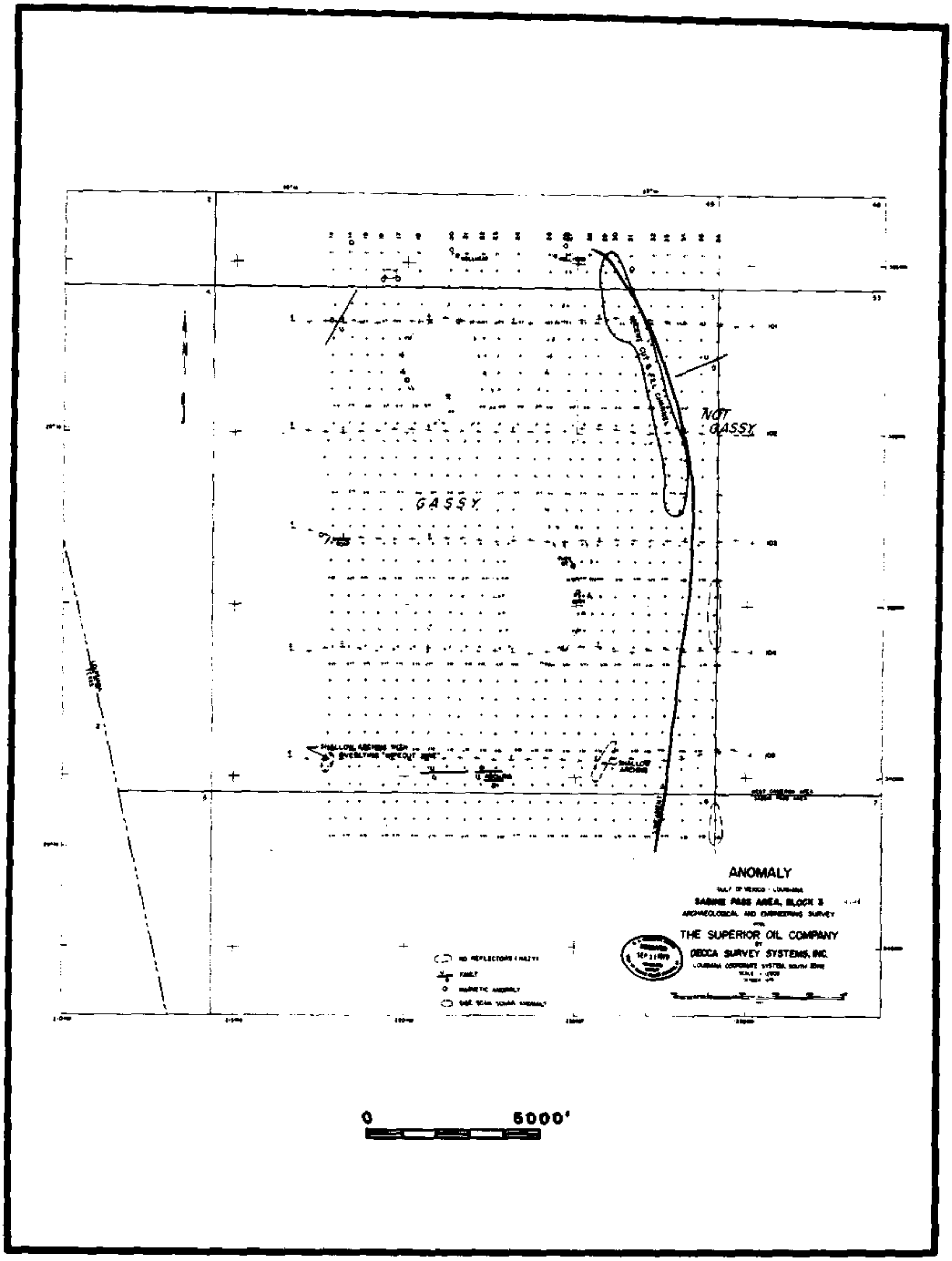


Figure 4-3. Anomaly map produced in the original lease block study of Sabine Pass 3, showing the eastern valley wall (Lineament X) and shallow channel adjacent to the wall (after Decca Survey Systems, Inc. 1979c:Anomaly map).

Sabine Pass 6

Several geophysical survey reports were examined in regard to this block (Decca Survey Systems, Inc. 1978c, 1981; Odom Offshore Surveys, Inc. 1979b, 1979d), along with archaeological reports by Hudson (1978e, 1981h) and Spencer (1979a). The most useful of the reports, simply because it covered the entire lease block, was that by Decca Survey Systems, Inc. (1978c). The report identified what was thought to be the eastern edge of the Sabine River valley (Figure 4-4), much like the escarpment noted above in Sabine Pass 3. In this instance the escarpment edge runs from the northeast corner of the block in an irregular line diagonally to the southwest. What was most interesting was the indication that an intermediate terrace might exist between the edge of the escarpment and the valley proper (Decca Survey Systems, Inc. 1978c:Fig. 7). A review of the original seismic records, however, indicated that what the geophysicists mapped as this terrace was, apparently, the top of biogenic gas within the Sabine Valley. Despite this, the area along the escarpment edge was considered a high probability locale and tightly spaced subbottom records could provide data on specific features worthy of further investigation.

Of the three archaeological reports available for this lease block, only Spencer's (1979a) study indicates the potential for prehistoric sites in and around the estuarine environment of the Sabine Valley once sea level began to rise. Spencer (1979a:A-4) argues, however, that transgression would have removed any potential alluvial features within the trench, thus eliminating associated archaeological sites. This assumption is contrary to the basic premise of the present study, but one which needs to be considered throughout the remainder of this report. In any event, correlation of the escarpment edge in Sabine Pass 6 with the postulated environments of Nelson and Bray (1970) provide three periods of distinct environmental association: 1) Prior to 9400 B.P. the escarpment was adjacent to a riverine system. 2) During the interval of 9400 to 6250 B.P. the escarpment was adjacent to an estuary or lagoon. 3) By 6250 B.P. the area was inundated. As with Sabine Pass 3, therefore, the escarpment edge and terrace slope in Sabine Pass 6 would have provided settlement loci from Paleo-Indian through Middle Archaic times.

Sabine Pass 9

Sabine Pass Block 9 was reported upon on three separate occasions by two different survey companies (Decca Survey Systems, Inc. 1978e; Odom Offshore Surveys, Inc. 1979d, 1979e), and two separate archaeological reports were produced (Hudson 1978g; Spencer 1979b). Figure 4-5 and 4-6 present shallow isopach maps from the Decca survey and one of the Odom surveys. These isopach maps contour the top of consolidated sediments and essentially show the thickness of post-transgressive deposits. Even though these two maps show the same area, they are quite different; emphasizing the variability in interpretations commonly seen in the offshore data. The most useful and accurate data is that supplied by the Odom survey (Figure 4-6). In their report (Odom 1979e) the shallow isopach map identified what was thought to be the eastern escarpment of the Sabine Valley, a relatively large channel scar abutting against the valley wall, and three potential tributary streams draining the escarpment (Figure 4-6). A review of a portion of the original seismic records indicated that Odom's interpretation appeared accurate. The area would have provided optimum settlement opportunities, particularly along the margins of the tributary channels and atop the bluff overlooking the large channel within the valley. As with Sabine Pass 6, the archaeological interpretation provided in conjunction with the Odom survey (Spencer 1979b) suggested that marine transgression would have destroyed the upper surfaces of both the escarpment and valley, and sites would have

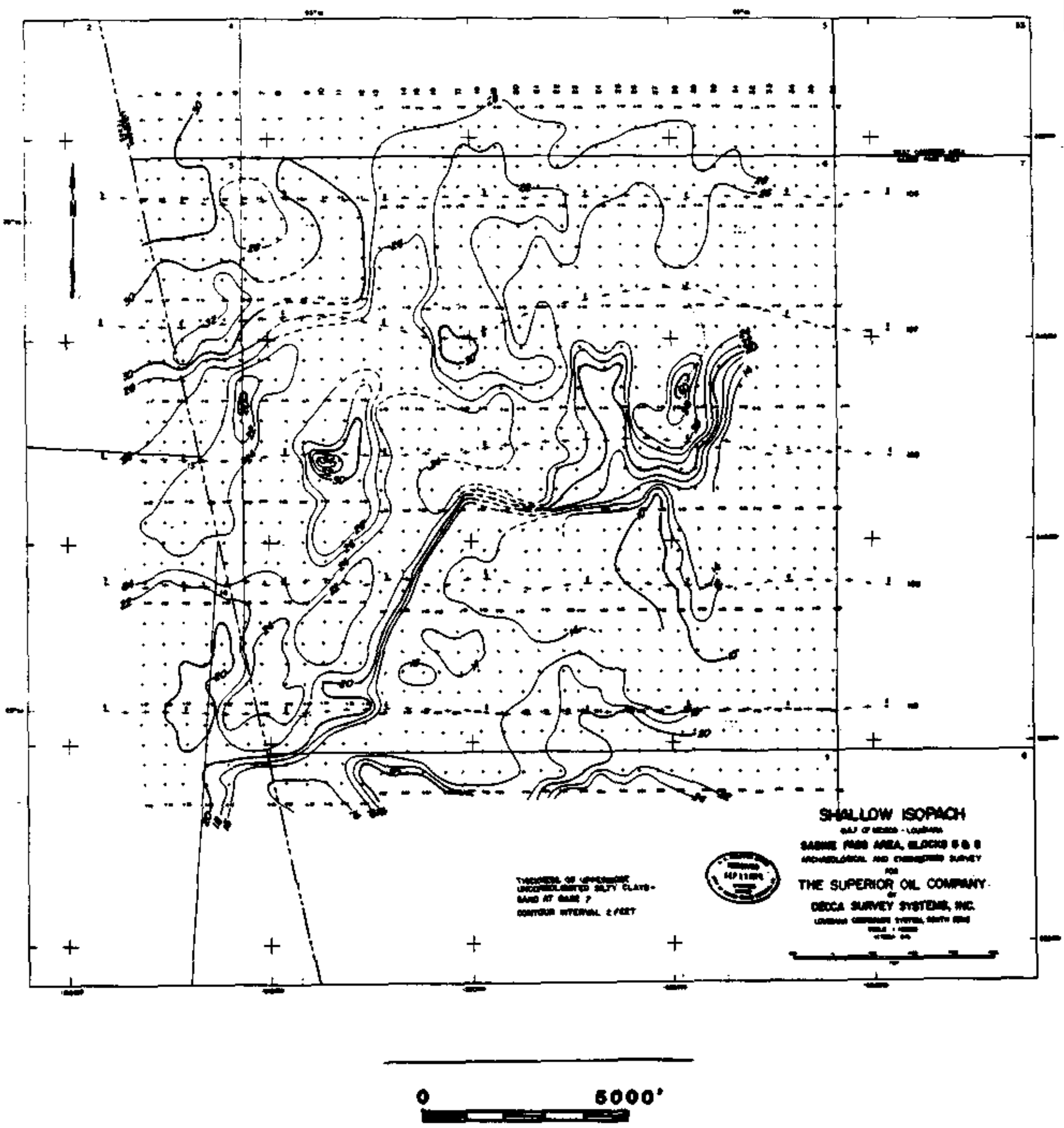


Figure 4–4. Shallow isopach map of Sabine Pass 6 produced in the original lease block survey. Note the prominent escarpment running through the center of the block (after Decca Survey Systems, Inc. 1978c:Shallow Isopach map).

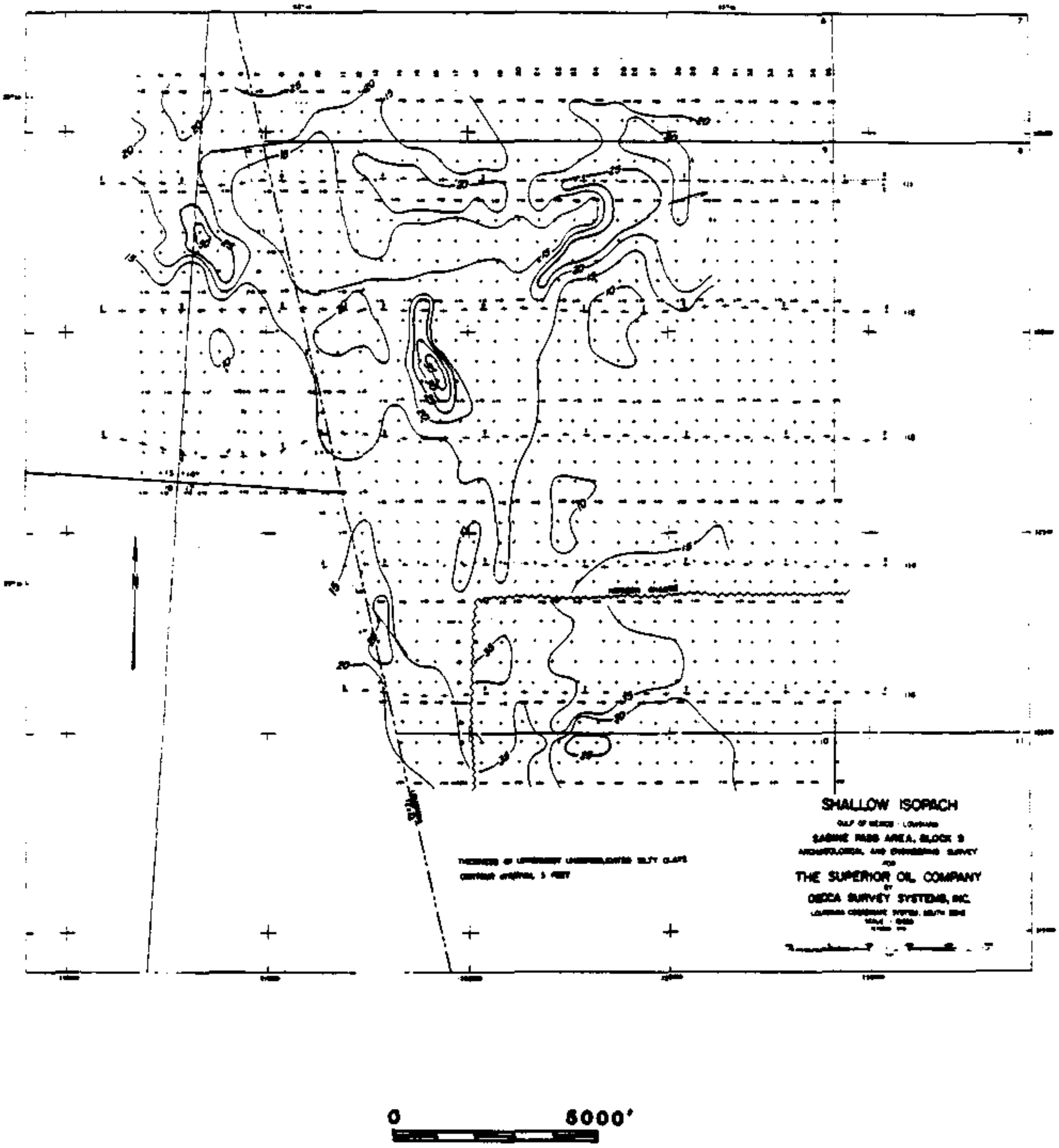


Figure 4-5. Shallow isopach map of Sabine Pass 9 produced by Decca Survey Systems, Inc. (after Decca Survey Systems, Inc. 1978e:Shallow Isopach Map).

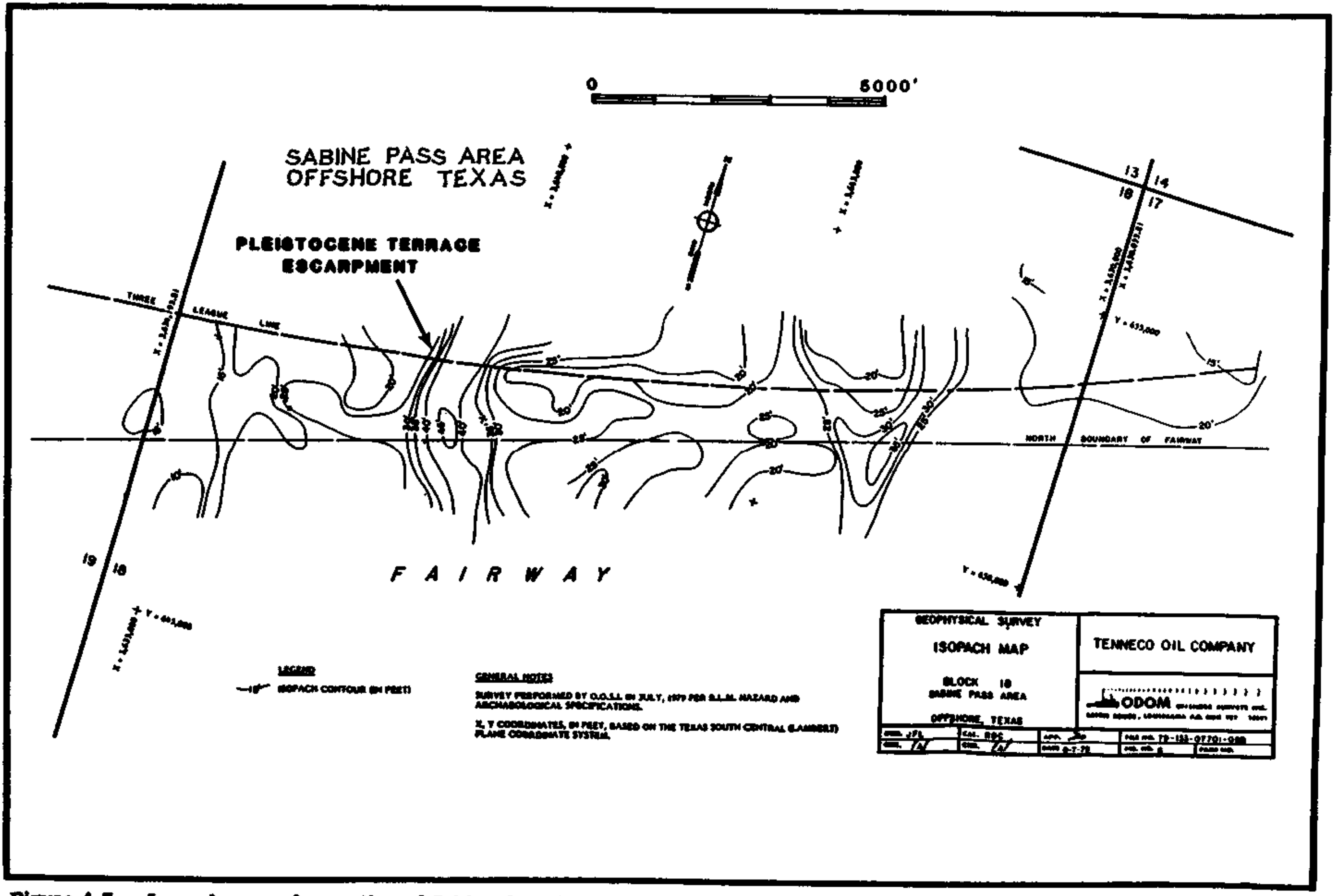


Figure 4-7. Isopach map of a portion of Sabine Pass 18 produced by Odom Offshore Surveys, Inc. (after Odom Offshore Surveys, Inc. 1979c:Isopach Map)

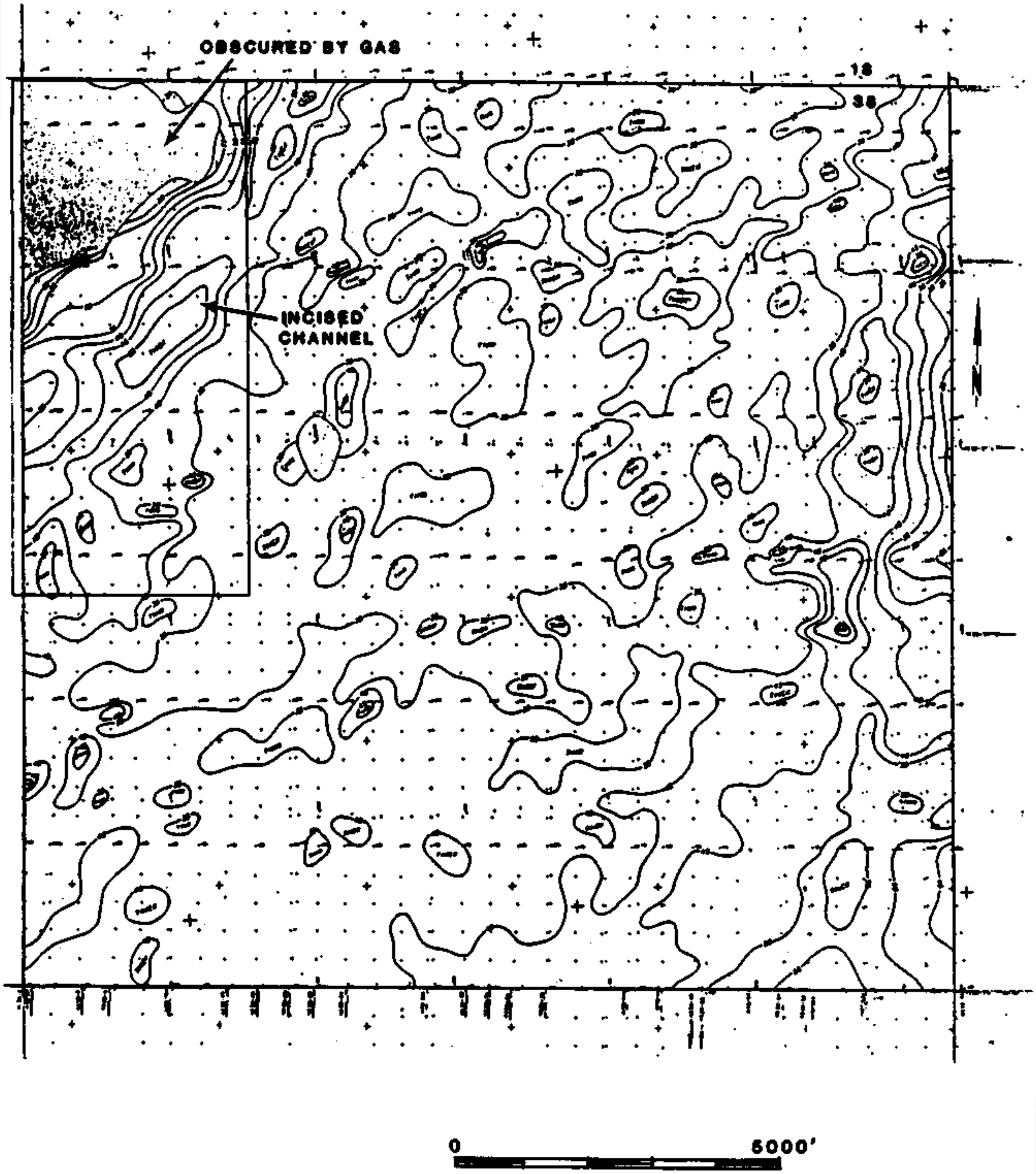


Figure 4-8. Shallow isopach map of High Island 38 produced by Fairfield Industries (after Chowdhury et al. 1979).

6050 B.P. the terrace edge was located adjacent to a lagoon or estuary. 3) By 6050 B.P. the region was inundated. Paleo-Indian through Middle Archaic occupations could have existed along the terrace margin and/or adjacent to the probable Deweyville channel.

High Island 49

Data supplied by Summit Geophysical International, Inc. (Taylor and Robertson 1981) were reviewed for this block. Their geophysical survey covered the southeastern half of the lease block. The archaeological report by Hudson (1981c) also was examined. The shallow isopach map produced by Taylor and Robertson showed a possible terrace edge in the northeast corner of the block possibly drained by a large tributary stream or old channel scar (Figure 4-9). Adjacent to the escarpment, bordering it to the south, was a shallow cut within the Sabine Valley which may represent a relict channel segment. Although the original archaeological report (Hudson 1981c) failed to identify any of these features and argued that potential for sites was low, the present study suggested otherwise. The margins of the escarpment, particularly those fringing the valley and adjacent to the channel scar, were considered potential areas for settlement during prehistoric time.

The area would have been favorable for occupation from before 9600 B.P. to 6450 B.P., according to Nelson and Bray's environmental reconstruction. Prior to 9600 B.P. the area consisted of an escarpment adjacent to a river valley. Between 9600 and 6450 B.P. the escarpment existed as a high rise adjacent to a lagoon or estuary. By 6450 B.P. it was inundated. Thus, occupations related to Paleo-Indian through Middle Archaic cultures could be postulated for this location.

High Island 163

The geophysical survey of this block revealed one of the more impressive channels seen in any of the lease block survey reports of the region. Figure 4-10 presents the deeper channel map produced from the seismic data (Williams 1982c). The channel runs roughly north-south through the block, and exhibits pronounced point bars and cut banks. Both the geophysical study (Williams 1982c) and the associated archaeological report (Williams and Crow 1982a) stress the great width of the channel (over 2000 ft). This suggests that it may be a Deweyville feature. A smaller channel, possibly a crevasse, can be identified emanating from the western (cutbank) edge of the larger channel. Based on previous data from terrestrial sites, one of the highest probability areas for site occurrence lies at the junction of a major stream and its crevasse distributaries. This section of the block, therefore, was selected for additional seismic research.

Overall, the channel/crevasse distributary junction would have been favorable for prehistoric occupation from before 9800 B.P. until it was inundated at 6550 B.P. Both Paleo-Indian and Archaic occupations may have utilized the banks of the old Deweyville channel.

Galveston 151

Although this block is on the extreme western edge of the study area, it was selected for a very specific reason: The geophysical survey (Lenzer and Robertson 1983), which covered only a portion of the block, identified two possible shell or sand deposits situated atop the probable Prairie/Beaumont Terrace edge just east of the Trinity River valley (Figure 4-11). These deposits are overlain by 15 to 25 ft of marine

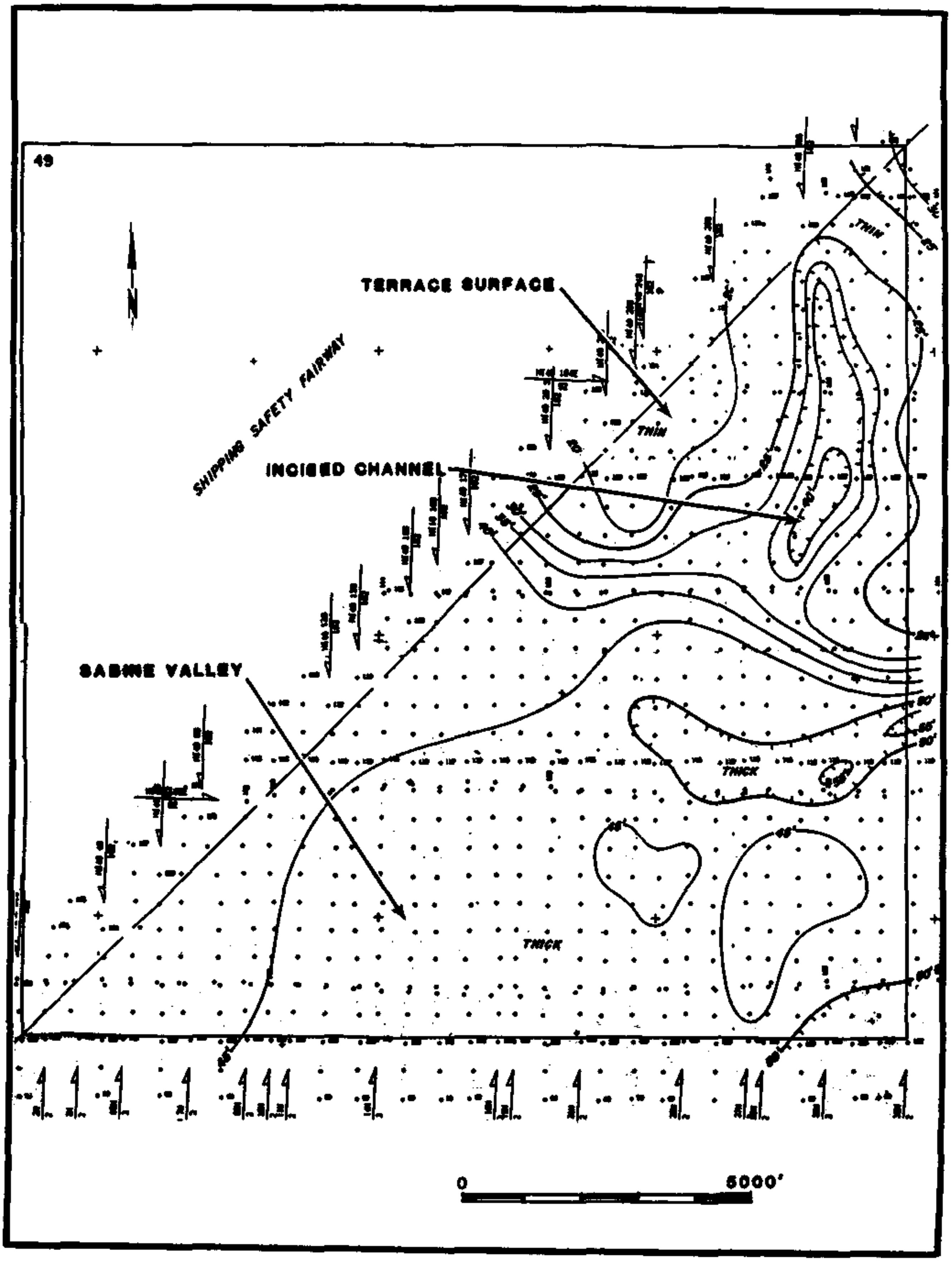


Figure 4-9. Shallow isopach map of a portion of High Island 49 produced by Summit Geophysical International, Inc. (after Taylor and Robertson 1981:Shallow Isopach Map).

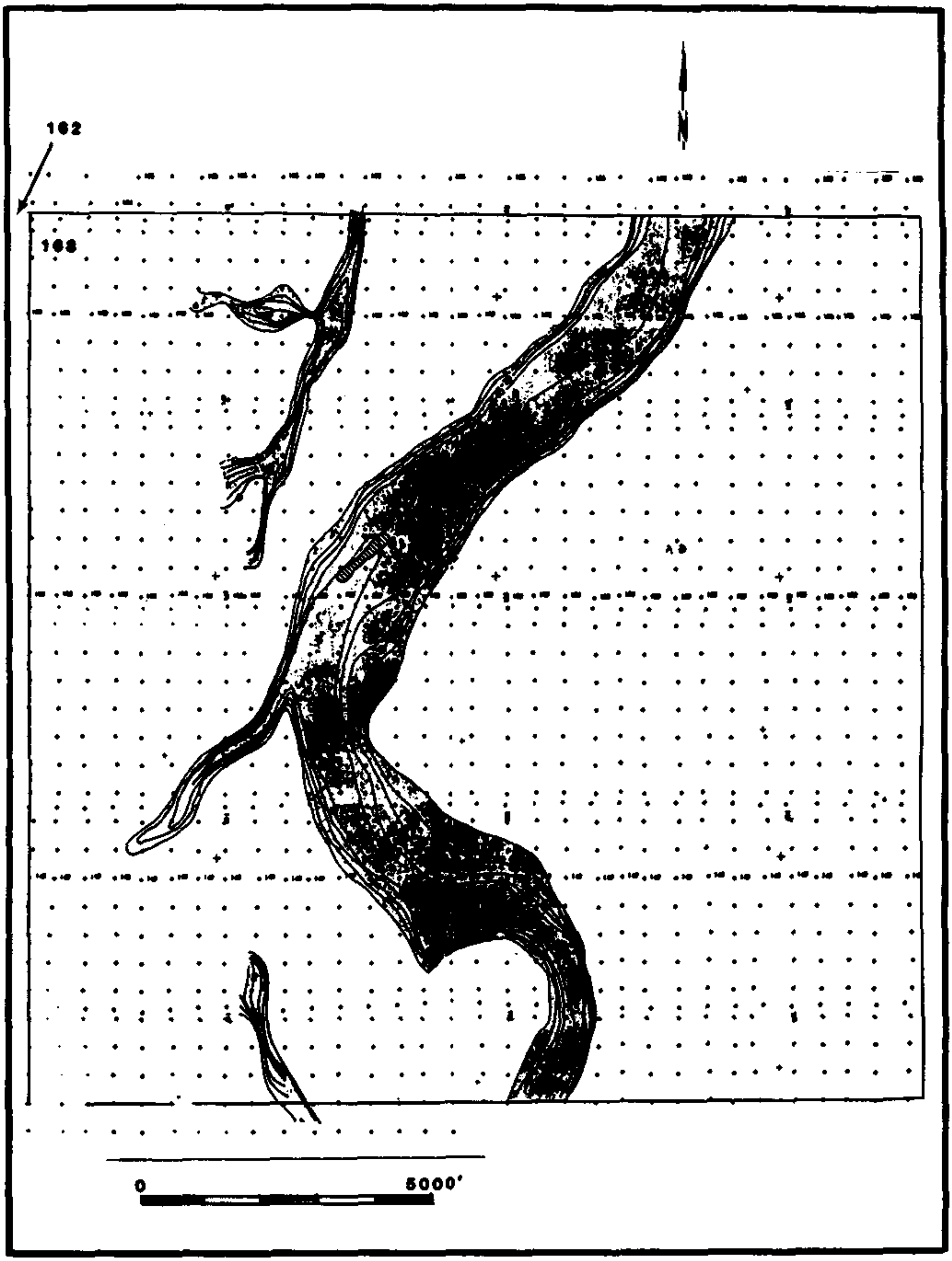


Figure 4-10. Deeper channel map of High Island 163 produced by Arco Exploration Company (after Williams 1982c:Deeper Channel Map)

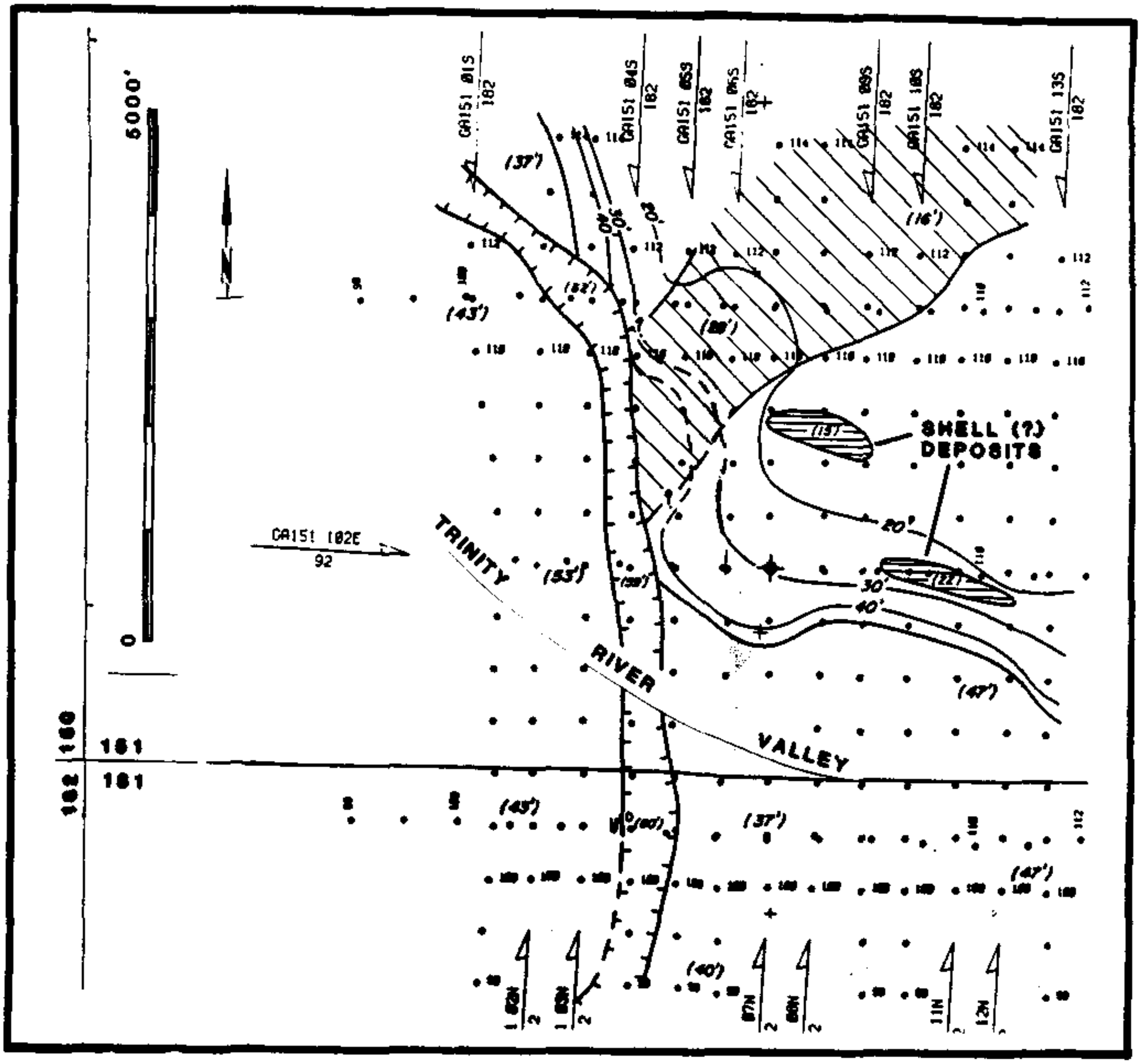


Figure 4-11. Isopach map of Galveston 151 produced by Gardline Surveys, Inc. (after Lenzer and Robertson 1983:Feature Map).

sediments, and, if shell, may represent large prehistoric middens. This was the only instance in the study area where a geophysicist pinpointed potential shell deposits in a context suggesting possible human origin. Close-spaced seismic data would, hopefully, help clarify the association of these deposits to the terrace and better record their exact shape. Additional features adding to the archaeological potential of the area were two channels noted north and west of the terrace edge, presumably ancient Trinity River courses. The channel to the north is over 1000 ft wide, suggesting a possible Deweyville origin.

Five environmental episodes can be postulated for this area with Nelson and Bray's data: 1) Prior to 10,000 B.P. the escarpment existed adjacent to a riverine system with relict and active channels of the Trinity River. 2) Between 10,000 and 9400 B.P. the escarpment probably lay next to an estuary or lagoon system. 3) Between 9400 and

7800 B.P. the area may have been inundated. 4) Following a possible reversal of sea level rise, the area again was exposed between 7800 and 6600 B.P. and would have been adjacent to an estuarine or lagoonal environment. 5) By 6600 B.P. sea level rise would have permanently inundated the entire region. Thus, Paleo-Indian through Middle Archaic occupations are possible.

Seismic Data Collection

Seismic data were collected by John E. Chance and Associates, Inc., during the periods March 12 through 15, April 2 through 5, and June 25 through 28, 1984. The survey vessel used was the 120-ft Global Surveyor. During this period approximately one day was spent at anchor during heavy fog, which prevented safe boat operation in the heavily utilized Sabine River mouth area. Eight days were spent on the actual block surveys. This was somewhat less than the 10 to 12 days originally estimated to conduct the survey. This is because one area was eliminated from survey on the basis of field observations. Additionally, in many of the areas surveyed, fewer line miles were required to adequately cover the area and features of interest than had been anticipated. The last four were days were used to gather broad-scale information on the Sabine Valley by means of a series of long transects that crossed key portions of the study area.

Seismic Positioning

The positioning system utilized during the block surveys was the Cubic DM-40A Autotape microwave system. This system has been used for several years by John E. Chance and Associates for commercial survey work in the Gulf of Mexico and has proven extremely reliable and accurate. Autotape accuracy is stated in real terms—not relative terms. The Autotape system can place one on a point and repeatedly return to that same exact point, reliably over extended periods of time. Autotape is a line-of-sight system with an unambiguous range of 10 km. Autotape probable range accuracy is 50 centimeters, plus 10 parts per million of the range. Autotape automatically measures the distance from a vessel to two or three stations (transponders) set at known positions. In this study, stations were placed at known monuments on drilling platforms in the project area (see Figure 4-2). Specific platform selection was made in relationship to the individual areas selected for seismic survey to enhance the geometry for trilateration to the survey vessel. Personnel were placed on drilling platforms to monitor the survey stations. The autotape system performed to expectations.

The second phase of the seismic survey, the long lines, required a different positioning system because of the great distances covered by each line. The Autotape system was inconvenient and insufficient because the triangulation requirements of the system provide for positioning within a relatively small area. On the long lines the survey vessel would have moved quickly out of the range of the system and accurate positioning could have been maintained only by constant movement of survey stations among drilling platforms. To alleviate this problem, the ARGO survey system was used on the long line survey. This is a radio wave system which uses shore-based stations which provide accurate positioning over a large area.

The ARGO system proved extremely accurate. This was demonstrated along several of the long lines which crossed the block survey locales surveyed earlier with the Autotape system. In all cases, the same features were identified (e.g. incised channels) during both surveys and the locations of the features corresponded.

Seismic Instrumentation

The primary seismic instrument used was the Ocean Research Equipment (ORE) 1032 Subbottom Profiling System, commonly called a "pinger". The pinger, and other similar high-resolution acoustic systems, have been used for the past decade to collect structural information on shallow subseafloor features. In conjunction with bore hole data, high resolution profiling has been shown to be a useful and accurate means of defining sedimentary units and depositional features (Curray and Moore 1963; Nelson and Bray 1970; Sieck and Self 1977). Today high-resolution subbottom profiling is an integral and required part of the hazard and cultural resources surveys undertaken relative to mineral exploration on the OCS. It has also seen increasing use in geoarchaeological approaches, particularly in studies attempting to delineate features and events relating to late Quaternary sea level changes and correlating these events with human settlement (e.g. Kraft et al. 1983; van Andel et al. 1980; van Andel and Lianos 1984).

The pinger was hull mounted in the vessel, minimizing the effects of rough water. The pinger transducer array may be operated at various frequencies from 3.5 to 7 kHz. During the study, a 3.5 kHz frequency level proved ideally suited for high resolution and penetration of the upper 50 ft in most areas. The power level used with the system was 10 kw.

All seismic systems operate on the principal that transmitted seismic energy "incident on an acoustic interface is partly reflected from this interface" (Sieck and Self 1977:353). An acoustic interface occurs where there is a contrast in acoustic properties. Normally, acoustic interfaces correspond to physical interfaces such as bedding planes, faults, gas zones, etc. With marine seismic surveying, the dominant acoustic interface is normally that between the water column and the sea floor. This interface will usually absorb and/or reflect a large proportion of the seismic energy.

Records are obtained by transmitting high-powered pulses of acoustic energy into the water column. The acoustic pulse of penetration and reflection is dependent upon the subbottom material, power output, and carrier frequency. Reflected signals are received by the same acoustic transducer used for transmission. The length of time of the signal from firing to receiving is recorded on electrosensitive paper (EPC chart) and subsequently used with velocity information to calculate the depths of subsurface features. At shallow burial depths within identified recent sediments it has been demonstrated that accurate depth readings are obtained by assuming that the velocity of sound in the sediments is the same as that in water (i.e. 5000 ft/sec) (Moore and Shumway 1959). This velocity was assumed in this study, and the close relationship between the positions of facies identified on seismic records and their actual locations in vibracores substantiated this assumption.

In addition to the pinger, an ORE Model 5810A GeoPulse high-resolution subbottom profiler was utilized during much of the survey. This instrument, commonly called a "boomer", operates at a lower frequency and achieves greater penetration than the pinger, though the resolution is less. During the study, the boomer was operated at a power level of 100 to 300 joules and the returning sound was filtered to record only the range of frequencies between 60 Hz and 2kHz. The sound source for the boomer is electromechanical and is mounted on a catamaran which is towed on the sea surface behind the vessel. A hydrophone array was towed parallel to, and about 20 ft away from, the catamaran.

The boomer served primarily to supplement and augment the pinger records. Because of its greater penetration, it was useful in aiding in the distinction between Prairie/Beaumont features and Deweyville features. However, because it was towed, the usefulness of the boomer and the quality of the records obtained were dependent upon sea state and weather conditions. When seas were greater than 3 ft, which occurred often during the survey, the boomer record usually was poor. In several instances, the sea state was such that the boomer could not be used at all and in those cases only pinger records are available.

Despite an extensive amount of research and practical applications, specific identification of sediments from seismic records is not normally possible. Correlative physical data, such as samples from bore holes, is a necessity in accurate interpretation of sediments from seismic records. While specific sedimentary characteristics are not normally identifiable, certain classes of features can be identified on seismic records. Distinctive features, such as cut and fill channels, and diapirs normally can be identified on the basis of their configuration. Gas features are commonly identified on seismic records, but are a poorly understood anomaly. They are produced by the breakdown of organic matter which forms natural gases, mainly methane. Biogenic (biochemical) methane is generally produced just below the sea floor by anaerobic bacterial decomposition. This shallow gas is of concern in this study. Gas bubbles in a sediment can decrease the sound velocity and increase attenuation by absorbing energy. Gas features can produce "wipe out" and "blurry" areas on seismic records or form "hazy" or "adumbrate" reflections and can occur as localized pockets or cover wide areal expanses. The configuration of a gas feature can serve as an aid in identification of its origin (e.g. marsh, organic channel fill, etc.).

A variety of types of subbottom features were identified on seismic records in this study. Most of these have been verified with data from vibracores. The specifics of identification and interpretations of features are presented later in the discussion of each of the areas surveyed. Here, it is important to emphasize that interpretation of features on seismic records requires a knowledge of the geologic processes that have occurred in the sediment column.

At all survey areas the strategy employed was similar. Initially a series of transects spaced 500 to 1000 ft apart was run over the selected areas to verify the existence of the features identified in the lease block review. In one instance, High Island 38, the features anticipated in the area were not revealed on the seismic records and the area was abandoned. The initial coverage was to verify the existence of target features and to gain areal understanding. Once this was done, close-order survey, using transects spaced 100 ft apart, was carried out across the desired locale. Once coverage was considered sufficient along the initial direction, a series of perpendicular lines were run over the area. The placement of this series of transects was primarily directed by reviewing the records of the initial transects. The objective was to position the perpendiculars so as to maximize information retrieval from the desired landform. The overall configuration of the survey employed in each area was dependent upon the size and form of the features examined.

Vibracore Data Collection

The instrument used to core the selected high probability locales and collect physical samples from those locales was a vibrator corer or "vibracore". The vibracore used consisted of a pneumatic impacting bin vibrator mounted on top of a core pipe made of 4-in standard pipe which contains a 3.5-in interior-diameter tubular plastic liner to contain the core. The vibracore was capable of 40 ft of penetration. A check valve at the top of the core barrel and a spring-leaf core retainer at the bottom were used to retain the core sample in the plastic liner during withdrawal and raising of the sampler. A mast, consisting of a steel H-beam supported in vertical position by a base consisting of four legs braced to the mast, was set on the seafloor. The vibrator and the core pipe were spring mounted to a slide attached to the mast and thus were set free to move vertically, guided by the mast, with weight of the slide exerting a constant pressure on the core pipe. The core barrel was designed to be driven into the sediment and pulled back (with the core) into the frame before lifting from the seafloor. Power was supplied to the pneumatic vibrator by an air compressor on the support vessel through a flexible wire-reinforced hose. A strip chart record provided the depth of penetration achieved by the vibracore.

The vibracoring was undertaken by McClelland Engineers and was conducted from the self-propelled, 86-ft jack-up barge Harold Bradshaw (Figure 4-12), which operated out of the port of Sabine Pass, Texas. Given the water depths at which coring was undertaken (usually greater than 30 ft) and the size of the vibracore used, the jack-up barge was a necessity. It provided a stable platform from which to work and to achieve the accurate positioning required. A crane on the jack-up barge was used to lift and lower the bulky and heavy vibracore (Figure 4-13).

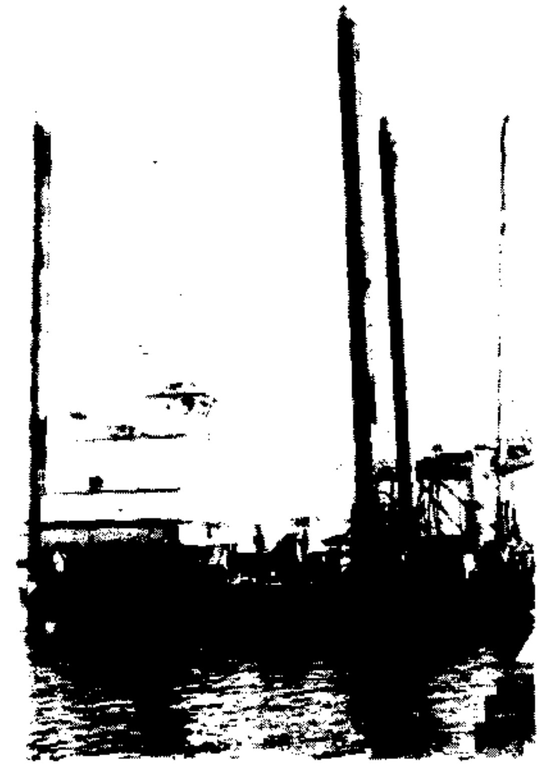


Figure 4-12. The jack-up barge Harold Bradshaw.

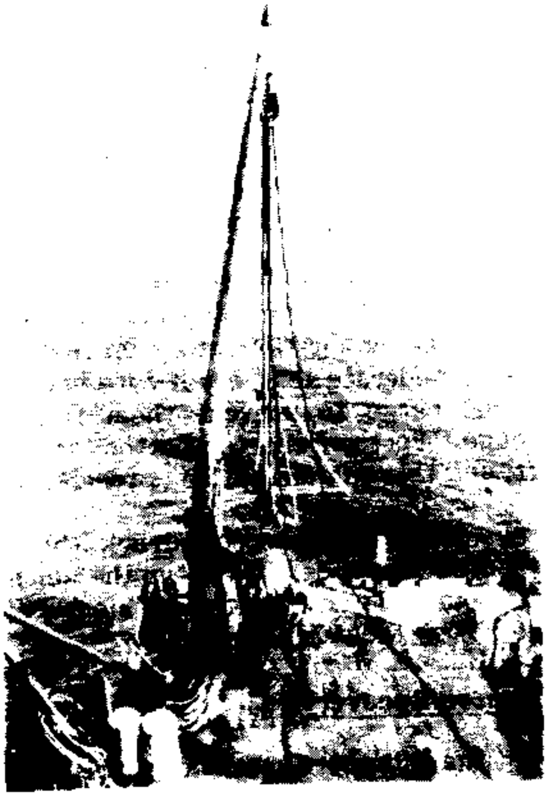


Figure 4-13. Lowering the vibracore into drilling position.

Vibracore Positioning

The positioning system used during the vibracoring is known as SYLEDIS, a short to medium range radiopositioning system. SYLEDIS achieves accuracies similar to those of Autotape, the positioning system used during the close-order survey of the selected locales. SYLEDIS operates over ranges varying from 10 m to up to 300 km, with an accuracy from 1 m within the line of site to 5 x 10^{-5} x the distance for areas beyond the line of sight. The coring was conducted within or near the line of sight of the three shore-based transmitter antennas such that accuracy was in the 1 m range. One reason SYLEDIS was used in this phase rather than Autotape was to eliminate the placement and exchange of transponders and personnel on offshore rigs. This would have been time consuming and difficult using a jack-up barge. An additional factor was the danger to personnel and equipment which could have resulted from transferring people to platforms in the weather conditions encountered during the vibracore work. The vibracoring was conducted from 7 November to 19 November 1984, a period of bad weather and high seas. During the 13 days spent collecting vibracores, seas ran above 5 or 6 ft for six days, prohibiting the taking of any vibracores on those days. Thus, only seven days of coring actually occurred.

On-site positioning was achieved by moving the barge as close to the desired position as possible. The hydraulic legs then were partially lowered, until they just touched the seafloor, and the barge was carefully maneuvered until the desired position was located just off the bow. The antenna for the positioning system was located atop the pilot's cabin on the barge at a known distance from the bow of the vessel. This offset was included in the development of the pre-field computerized plot of positioning points.

In the field, the distance and the direction to the vibracore from the bow of the barge when the vibracore was finally placed in the water, were measured as each core was taken. These measurements were taken into account in developing the X-Y coordinates for each vibracore. A list of X-Y state plane coordinates for vibracore locations is provided in Appendix E.

Positioning the barge exactly was not always easy. In calm weather, it could be achieved in 15 or 20 minutes. In seas above 3 ft, however, positioning was often difficult and many times took up to 45 minutes or an hour. A major problem was that, in even moderate seas, great care had to be taken in lowering the hydraulic legs of the jack-up barge to prevent them from pounding against the seafloor and suffering damage. Fortunately, the bottom sediments in all of the areas cored were relatively soft, and this minimized the potential for damage.

In every case, vibracores struck the target land surfaces within 1 to 3 ft of the suspected depth derived from the seismic records. This indicates great accuracy in positioning and also provides a measure of reliability in terms of the interpretation of features on the seismic records.

Vibracore Recovery

After the vibracore was placed on the seafloor, the weight of the vibrator and core tube alone normally drove the core through the upper several feet of soft sediments. The pneumatic vibrator was then activated until the desired depth was achieved. In most cases the corer was stopped by, or achieved only minimal penetration into, the dense clays or sands of Prairie/Beaumont and Deweyville features. The deeper organic deposits which contained large pieces of wood also stopped the vibracore.

After drilling to the required depths, the vibracores were brought aboard the barge, the core liner tubes were extracted, the cores were cut into 5-ft lengths, and each section was recorded and labeled. These sections then were stored vertically in a holding bin aboard the barge before being taken to the laboratory for processing.

Our intention was to collect 91 vibracores at seven locales in the study area. As a result of the shortened field time, it was possible to take cores only in five of the selected areas; those in Sabine Pass 3, 6, 9 and 18 and High Island 49. Two previously selected locales in High Island 163 and Galveston 151 were eliminated. These two locales were not high priority areas and were to be cored only if sufficient field time was available.

Seventy-six vibracores were taken, 15 fewer than had been projected. The penetration records indicate that these 76 cores achieved a total penetration of approximately 1815 ft. The total column length of sediments recovered in the cores, however, measured only 987 ft, representing an overall recovery of 54%. The recovery rate for individual cores ranged from 34% to 78%, with most cores falling in the 50% to 60% range.

Correlation of the vibracores and the penetration records with the seismic records suggested that the lower sections of the cores were achieving complete or almost complete recovery. It appeared that core loss was occurring in the upper portion of the sediment column. It was thought that two factors were responsible for the loss of record. One of these was the compaction of sediments in the core as a result of the vibration. This, however, was felt to be minimal. Most core loss, therefore, was thought to have occurred because some of the upper clays were so soft and fluid that they simply were pushed out of the way of the core tube and did not enter the barrel. In order to test this, one core in Sabine Pass 3 (Core 1-D2, see Appendix E) was lowered slowly into the seafloor sediments and was not vibrated. The weight of the core mechanism alone drove the core to a depth of 17.0 ft, entirely within deposits interpreted as estuary/bay bottom clays and marine silts and clays. When recovered, however, the core was only 10.5 ft long, a 62% recovery. This indicated that core loss was occurring in the upper, marine or bay/estuary segment of the column and was not due to operation of the vibrating mechanism. It became apparent that little if any core loss was occurring in the lower, pretransgressive sections of cores. These lower sections are the critical sections relative to archaeological deposits, such that core loss did not affect the identification of possible archaeological materials. It is interesting to note that the type of recovery encountered in this study is the same as that reported by Nelson and Bray (1970:Fig. 4).

Core Treatment

Once the cores were returned to the laboratory, each 5-ft section was split by running a hand-held circular saw along the length of the core, cutting only as deep as necessary to slice through the plastic liner. After the core liner was cut, a wire was used to cut the core (Figure 4-14). One half of each core section was wrapped in a plastic casing and stored. This section would serve as an archival record in the event that additional corroborative analyses need be conducted. The opposing half was placed in the laboratory, covered with strips of plastic cellophane wrapping, and allowed to air dry for one or two days, depending on the amount of moisture retained in the core (Figure 4-15). Once dried sufficiently, each section was scraped using a bent and sharpened spatula, with the scraping motion perpendicular to the length of the core.

Next, each section was photographed at a scale of approximately one foot per frame of film. All cores were photographed by 35 mm color print film (Fujicolor 200), while selected cores or portions of cores were photographed by 35mm color slides (Kodachrome 25 or 64) or black-and-white print film (Kodak Panatomic-X). Entire cores also were photographed on one negative or slide by placing the various sections

Figure 4-14. Cut section of core.

Figure 4-15. Examination of split cores in the laboratory.

in wooden frames side by side. After photography, the various sections were wrapped and placed in temporary storage prior to logging and sampling. Permanent storage of these and the unsampled core sections will be at Texas A & M University. Data resulting from the seismic survey and core analyses are filed with the National Oceanic and Atmospheric Administration, National Oceanographic Data Center, Rockville, Maryland.

In order to alleviate the need to examine each core throughout the course of analysis, the color prints for each core were spliced together by section and mounted on cardboard. These photographs became invaluable as the need arose to examine the actual core, rather than the somewhat less-detailed core logs, time and again during the study.

Core logging followed standard geological procedures, and all data were recorded on a core log form (Figure 4-16). In addition to lithology, logs recorded Munsell colors, penetrometer readings, and general impressions about each strata or depositional unit recognized.

Sampling of the cores for the various detailed analyses to be employed occurred next. The core photograph strips, along with the core logs, were aligned by core line and block on a table in the order acquired. Each prospective sample location within a core then was marked on the photograph of the core. Once each block was completed in this fashion, the actual cores were removed from temporary storage and sampled. After sampling, they again were wrapped and placed in more permanent storage with the unsampled halves. The treatment of each type of sample is provided below.

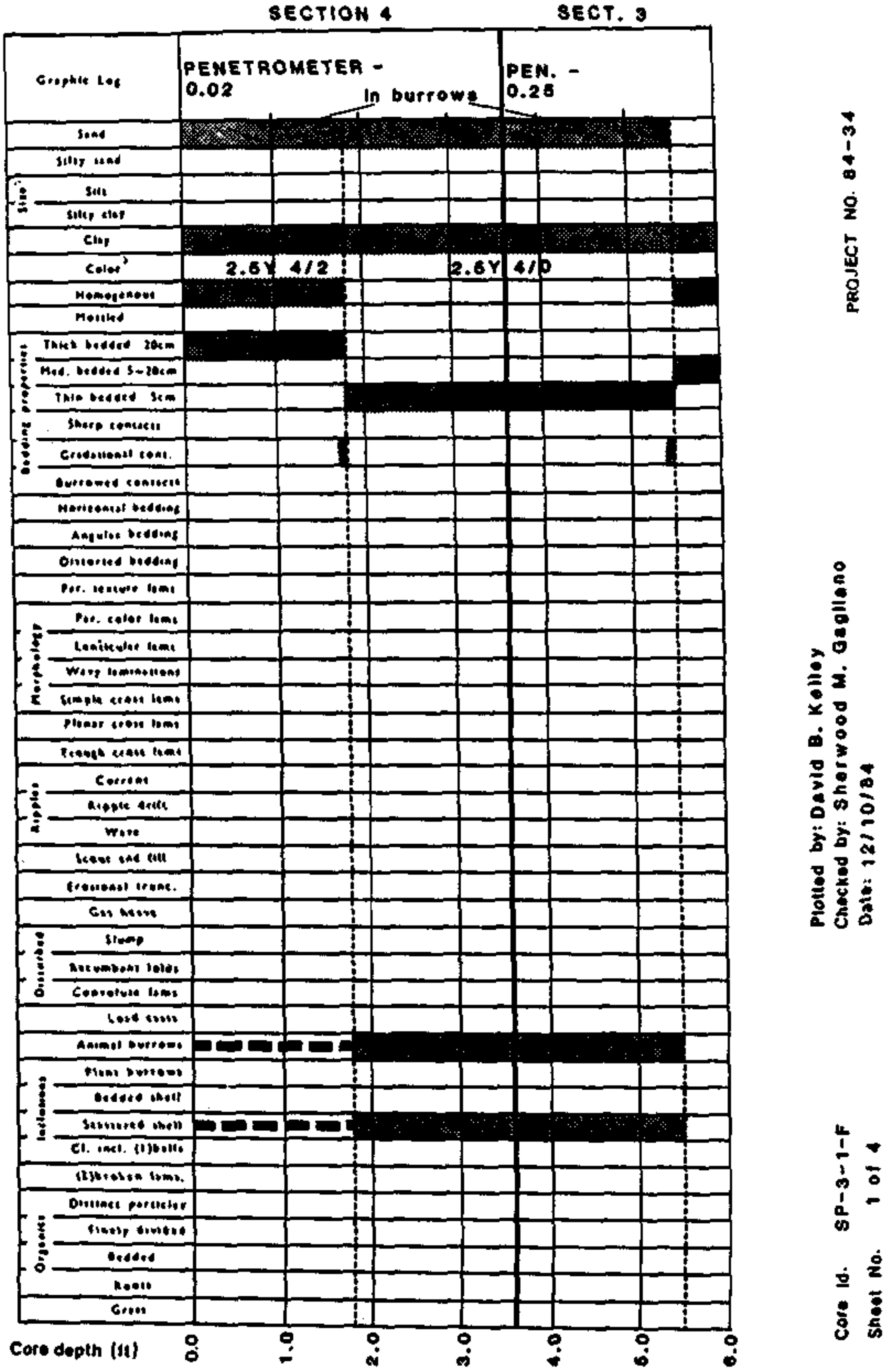


Figure 4-16. Log of Core SP3-1-F.

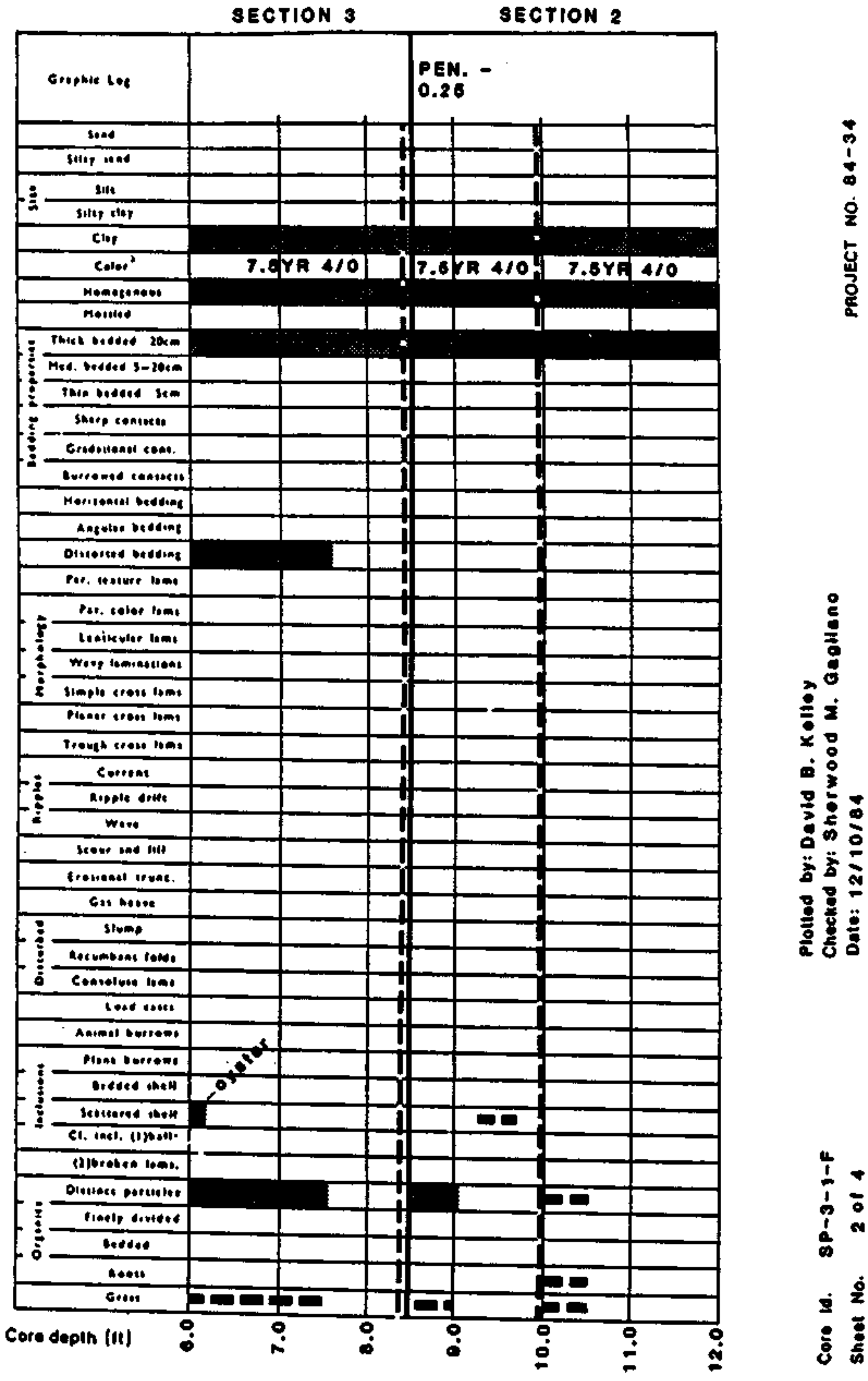


Figure 4-16. Continued.

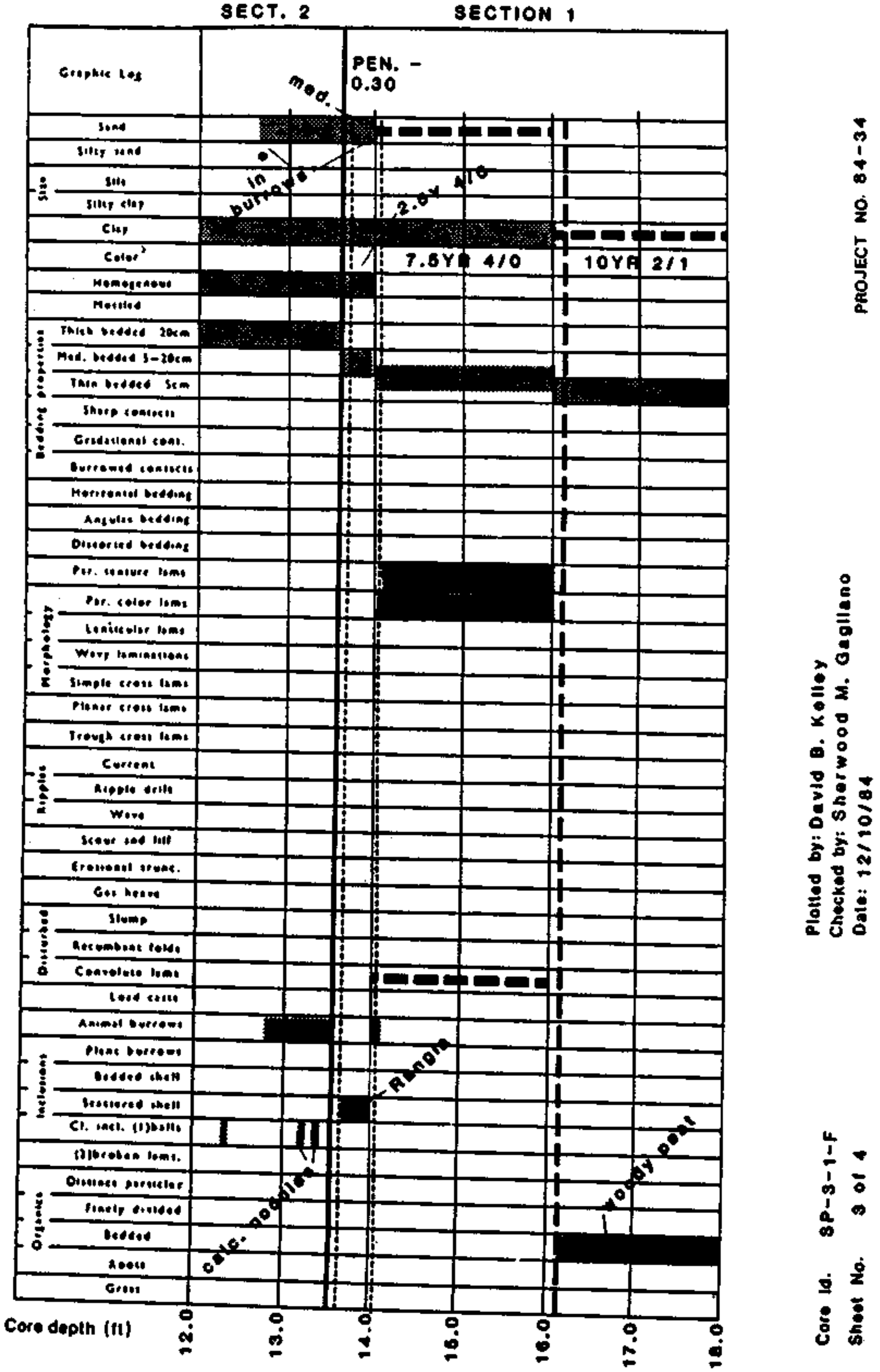
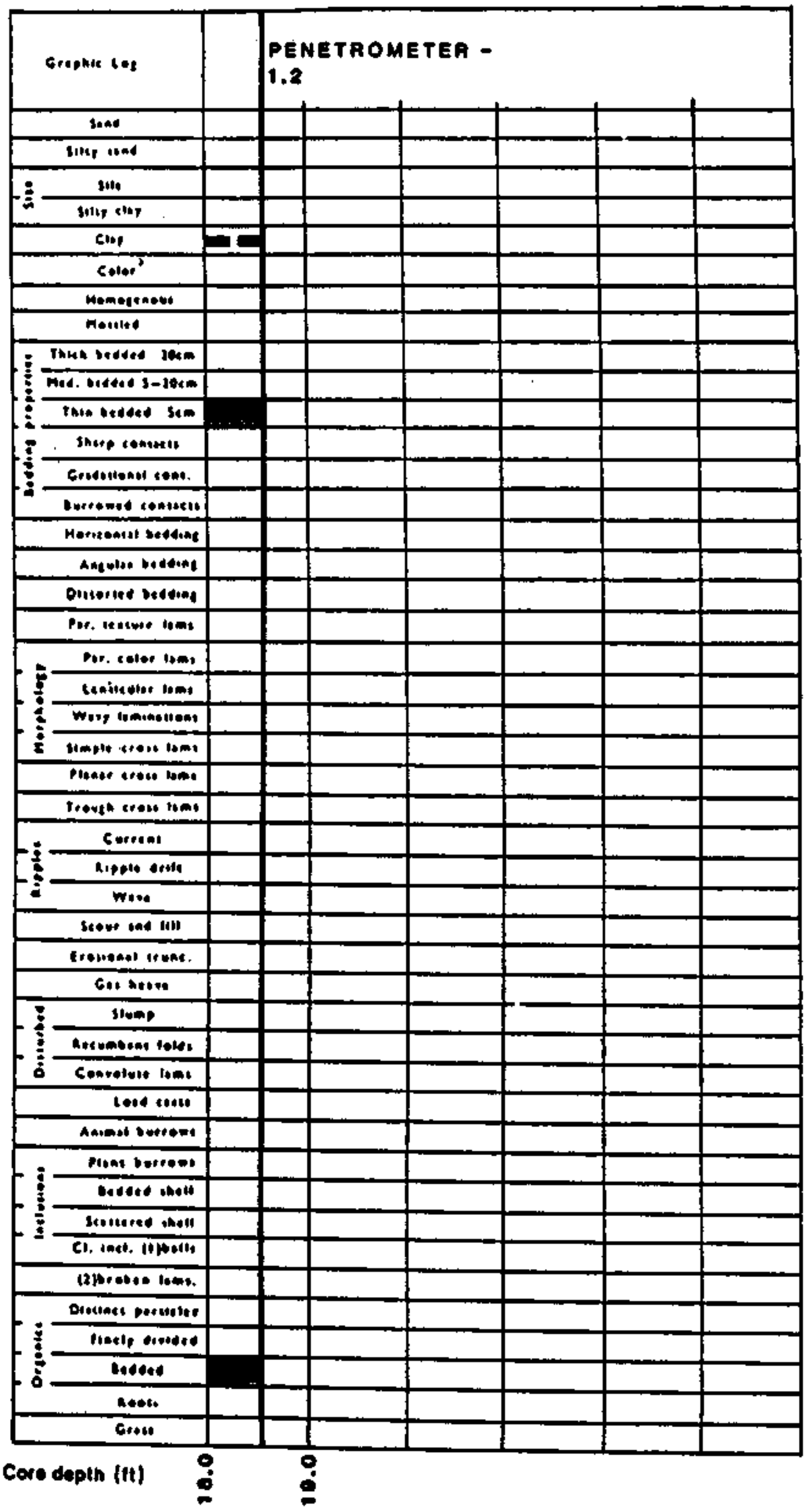


Figure 4-16. Continued.



PROJECT NO. 84-34

Plotted by: David B. Kelley
Checked by: Sherwood M. Gagliano
Date: 12/10/84

Core Id. SP-3-1-F
Sheet No. 4 of 4

Figure 4-16. Concluded.

Grain-Size Analysis

Grain-size analyses have long been used to estimate or aid hypotheses of depositional environments of natural sediments (Buller and McManus 1972, 1974; Folk and Ward 1957; Krumbein 1934; Krumbein and Pettijohn 1938). The most successful results have come from comparison of third and fourth statistical moments of grain-size interval distributions. While such detail of analysis was beyond the scope of this endeavor, a basic grain-size analysis was considered useful in providing insights into the nature of archaeological deposits and the mechanism by which sediments at sites were deposited. The recent archaeological literature indicates an increasing interest in archaeological sediments and approaches to their study, including grain-size analysis (Butzer 1971, 1982; Davidson and Shackley 1976; Gagliano et al. 1982; Shackley 1975, 1981; Stein and Farrand 1985; and particularly Stein 1982, 1985). None of the studies suggests that grain-size analysis in and of itself always will serve to distinguish a culturally derived sediment from a natural deposit, the concern of this study, but it is valuable when used in hand with other analytical techniques.

An earlier study (Gagliano et al. 1982) suggested that grain-size analyses of coastal sites had utility in specific situations. That study indicated, in general, that cultural activity introduced mid- to large-sized artifactual and nonartifactual particles into a sediment. Thus, when an archaeological sediment is deposited on a fine-grained natural deposit, such as a natural levee, the two deposits are likely to differ significantly in their grain-size distribution. Grain-size analysis appears less useful for site identification where landforms are composed mainly of larger-than-sand-sized particles.

This fact suggested that grain-size distributions were to have site identification utility only in specific situations in the present study. Beyond this, however, grain-size distributions were used to characterize the various strata identified in the vibracores and to gain information on natural landform types and their processes of deposition.

As noted, samples were selected and then extracted from cores after an initial evaluation of a complete line of cores. This permitted sampling of the complete range of variability seen in core sediments. While the major intent was to sample locations having the highest probability of containing archaeological materials, sampling also was directed at gathering purely geological information. Samples were cut out of the selected area on the core with a clean knife or spatula. No effort was made to collect samples of a specific size; samples just had to be of sufficient size to be used in the analysis. Samples were normally on the order of 150 gms or larger; however, all of the sample was not necessarily used in the grain-size analysis. As is noted below, the point-count analysis was conducted on selected fractions from selected grain-size samples. After samples were selected they were placed in glass half-pint jars and sealed until analyzed.

Analysis of samples utilized systematic procedures derived from standard grain-size analysis established by Folk (1968). Samples were considered to consist of soil "grains" of two major size categories: the coarse fraction, consisting of particles larger than 4.0 phi (or .062 mm), and the fine fraction, those particles less than 4.0 phi. One hundred fifty-four samples were subjected to coarse fraction analysis, while both the coarse and fine fractions were analyzed for 24 samples.

The 154 samples used in the coarse fraction analyses were soaked in water for 24 hours to disperse clays before drying, then they were air dried. A dry weight before washing was measured and the sample again was soaked in water to further disaggregate clays and aid in washing. Samples then were washed through a 4.0 phi (230-mesh) wet sieve with a water jet and gentle agitation until all silt and clay were removed. The washed sample was then dried and weighed. Subtraction of this weight from the prewashed sample weight provided the weight of the silt and clay fraction.

Further division of the coarse fraction is based on the standard phi division. Phi divisions are negative logarithms to the base 2 of particle diameters, used because many size distributions in nature have been found to be log normal, i.e., produce a normal distribution (bell curve) with a logarithmic abscissa and an arithmetic ordinate. Five to eight 1-phi divisions of the coarse fraction were made using standard 8-in sieves vibrated in a mechanical shaker for 15 minutes. The weight of each phi division was measured to .01 g. The measured weights then were used to construct cumulative curves of grain-size distributions.

Twenty-four samples were carefully selected from the original 154 samples and subjected to a size analysis of their fine-grained fractions. The pipette procedure used in these analyses follows that of Folk (1968). Each sample was wet sieved though a 0.062 mm screen, thereby collecting the fine fraction in a pan and leaving the coarse fraction on the screen. The fine fraction then was dispersed with Calgon at an average concentration of 2.1 grams Calgon per 1000 ml water. The solution then was placed in a 1000 ml beaker and vigorously stirred. Pipette samples were taken at various times (up to 8 hours) and various withdrawal depths for a total of seven withdrawals per sample. These withdrawals then were dried, weighed, and subjected to various calculations to result in phi class weights ranging from 4 phi to 10 phi. These 24 analyses then were combined with their coarse-grained fraction data and plotted. The graphic mean and graphic standard deviation (Folk 1968) then were calculated for these 24 samples.

Point-Count Analysis

The term "point count" is derived from a technique used in sedimentary petrography in which the proportions of various mineral components in a sample are determined by counting the individual grains underlying a network of points placed over a thin section (Muller 1967:145). Counting of individual grains (as opposed to subjective estimates of abundance) has been a standard practice since the 1920s in studies of the mineral content of the heavy fraction of sediment samples (Krumbein and Pettijohn 1938:470). Estimates of abundance, however, are still used in characterizing the general content of sediment samples in the study of Holocene sediments (Coleman 1966, 1969) and in archaeological sediment analysis (Shackley 1975:78-79).

The approach used here is based upon the previous study by Gagliano et al. (1982) which used point counts as a technique for discriminating between archaeological deposits and noncultural deposits in the Gulf coastal zone. That study suggested that point counts had a high degree of reliability in identifying culturally derived deposits and that it is a straightforward, efficient, and practical analytical technique.

Gagliano et al. (1982) indicated that point counts conducted on the two largest fractions from a screened sample of matrix, the -1 phi and +.25 phi fractions, were sufficiently reliable in the identification of sites. The smaller-sized fractions (in that case the +2 phi, +2.75 phi, and +4 phi fractions) were very time-consuming to process and analyze and did not add significantly to the ability to distinguish archaeological deposits.

Following these indications, point counts were conducted only on the two largest sized fractions retained from the grain-size analyses: the -1 phi and the 0 phi. (The previous study had used the +.25 phi rather than the 0 phi fraction, but the minimal difference in the screen sizes does not affect the comparability of results.) The point counts were made directly on the fractions obtained from the grain-size analyses. In some instances the sample was excessively large for counting, and, therefore, was split using a standard microsplitter. The microsplitter produces a subsample which retains the approximate proportions of the components within the original sample. While this procedure is still subject to sampling errors (Shackley 1975:36) it is not felt that such errors were detrimental to the present study. Several split sample portions were compared and no major differences in constituent composition were indicated. Splitting was necessary only on some of the 0 phi samples. None of the -1 phi samples were split.

Samples were examined and counted macroscopically and, as necessary, with the aid of a stereomicroscope at 7x to 30x magnification. The microscope was specifically required for the 0 phi fraction. All particles in the sample were identified, categorized and counted. The categories into which particles were placed are essentially those defined by Gagliano et al. (1982). The degree and precision to which identification could be carried, of course, varied between the two sample sizes, such that the categories into which items were placed differ slightly for the two samples.

Identification was facilitated by the preparation of "particle reference standards" (Shackley 1975:79), a series of slides of sieved fragments of various materials likely to be encountered in the analysis. Hydrochloric acid (HCl) sometimes was used to distinguish carbonates from silicates. Biotic components were identified to the highest taxonomic level possible. In order to make the results comparable between samples, counts have been converted to particles per kilogram.

Certainly, not every particle present in the sample was counted and probably not every particle counted was correctly identified. However, an effort was made to come as close to this ideal as possible. There are, additionally, many problems in this type of analysis. (For instance, how many "particles" of root fiber are there in a clump of root fibers? Is this particle a piece of ceramic or a piece of baked clay?) The point-count technique does, however, appear to be a reasonable, efficient, and practical approach to the study problem. The results of the point-count analyses are presented in tabular form and discussed in later sections dealing with the specific locations which were cored.

Foraminifera Analysis

The purpose of the foraminifera analysis was to characterize the environments of deposition of the various strata represented in the collected cores and, to the extent possible, assess environmental shifts. Rather than sample all or most of the cores in a block, foraminifera samples were selected mainly from a single "control" core. This control core was one which included the maximum number of strata identified within each tested locale. However, strata not represented in the control core also were sampled.

Twenty-two foraminifera samples from three control cores were submitted for analyses. These control cores were: Core 1-F in Sabine Pass 3, Core 4-C in Sabine Pass 9, and Core 2-B in Sabine Pass 18. Although other samples were taken, these three cores were considered sufficient to enable the necessary assessment of the majority of the various environments of deposition represented in the study area.

Once a sample location on a core was selected, the soil matrix containing the foraminifera sample was removed and placed in a sterile, plastic Whirl-Pak and then sealed. The samples were submitted to Dr. Barun K. Sen Gupta, Department of Geology, Louisiana State University for analysis. The results of the analysis are presented in Appendix A.

Pollen Analysis

The objective of the pollen analysis was to aid in the assessment of the environment of deposition of the various deposits identified in the cores. Thirty-three pollen samples from 14 cores, from all five blocks examined, were analyzed. The pollen was analyzed by Dr. Frederick M. Wiseman, Paleoenvironmental Laboratory, Massachusetts Institute of Technology. The results of the analysis are presented in Appendix B.

Pollen preservation, in general, was good. Poor preservation was noted in only a few samples, however, and these principally were deposits that were either periodically exposed to air or to moving water, resulting in oxidization or mechanical destruction of pollen grains.

As is discussed below, the interpretation of an environment as derived from the pollen data correlated closely with the interpretations derived from the foraminifera analysis, and content and sedimentary characteristics of the deposit. While this seems a reasonable outcome, the results of other pollen assessments of buried deposits in coastal Louisiana are commonly quite divergent from those obtained from other analyses (Frederick M. Wiseman, personal communication, 1985). Few studies of offshore pollen from late Pleistocene and early Holocene deposits have been undertaken in the Gulf of Mexico, such that comparisons cannot now be drawn. The pollen data presented here will serve as a base for future palynological studies.

Geochemical Analysis

The objective of the geochemical analysis was to aid in the final identification of an archaeological deposit primarily when other techniques indicated that a cultural association was possible. An associated purpose was, to the extent possible, develop chemical parameters as aids in delineating archaeological sediments in the marine environment. The geochemical study was conducted by Dr. Paul Templet, Templet Resources, Inc., Baton Rouge, and the results of his analysis are presented in Appendix C.

The use of chemical analyses of soils to help locate or spatially define archaeological sites is becoming increasingly more common. Analyses of phosphates, which have been shown to concentrate in soils (anthrosols) at human habitation sites, have received considerable attention (e.g. Arrhenius 1931; Buehrer 1950; Cornwall 1958; Eidt 1973; Mattingly and Williams 1962; and Woods 1975). Woods (1975, 1977) has proposed a technique for phosphate analysis by solubility fractionation that allows distinction between modern and prehistoric phosphate concentrations. Other chemical parameters which have been shown to have varying degrees of utility as discriminators of archaeological deposits include: organic carbon (Buehrer 1950); nitrogen (Eddy and Dregne 1964); pH (Parsons 1962); calcium (Buehrer 1950); potassium and magnesium (Buehrer 1950); potassium and magnesium (Buehrer 1950; Wise 1944; Kimber et al. 1966); iron (Limbrey 1975; Bowen 1966); copper and zinc (Bowen 1966; Sauchelli 1969). A brief review of the application of these chemicals in archaeology is contained in Woods (1982).

To date, archaeological applications of chemical analyses have been confined almost exclusively to terrestrial sites. It is obvious, however, that inundation of archaeological deposits on the OCS will have had an impact on the chemical content of the deposits. One investigation, the National Reservoir Inundation Study, funded by the National Park Service (Lenihan et al. 1981) has dealt with the effects of inundation on archaeological remains in reservoir settings. Even though it dealt with inundation by freshwater, some of the general results of that study are presumed applicable to the OCS, particularly in light of a lack of comparable data from submarine settings.

Lenihan et al. (1981:117) noted that the impacts to chemical properties of a site are selective in nature, unlike mechanical impacts such as wave wash, which are general. It is also apparent from the National Inundation study that several of the chemicals which have proven most useful in distinguishing areas of human activity at archaeological sites are those which are impacted and altered by the effects of inundation. The study noted that while phosphates were significantly reduced as a result of continuous inundation, intrasite patterning of phosphates may still exist (Lenihan et al. 1981:188). While the data were not definitive, it appeared that potassium and calcium concentrations were also reduced by inundation while magnesium and sodium were stable and continued to reflect pre-inundation levels (Lenihan et al. 1981:191). Organic content of sites may be reduced but the data were equivocal (Lenihan et al. 1981:190).

Overall these data suggest that many of the chemical constituents critical in the delineation of archaeological deposits will be altered by inundation. Primarily, they will be reduced as a result of leaching processes. These general effects of inundation, however, are influenced by a variety of factors such as chemical content of the water, depth of burial of a site by sediment before or after inundation, length of time of inundation, characteristics of the soil matrix of a site, etc. While the OCS situation can be not directly correlated with the settings examined in the National Inundation study, at a general level some of the effects on chemical constituents are going to be similar. Relying on this fact, coupled with our assessments of the history of the processes of inundation occurring in the study area, several assumptions about the probable impact on the chemical environment of archaeological sites which may have existed in the area have been developed. These assumptions are outlined below.

1. Site environments have changed over time, some from upland or bottomland hardwood settings to swamp, to marsh, to submerged. The potential for leaching occurs in all settings such that the more soluble and less tightly bound constituents have been substantially reduced.

2. While phosphates are undoubtedly concentrated at human habitation sites, the more soluble (available) forms have been leached by rainfall during the early history of the site and by fresh- and saltwater covering the sites as they were inundated. The tightly bound phosphate forms are less susceptible to leaching and may still be a pertinent indicator of human habitation.

3. A number of metals, including copper (Cu), magnesium (Mg), manganese (Mn), iron (Fe), calcium (Ca), potassium (K), and zinc (Zn) should be concentrated at human habitation sites because they are constituents of the food gathered by humans or are components of waste products. Many of the metals could be held by clays (ion exchange capacity) in the oxidized form in which they usually exist when air is present, thus remaining on-site even though rainfall tends to leach out ions.

4. As a site became covered by fresh- or saltwater, and, subsequently, by a layer of silt, the bacterial decomposition of the organic matter present would have

> quickly depleted the available oxygen, and the site would have become anaerobic. Under anaerobic conditions the metals present would have been converted from the oxide forms to the insoluble sulfide form by anaerobic bacterial action and should resist further leaching. Thus, the metals may serve as relatively stable and permanent markers of human habitation.

Eleven chemical constituents were selected for analysis. These were total organic carbon (TOC); total Kjeldahl nitrogen (TKN); total, or tightly bound, phosphates (TP); available (soluable) phosphates (APO4); zinc (Zn); iron (Fe); manganese (Mn); copper (cu); calcium (ca); and magnesium (mg). While nitrogen and phosphates are commonly used in archaeological analysis, zinc, copper, calcium, magnesium, iron, and manganese are less commonly examined. Calcium and magnesium have been shown to concentrate in archaeological deposits, both derived from organic debris, human waste, or wood ash (Woods 1982:1298-1299). Copper and zinc both can accumulate at archaeological sites and are, apparently, largely derived from human waste (Woods 1982:1399). Woods (1982:1399) does note that copper seems to be depleted rapidly over time while zinc is relatively stable. Zinc was shown to be a good discriminator of archaeological deposits in the earlier study of sedimentary characteristics of coastal sites by Gagliano et al. (1982). Iron and manganese, while possibly not pertinent as discrimination of human activity, are abundant in sea water and would, hopefully, be useful in standardizing the other chemical elements.

As noted, the geochemical analysis was intended primarily as a final assessment of samples which other parameters indicated may be cultural. Nine samples from three lease block areas (Sabine Pass 3, 6, and 9) were selected for analysis. These samples were air dried, ground and sieved through a 200 mesh screen. The sieved fraction was used in analysis. Most of the analytical chemistry procedures used follow those presented by Plumb (1981) and are briefly described below.

Metals

Heavy metals were determined by the methods described in Plumb (1981). Basically, 0.5 g of prepared soil was digested with a mixture of hot HNO_3, H_2SO_4 and perchloric acids. This was followed by appropriate dilution and analysis by atomic absorption spectroscopy. Results are reported as ppm dry weight.

Total Kjeldahl Nitrogen (TKN)

Total Kjeldahl nitrogen was also determined by the method described in Plumb (1981). The sample was heated in the presence of concentrated sulfuric acid and Kjeldahl catalyst until the solution was colorless or pale yellow. This was followed, in order, by dilution, distillation, Nesslerization and colorimetric analysis. Results are reported as weight percent Kjeldahl nitrogen.

Total Organic Carbon (TOC)

To remove carbonates, soil samples were acidified with 6NHCl for twelve hours, then filtered, water-washed and dried. A 250-mg sub-sample was analyzed using a radiofrequency furnace and reported as weight percent organic carbon.

Phosphates

As noted earlier, both available or leachable phosphates (APO4) and total or tightly bound phosphates (TP) were examined. For available phosphates a colored phosphomolydate was developed and the intensity of the color compared to standards to arrive at quantification (Plumb 1981). Total phosphates (TP) were extracted in an HCL solution following the procedures described by Woods (1977).

Interpretation of the results of the chemical analyses were complicated by several factors. Neither the expected chemical composition of the deposits examined nor the impact upon those constituents as a result of transgression and subsequent burial were known with precision. In addition, the assessment of samples as cultural on the basis of nonchemical characteristics was done at a level of probability, positive association was not possible. In light of these problems, it was decided to rank the nine samples selected for geochemical analysis on the basis of their likelihood of being cultural. This ranking relied on an assessment of the other characteristics of the sample such as location, age, and pollen, foraminifera, and particle content. The chemical parameters were compared against this priority ranking in order to determine which, if any, elements or combination of elements correlated with the ranking. These were then evaluated in light of the known chemical characteristics of archaeological deposits. All of the geochemical data are fully presented in Appendix C and are only summarized here. The chemical parameters that correlated most highly with the priority ranking were total phosphates (TP), Zn, Fe, Ca, Zn normalized by Fe (Zn/Fe), the sum of nutrients normalized by Fe (TKN +APO4 +K/Fe), and K normalized by Fe (K/Fe). However, at a high level of confidence only TP and Zn/Fe are acceptable. Total phosphates, as discussed earlier, has been found to be possibly the most useful chemical discriminator of archaeological sites (Woods 1975, 1977) and Zn/Fe was found to be useful in distinguishing site from nonsite samples in the earlier CEI study (Gagliano et al. 1982).

Radiocarbon Dates

Twenty samples were submitted to the Center for Applied Isotope Studies, University of Georgia, for radiocarbon dating. A half-life of 5568 years for radiocarbon was assumed in calculating sample ages, and the National Bureau of Standards Oxalic Acid, normalized to 1950 A.D., was used as the standard. No corrections were applied to any of the dates given in this study, since all of the dates are older than 7000 years B.P., the limit for which reliable corrective factors are available (Klein et al. 1982).

An effort was made to collect samples that would be most useful in: (1) dating an identified archaeological deposit; (2) dating a specific geologic feature or set of features; and (3) providing information on sea level change. The actual submission of a sample for dating in some cases, therefore, had to await a final interpretation of the cores and reconstruction of the geology. As a result, many samples were taken, but not submitted, since they were considered redundant or noncritical to interpretation.

Samples were collected from a variety of mediums including shell deposits, organic clays, peat and woody peats. Standard techniques were used in the collection and treatment of samples. Care was taken not to touch or handle the samples. Samples were taken using a clean knife or spatula, and then placed on a sheet of aluminium foil and dried under 200-watt lamps. Samples then were wrapped in aluminium foil prior to mailing. A list of radiocarbon dates providing information on location, sample medium, and elevation relative to present sea level is provided as Appendix D.

CHAPTER V: RESULTS

This section presents a synthesis of the results of the seismic survey, vibracoring and sample analyses relative to each of the selected high probability locales. Each of these locales is treated primarily as an independent unit and the discussion is directed at a final assessment of the potential for archaeological resources at that locale. At least one example seismic line and interpreted geologic cross section is presented for each locale. Descriptive terminology of sedimentary structures and their interpretation relative to environment of deposition are fully discussed by Botvinkina (1959), Bouma (1962), Coleman (1966), Coleman and Gagliano (1965), Coleman et al. (1964), McKee (1957), Van Straaten (1959), and others. The present study has drawn on this literature in the following discussion.

At the outset, it is noted that the results of our seismic surveys of the different areas were similar to the original lease block surveys in terms of the horizontal and vertical placement of identified subbottom features and surfaces. Our interpretation of the sedimentary structure, environment of deposition and age of these features often differs markedly, however, from that provided in the original lease block studies. The present interpretation, of course, has the advantage of having physical vibracore samples from most of the strata seen in the seismic records. Systematic ground truthing of shallow seismic records is rarely pursued in work conducted on the OCS, admittedly because of time and money constraints. Bore hole data are available largely in the form of foundation cores but also from other miscellaneous sources such as Nelson and Bray (1970). These data are rarely used, however, as an aid in interpreting seismic records from lease block surveys. This is, in part, because the core log information is scattered and difficult to access, but also because it is simply unknown. Inconsistencies and variability in interpretation of lease-block geology results largely from a common lack of placing the specific survey locale within the context of the established regional geology. Reference to the pertinent literature and use of bore-hole data where available would greatly enhance the precision and reliability of lease block interpretations.

Our interpretation of identified features and strata relies, finally, on the results of the suites of analyses to which samples from these features were subjected. While each of these analytical techniques (i.e. pollen analysis, foraminifera analysis, grain-size analysis, point-count analysis, geochemical analysis, and radiocarbon determination) may permit only a very specific assessment of a sample, together they bring to bear a composite of evidence which, it is hoped, will lead to accurate identification and interpretation, specifically relative to the ultimate concern of this study—whether the sample represents an archaeological deposit.

In the following discussions, considerable reliance is placed on the previous study of Coastal Environments, Inc. (Gagliano et al. 1982) which serves as a comparative base for interpretation of some of the analyses, in particular of the point-counts. Geological interpretations rely on our own, as well as previous work in the region. Fortunately, because of the extensive amount of published data available from the Northern Gulf of Mexico region and the offshore Sabine/High Island area, it is possible to develop rather precise interpretations of the geologic histories of the specific locales studied.

Sabine Pass 3

The seismic survey conducted in Sabine Pass 3 was directed at gathering data from the area of the presumed Sabine River valley escarpment edge. The sea level and environmental data provided by Nelson and Bray (1970), and discussed earlier, indicated that this location had been a Prairie/Beaumont escarpment adjacent to a river valley prior to 9400 B.P. Sea level rise produced an estuary or lagoon within the confines of the valley between 9400 B.P. and 8600 B.P. The valley reverted to a riverine swamp environment between 8600 B.P. and 6600 B.P. with a drop in sea level. With sea level rising again after 6600 B.P., the valley became an estuary, and by 6050 B.P. the escarpment in Sabine Pass 3 had been inundated.

As discussed earlier, escarpment-edge settings are considered high probability locales relative to prehistoric occupation. This is particularly true when the escarpment is adjacent to biologically rich estuarine or lagoonal systems, a situation which, according to Nelson and Bray's model, occurred twice at this locale (9400 to 8600 B.P. and 6600 to 6050 B.P.). Radiocarbon dates collected in this study, and as are discussed later, bring into question the drop in sea level between circa 8600 and 6600 B.P. proposed by Nelson and Bray, and suggest instead that over the period from 9400 B.P. until inundation at about 6000 B.P. sea level followed a continuous rise while the valley area experienced a similar continual change from a riverine to an estuarine environment. It was hypothesized that some areas along the valley wall slope would have been covered with estuarine sediments prior to transgression and would have been below the effects of wave-front erosion when this transgression occurred. Cultural deposits on this buried surface (i.e. the Prairie/Beaumont Terrace) would experience a reasonable chance of preservation.

The seismic data collected confirmed the escarpment setting of this location. Figure 5-1 presents a plan of the area surveyed. Contours are on the surface of the identified Prairie/Beaumont Terrace and are measurements of feet below seafloor to that surface. (The use of similar isopach maps measuring depth to a specified surface is a common practice for mapping subbottom geologic features and is followed throughout this study.) Also shown in this figure are the tracks of the survey vessel and the location of positioning control points ("shot points") along these tracks. The two lines of vibracores placed in this area are shown and the position of each vibracore is designated by a dot and labeled by letter. State plane grid coordinates (Louisiana South zone, Lambert, in feet) border the figure.

Major features identified are the Prairie/Beaumont Terrace and the Sabine Valley. Clear definition between these two features is shown in Figure 5-2a, which is a section of an east-west seismic line (Line Number 7) crossing near the center of the study locale. Figure 5-2b presents a legend for the vibracore interpretations. The locations of six vibracores placed along this seismic line are shown. The tops of the cores are at the seafloor. The flatness of the seafloor signature provides a measure of the seastate during the survey. The undulations shown here indicate seas of about 2 to 2.5 ft.

On the seismic record, the Prairie/Beaumont Terrace is easily identified in the eastern half of Figure 5-2a; its surface is at a depth of about 20 ft below the seafloor. The Prairie/Beaumont formation is characterized by a well-defined, dark surface reflector and a series of relatively closely spaced, horizontal (bedded) reflectors. Generally, the Pinger achieved penetration of these deposits of up to 40 milliseconds or about 100 ft. This signature was found to be characteristic of the Prairie/Beaumont formation identified elsewhere in the region. Commonly, throughout the study area, a distinctive reflector also was seen within the Prairie/Beaumont formation at depths of 50 to 75 ft below the sea floor. Channel features were commonly noted incised within this presumed former land surface. The age of this deep surface is unknown, though Berryhill et al. (1984:Sheet II) have referred to apparently the same surface as simply "Pre-Wisconsin". About 3,000 ft east of the area surveyed in Sabine Pass 3 the

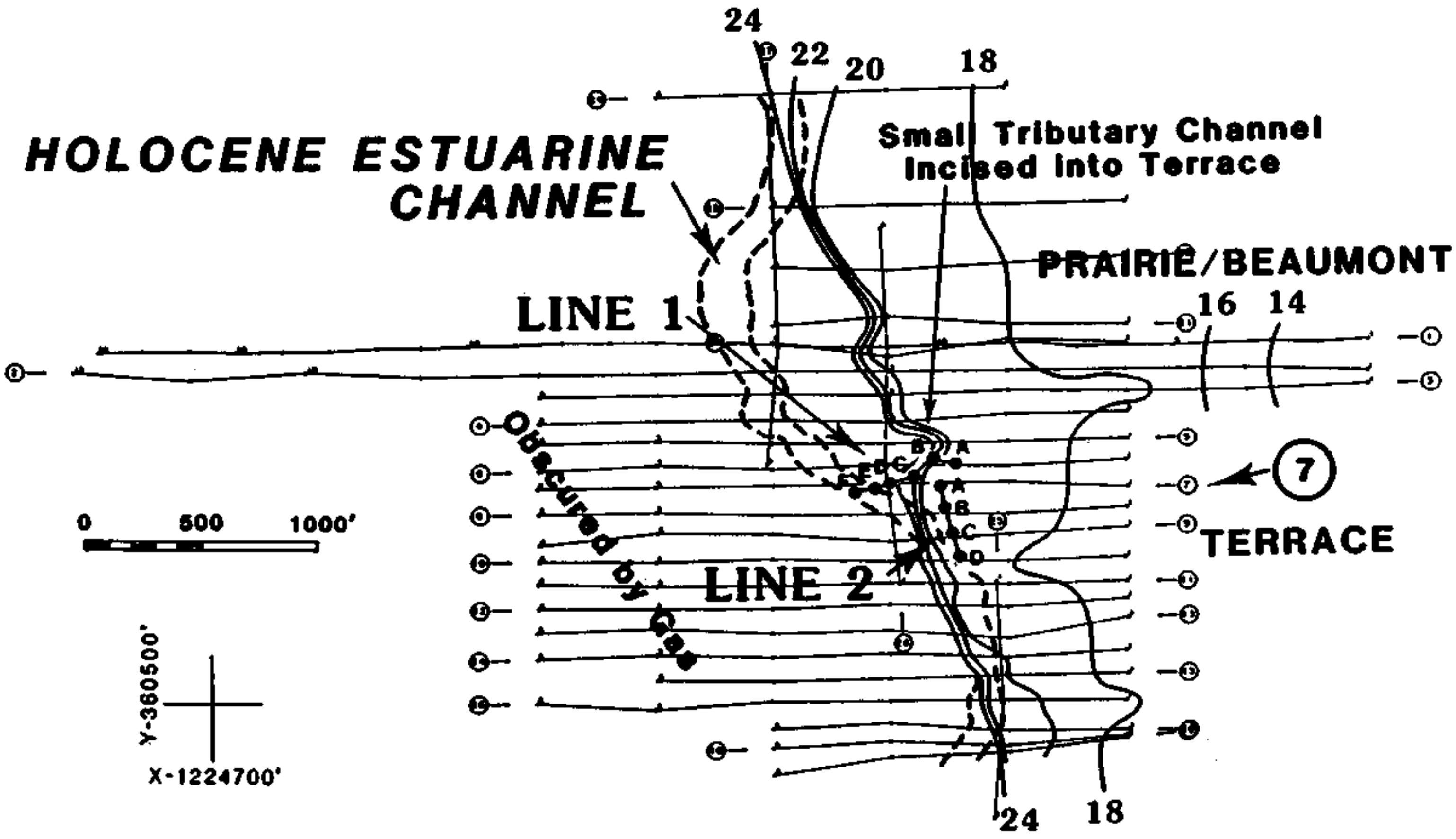


Figure 5-1. Plan view of the survey area in Sabine Pass 3 showing the locations of major geologic features. Note locations of Seismic Line 7 and Vibracore Lines 1 and 2.

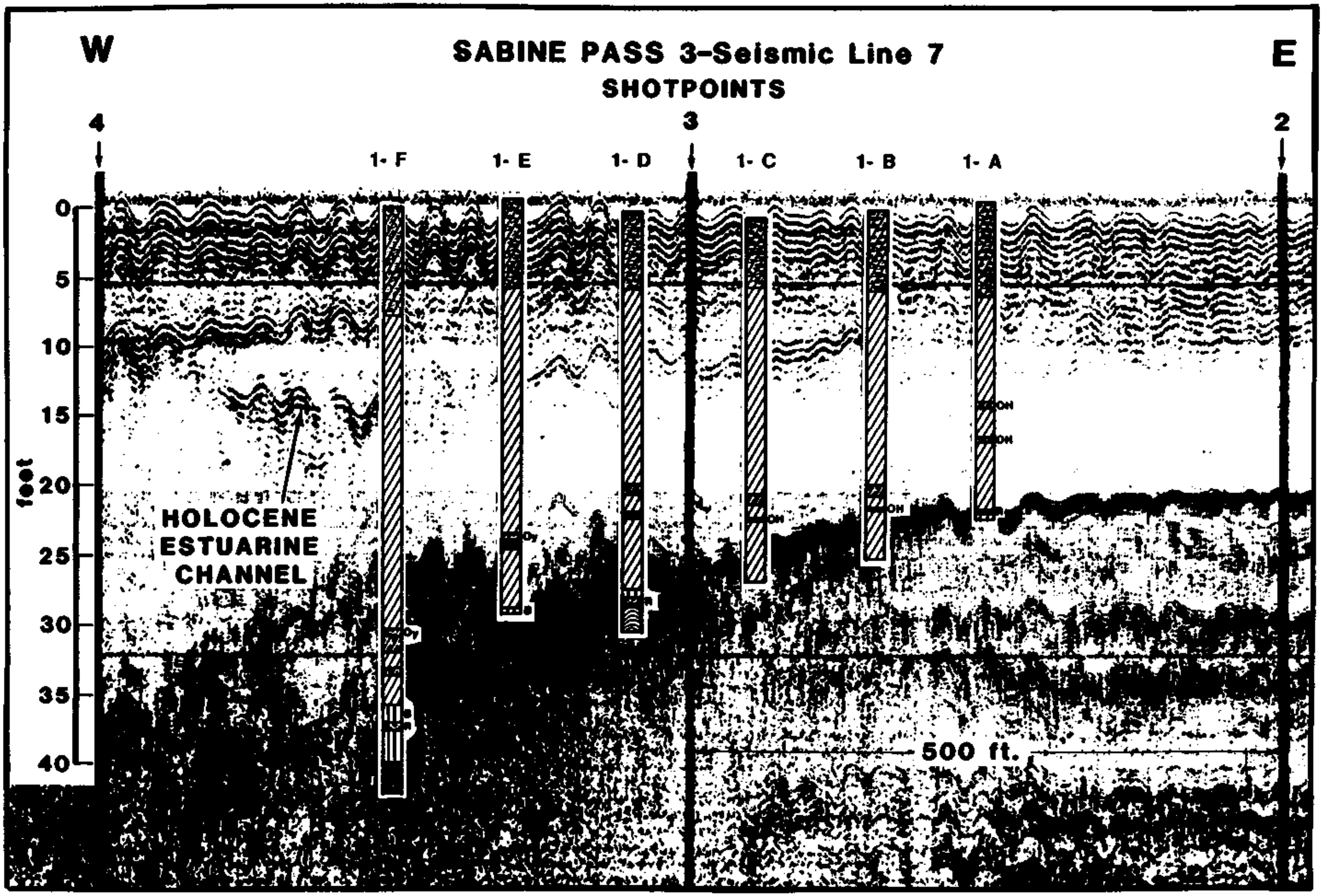


Figure 5–2a. Section of an east-west seismic line across the Sabine Pass 3 survey area. Data from vibracores have been superimposed over the seismic record.

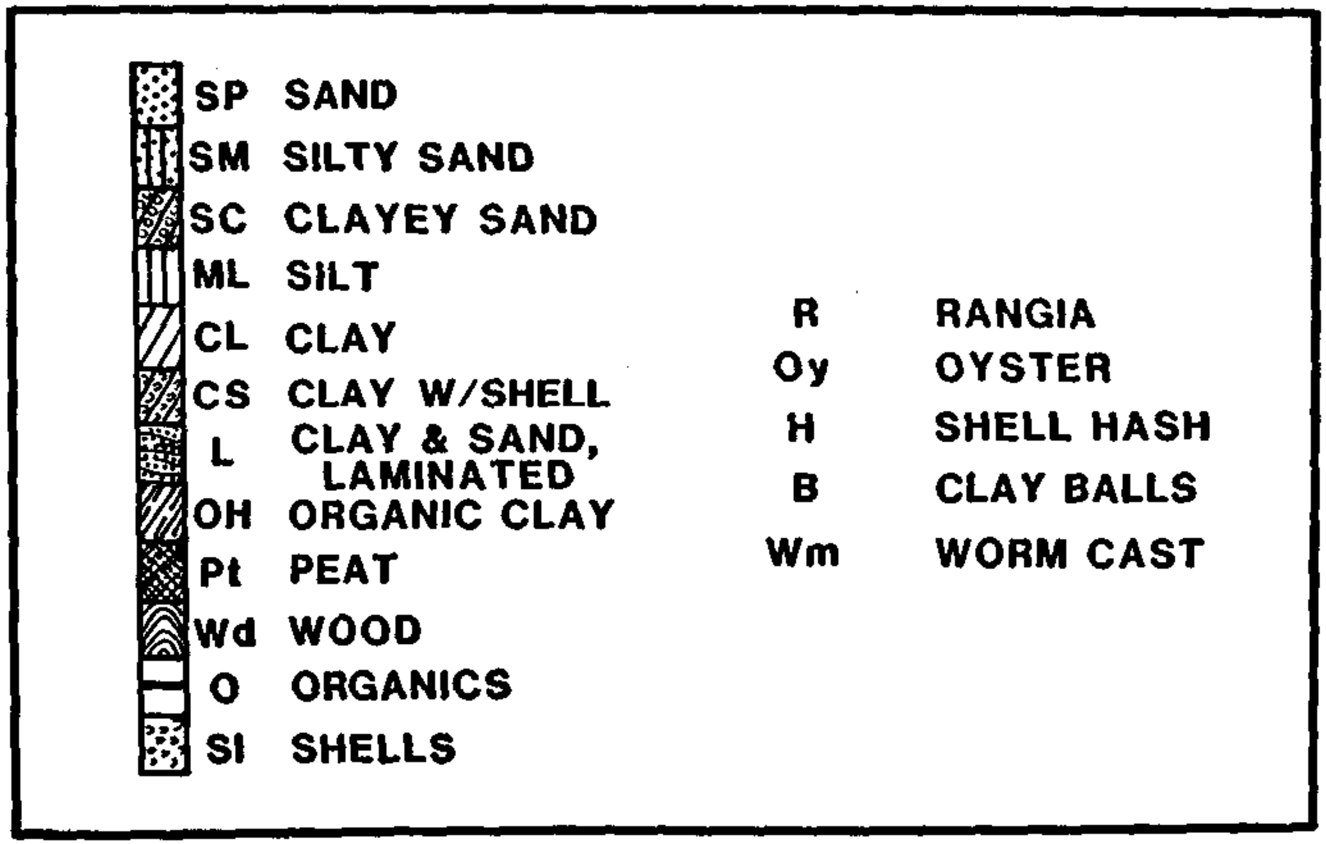


Figure 5-2b. Key to cores shown in Figure 5-2a. This key is applicable to all subsequent seismic line records.

Prairie/Beaumont surface slopes gently upward and rises to near the sea floor. The slope of the Prairie/Beaumont surface toward the Sabine River valley of about 0.7 ft in 100 ft is only slightly greater than the slope of the onshore Prairie/Beaumont surface into the present Sabine River valley. There it measured at about 0.5 ft in 100 ft.

At about the 20-ft contour line, near the location of Core 1-B in Figure 5-2a, the Prairie/Beaumont surface dips steeply toward the west, reflecting the fall off into the former Sabine River valley. The steepness of this slope is presumed to indicate a former channel location which has cut into the valley wall at this point. The former Sabine River floodplain, occupying the western half of Figure 5-2a, is obscured by gas, which attenuates the acoustic signal preventing detection of features within the deeper parts of the trench. The gas (methane) is biogenic in nature, derived from organic floodplain and estuarine deposits. As shown in the seismic record in Figure 5-2a, this biogenic gas appears as a dark "haze" or "adumbrate" reflective mass with an irregular surface. This "gas signature" was common throughout most of the valley area identified as being Holocene, or younger Deweyville, in age. In some areas the surface of the gas reflector was less irregular and generally flat. While it may be that the two distinct signals (i.e., the level gas surface and the irregular gas surface) are the result of different underlying geologic features, no pattern was noted in the occurrence of the two types of reflectors which permitted an assessment of the underlying structure. Cores will be required for this identification.

Whelan et al. (1975) have shown that relatively small methane concentrations of only 3 ml per liter in sediments are sufficient to absorb or scatter the acoustical signal from a 3.5 kHz profiler. While upward migration and accumulation of gas does occur, the vibracores collected in this study demonstrate a close correlation between heavily or totally organic strata (e.g., peaty muck, with circa 50% organic content, to peat), and identified gas "fronts" on the seismic records. Much of what is identified as biogenic gas on seismic records is, in fact, an actual organic deposit. This supports the observation of Roemer and Bryant (1977:57) that "gas has been used too often in describing many naturally occurring phenomena that represent stratigraphic deposits".

An additional feature identified on the seismic records is an apparent channel located in deposits above the Prairie/Beaumont Terrace (Figure 5-2a). This channel originates at 7 to 9 ft below the sea floor and its base appears to be between 15 and 20 ft below the sea floor (Figure 5-2). Dark and/or hazy reflectors in the bottom of the identified channel suggest sedimentary differences or organics. This channel could be followed on the records running roughly north-south through the entire area surveyed, essentially parallelling the terrace escarpment (Figure 5-1). Whether or not the escarpment controls the position of this stream is unknown. The location of the channel within the column of sediment above the Prairie/Beaumont surface initially suggested it was a Holocene estuarine feature. Radiocarbon determinations from this area (discussed below) indicate a post-7000 year B.P. date for the channel feature.

The seismic record of the sediments above the Prairie/Beaumont Terrace in Sabine Pass 3 was similar to that found throughout the study area. As shown in Figure 5-2a, the upper 10 ft or so of sediments produce a series of thin, generally parallel, distinctive reflectors. Below 10 ft to either the top of the Prairie/Beaumont Terrace or to the Sabine Valley gas front, few distinctive strata are evident. In the Sabine Pass 3 area a set of reflectors at about 8 to 10 ft below the sea floor can be seen sloping gently to the west into the former Sabine valley (Figure 5-2a). Throughout the study area it was noted that these upper deposits thickened, particularly over the main Sabine River valley, but also over smaller tributary channels. Presumably this indicates subsidence and compaction of the organics within stream valleys, the results of which are reflected well up into the sediment column.

Ten vibracores were placed in the Sabine Pass 3 area. Line 1, consisting of six cores, was placed along an east-west line which provided coverage of the slope of the Prairie/Beaumont Terrace out into the Sabine Valley. This line was also positioned to place cores into the identified estuarine channel (Figure 5-1). This line of cores is shown on the seismic record in Figure 5-2a. The second line of cores (Line 2) was placed on the upper slope of the Prairie/Beaumont Terrace parallel to the escarpment (Figure 5-1). Precise coordinates for all vibracores are provided in Appendix E.

All of the cores placed on the Prairie/Beaumont Terrace impacted that feature within 1 or 2 ft of the expected depth obtained from the seismic records. This close correlation between the cores and the seismic records was consistent throughout all of the areas examined. This argues not only for the accuracy of the interpretation of the seismic records, but also for the precision of the positioning system used. As can be seen in Figure 5-2a, the vibracores achieved little penetration of the compact clays of the Prairie/Beaumont Terrace. Here and elsewhere penetration was greatest within the fill of the Sabine River valley or smaller tributary streams. The two deepest cores on Line 1 (Cores 1-D and 1-F) both encountered dense organics (peat or wood) which represent pretransgressive, freshwater backswamp or channel fill deposits.

A geological interpretation of the Sabine Pass 3 area from the combined seismic and vibracore data is presented as Figure 5-3. The locations of cores are shown, as are radiocarbon determinations and specific analysis samples selected for discussion. Other samples were selected and analyzed but are not considered critical to the interpretation, and, therefore, are excluded from the following discussion. Core 1-F was selected as a control core and extensively sampled. This core is shown in Figure 5-4. Included in the figure are sample locations and geologic interpretation.

The basal feature, the Prairie/Beaumont formation, was encountered in two of the cores shown (Cores 1-A and 1-C; Figure 5-3). This Pleistocene feature is characterized by a stiff, compact, oxidized, and mottled gray (10YR 5/1) to olive gray (2.5Y 4/4) clay which stopped core penetration. Other cores into the Prairie/Beaumont in this area indicated the presence of small, rounded clay nodules or "clay balls", animal burrows and small "calcareous" (iron/manganese) nodules (Figure 5-5). Pocket penetrometer readings on the identified Prairie/Beaumont deposits yielded unconfined compressive strengths at or above 2.5 tons/ft^2.

West of, and partially overlying, the Prairie/Beaumont formation are organically rich sediments which represent freshwater backswamp or channel fill deposits (Figure 5-3). Organic content of these deposits ranged from over 80% to about 50% and can be classified as peaty muck to peat (Kearns and Davison 1983). These swamp deposits contain numerous stems, roots, seeds and wood fragments (Figure 5-6). A large piece of cypress (Taxodium sp.) wood was found in the bottom of Core 1-D1.

Analyses of matrix samples from the basal organic deposit were void of foraminifera, indicating a freshwater environment (see Appendix A). Several pollen samples from the Sabine Pass 3 area were analyzed in an effort to assess local environmental settings. A pollen record presents a distorted picture of the actual vegetation composition of any site or area. Pollen productivity, dispersal, deposition and post depositional distribution all affect the pollen record. Ideally, interpretation of the pollen spectra should be based on comparison with modern pollen analog samples from coastal vegetation zones. The modern analogs incorporate the factors of differential

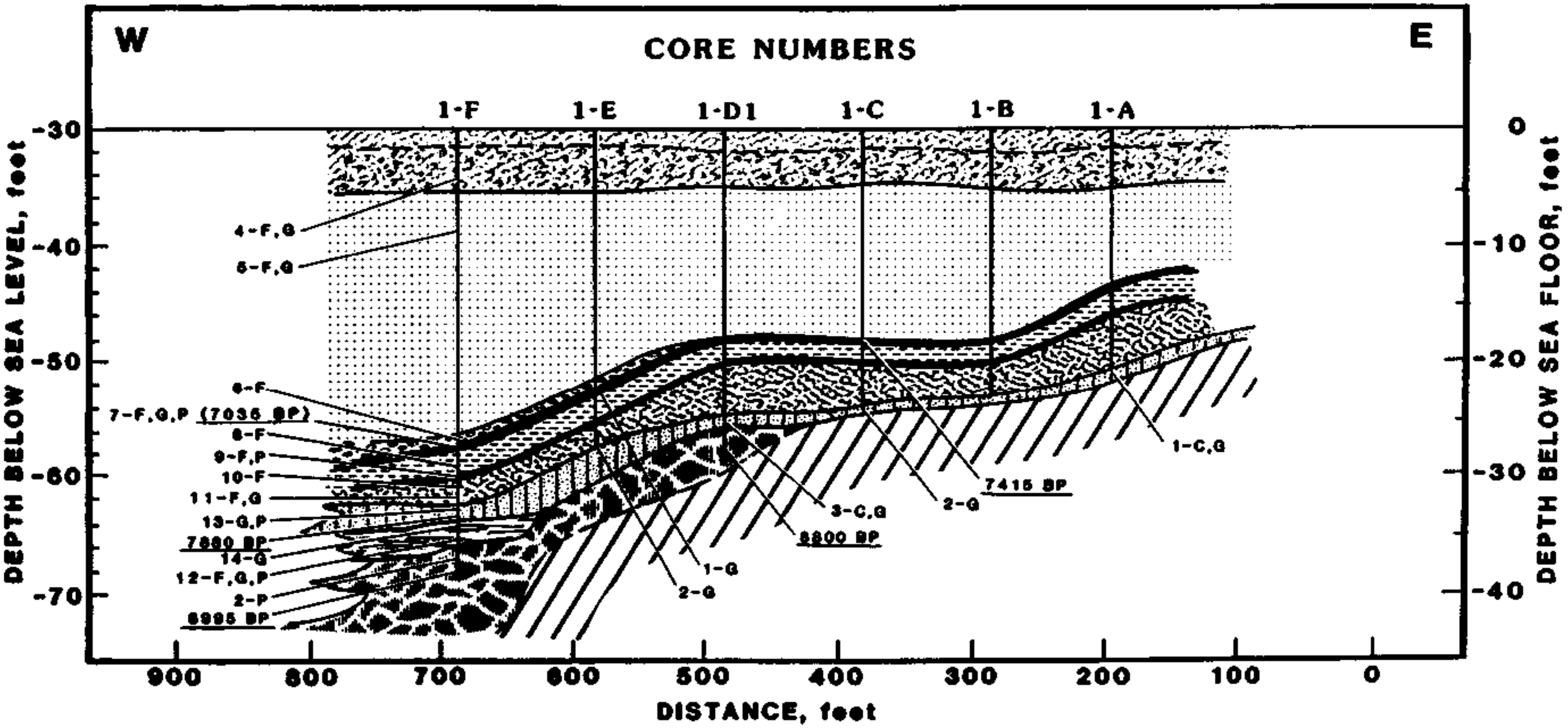


Figure 5–3a. Geological interpretation of Sabine Pass 3, based on Core Line 1. Key shown in Figure 5–3b.

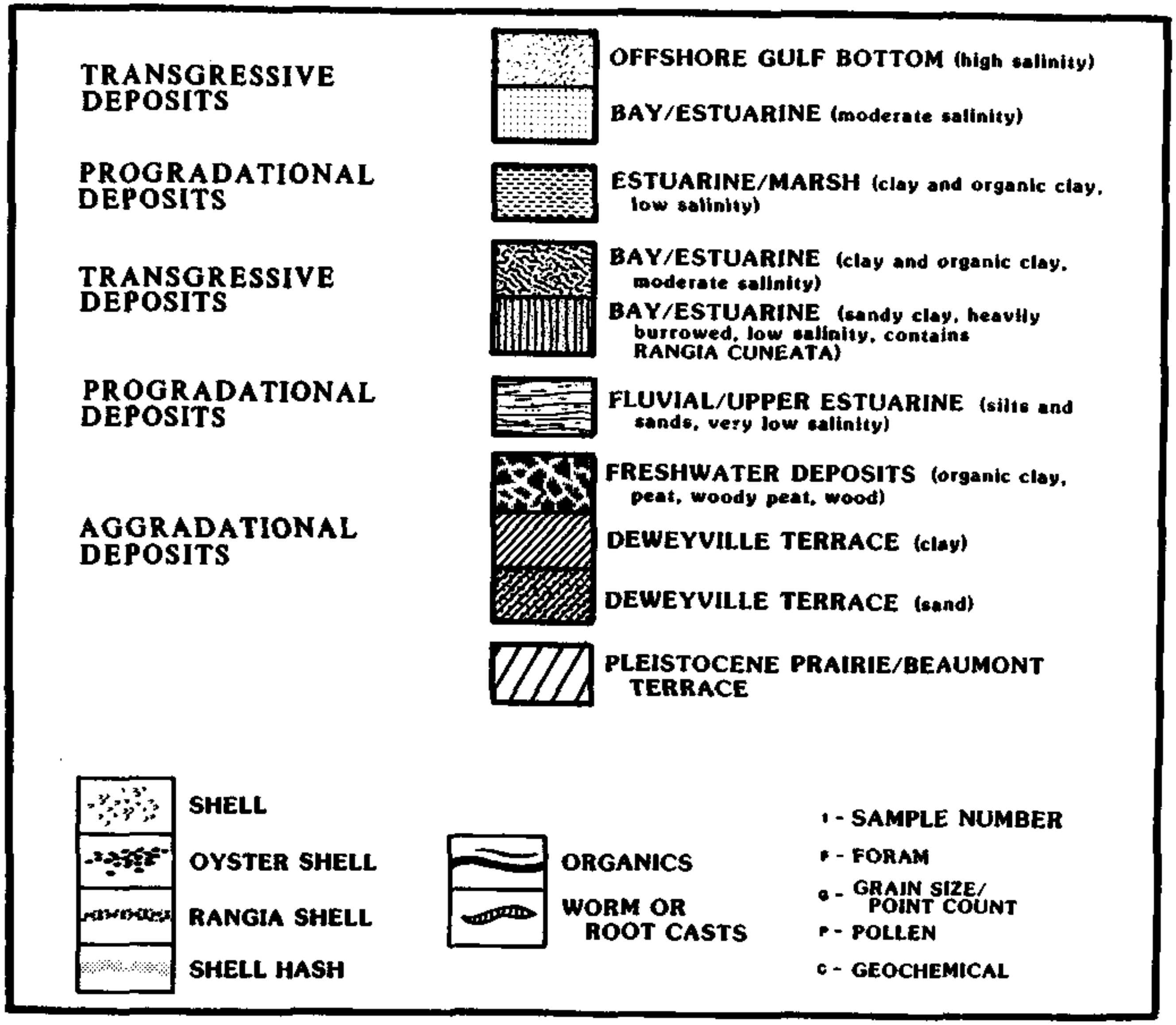


Figure 5-3b. Key to geological interpretation shown in Figure 5-3a. This key is applicable to subsequent geological cross sections.

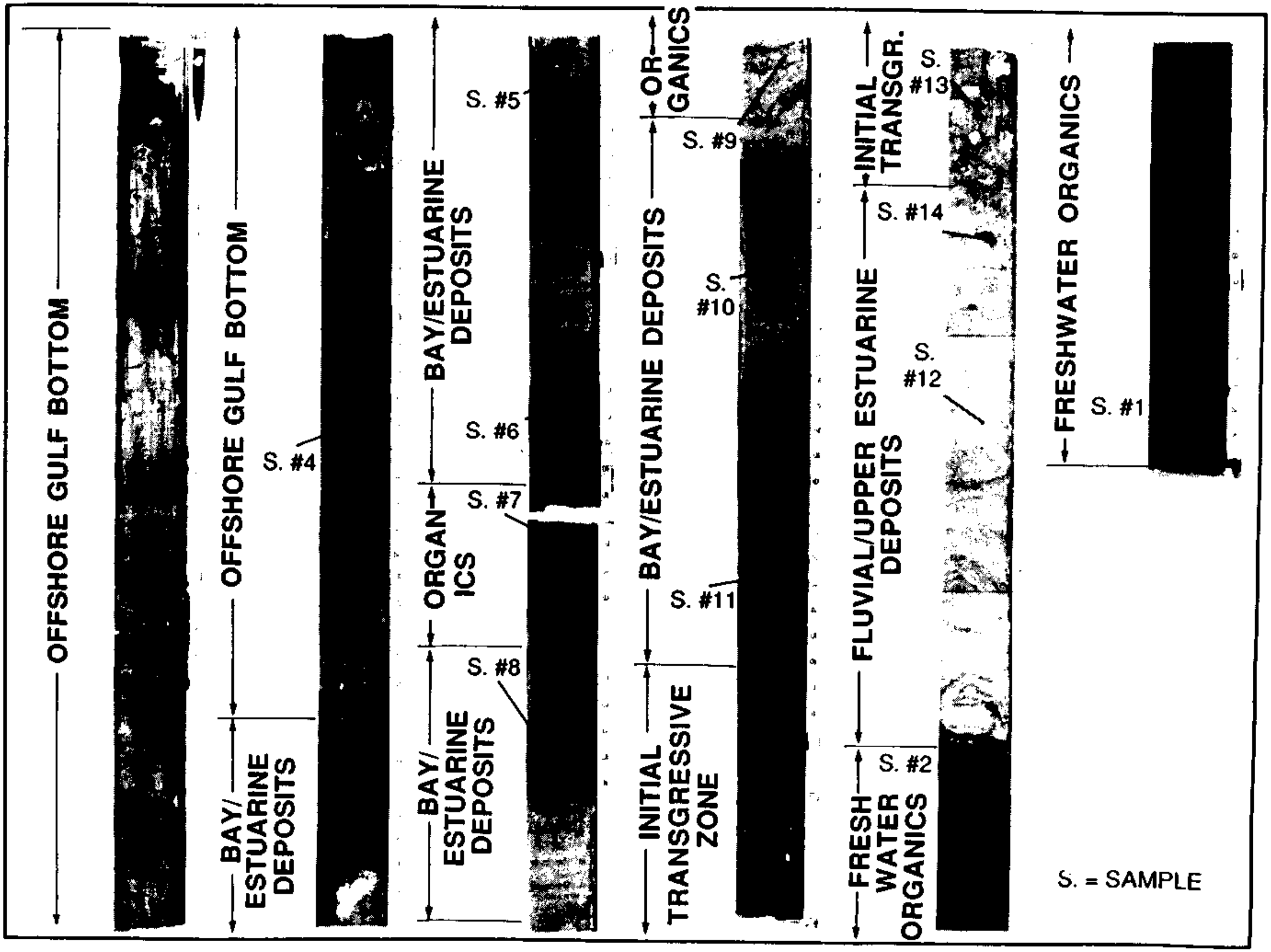


Figure 5-4. Core 1-F, Sabine Pass 3 area. Selected sample locations are shown.

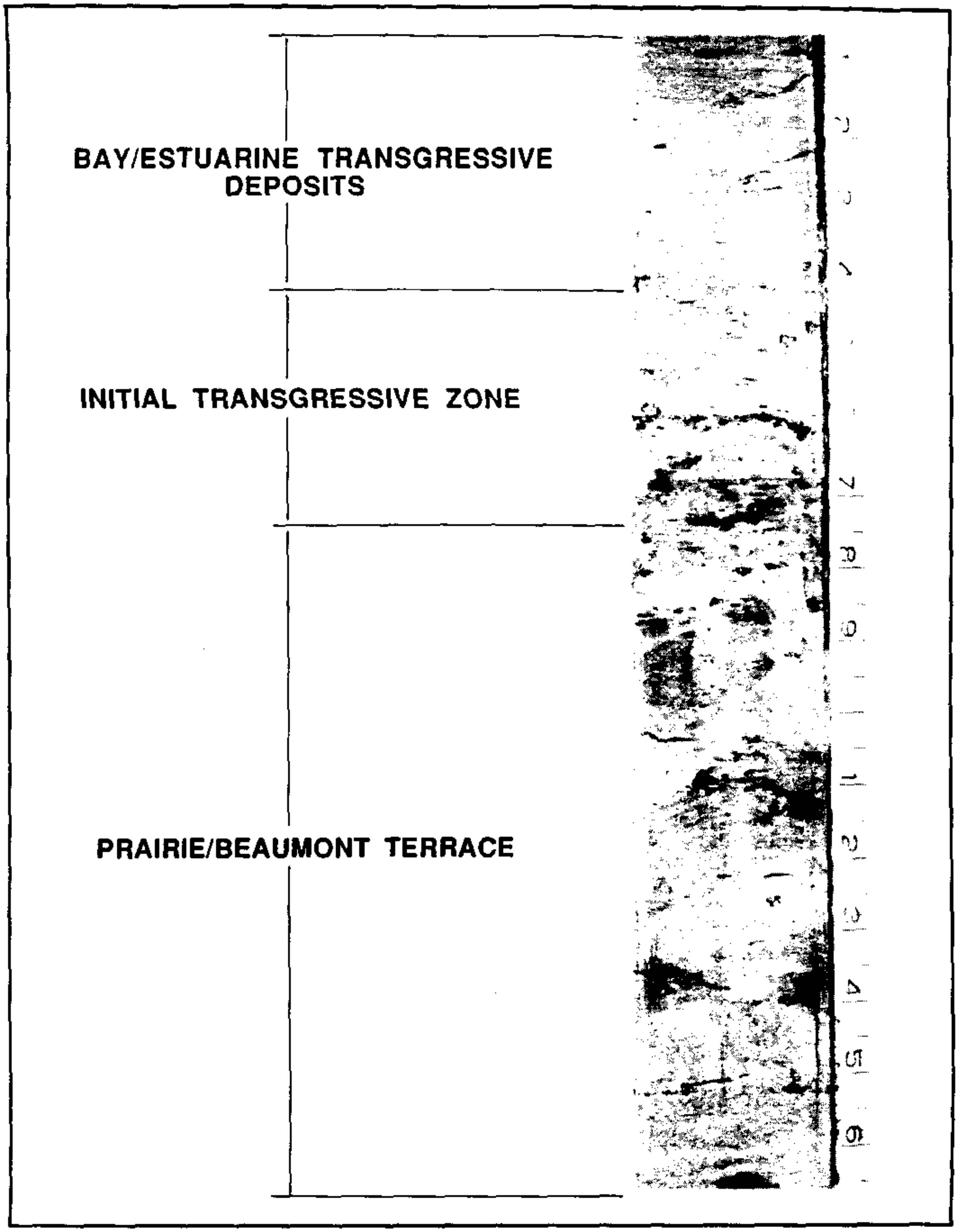


Figure 5-5. Surface of the Prairie/Beaumont Terrace and overlying bay/estuarine clays in Core 2-A, Sabine Pass 3. The initial transgressive zone is only faintly represented here.

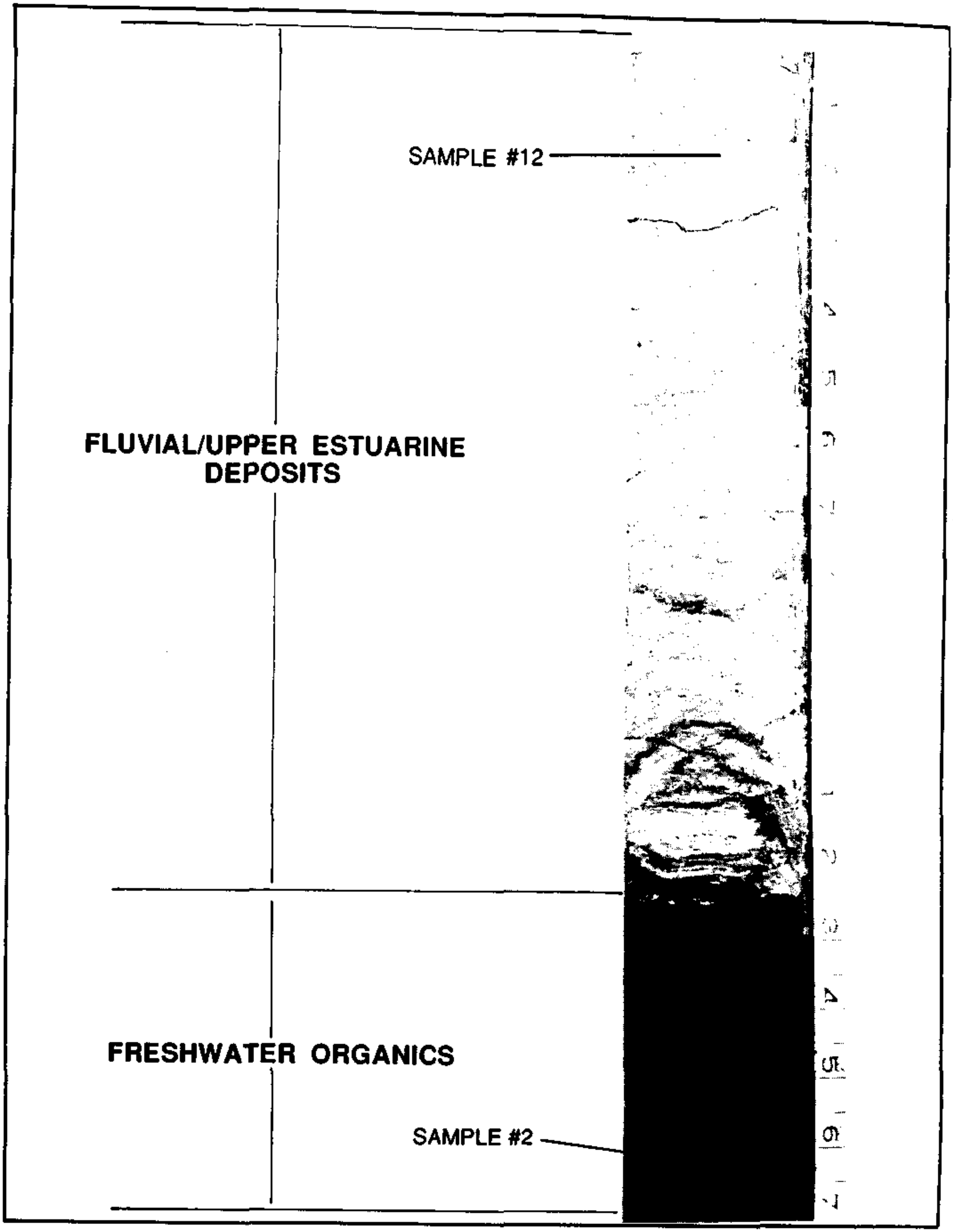


Figure 5-7. Fluvial/upper estuarine deposits at contact with freshwater organics, Core 1-F, Sabine Pass 3.

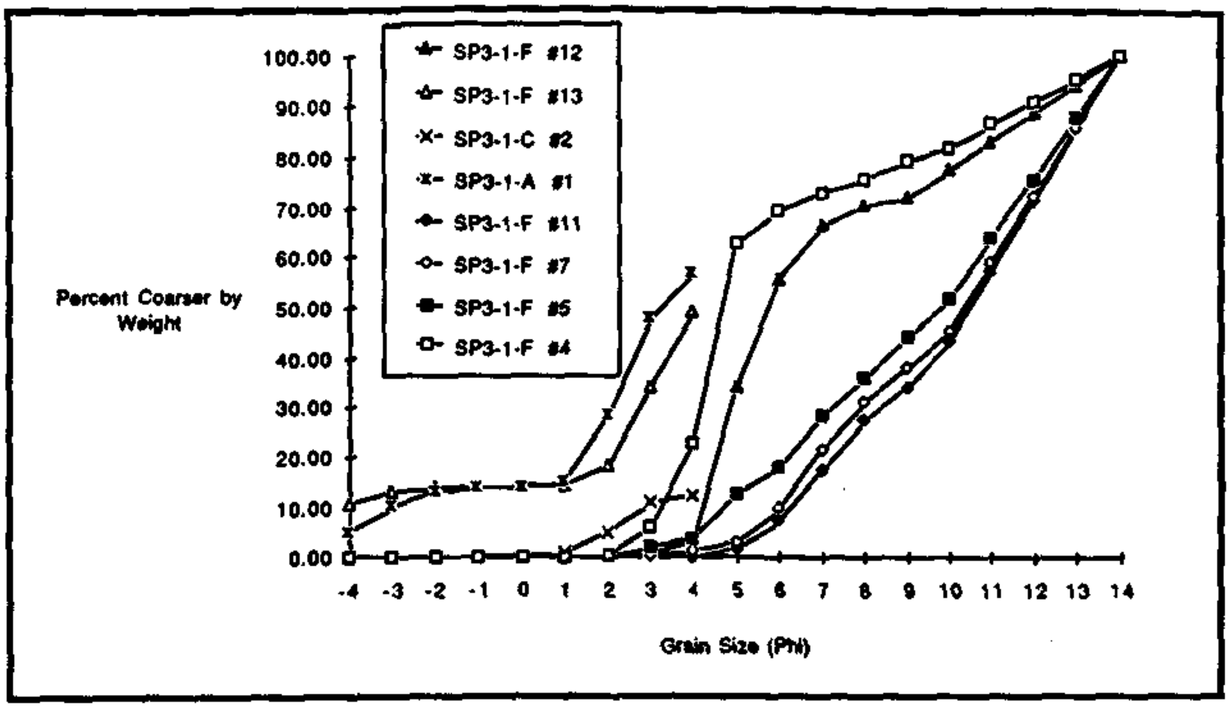


Figure 5-8. Grain-size distributions from the Sabine Pass 3 area.

particles. The curve indicates that the sediments are relatively well sorted. Point counts of two size fractions from this stratum (-1 phi and 0 phi) indicate that constituents are primarily "clastic concretions" which are clumps of cemented clastic particles. Also found are small quantities of unidentified shell particles and carbonized vegetable material.

This type of sedimentary structure is current produced, results from variations in water flow, and is typical of the type of deposition found in a delta front setting, specifically near the mouth of a distributary channel (Coleman and Gagliano 1965:188-190). At the mouth of such a channel, the current is released from the confines of its banks, the channel flares out and the flow is distributed. In response, the current diminishes and the rate of deposition increases. During low water, or in areas of slack water, clays are deposited. These actions, plus differential erosion across the sediment caused by rapidly moving water, can produce the structure seen here. Specific sedimentary microenvironments of the distributary mouth area include the subaqueous levee, the channel and the distributary mouth bar. These environments can, and often do, represent a sequence of events occurring at a single location; however, precisely what point in this sequence is represented by the stratum in Sabine Pass 3 is difficult to determine.

A sample (Core 1-F#12, Figure 5-3) from this fluvial/upper estuarine stratum was analyzed for both pollen and foraminifera. Foraminifera were found, with the assemblage dominated by *Ammotium salsum*, a species indicative of a shallow water, low salinity environment (see Appendix A). Little pollen was recovered from this stratum, as *Pinus* and *Nyssa* were the only types identified. The rarity of pollen is presumed to be due to rapid oxidization and mechanical weathering, characteristics of rather high-energy depositional environments (see Appendix B). The foraminifera and the pollen data together support the interpretation of an active, delta front, river mouth/environment for this unit. Lithologically similar deposits were noted elsewhere in the study area. In every case these fluvial/upper estuarine deposits immediately overlie interpreted freshwater organic deposits, or occur within the confines of identified pre-transgression channels.

Blanketing the fluvial/upper estuarine deposits, the organic freshwater deposits, and the Prairie/Beaumont Terrace is a stratum characterized primarily by its disturbed nature (Figure 5-9). This stratum, identified as a bay/estuarine transgressive deposit in Figure 5-3, consists of clay and sand, is typically mottled in appearance, and contains numerous burrows of bottom-dwelling marine organisms. The burrows are often sand-filled. Colors range from light grayish brown (10YR 6/2) to dark gray (2.5Y 4/10), and evidence of oxidation can be seen. Elsewhere in the project area organic clay and organics occur interbedded locally as thin lenses in this unit; however, none were noted in the Sabine Pass 3 area. *Rangia cuneata* shells are moderately abundant in this facies, and, in fact, throughout the study area the occurrence of *Rangia* was largely confined to this deposit. The *Rangia* shell in the deposit are commonly whole or nearly so and, while often quite chalky in texture, demonstrate only moderate to minimal wear, suggesting a low-energy environment. Presumably, the shells are at or near their original location of growth or deposition.

Other shell species identified in point counts from this deposit included barnacle (*Balanus* sp.), oyster (*Crassostrea virginica*) and, less commonly, *Mulinia* sp. This faunal assemblage is characteristic of environments ranging from river-influenced, low-salinity (less than 10%) settings to slightly higher salinity, delta front distributary and interdistributary situations (Parker 1960:309-310). Optimum salinities for *Rangia* growth and reproduction are between about 5 ppt and 11 ppt, though the genus can survive a wider salinity range. In particular, *Rangia* are likely to be associated with the upper and middle portions of bays and lagoons. The foraminifera assemblage in this stratum is dominated by *Ammotium salsum* and *Ammonia parkinsoniana*, types indicative of a low salinity, shallow water, estuarine environment (Appendix A). Pollen were absent from this facies, suggesting extensive mechanical weathering and possibly rapid oxidation due to alternating periods of inundation and desiccation, processes which can remove pollen (Appendix B). Point counts from two samples in this stratum (Core SP3-1-C#2 and Core SP3-1-D1#3, Figure 5-3) contained sawgrass (*Cladium jamaicense*) seeds (Table 5-1). Coleman (1966:47) has noted that, at least within marsh deposits, the seed assemblage is a useful criterion for distinguishing between the major marsh subtypes; saline, brackish and fresh. While this transgressive stratum is not a marsh deposit, per se, the seed content is certainly an indicator of the surrounding vegetation. *Cladium jamaicense* is a sedge which grows in fresh to slightly brackish (intermediate) marsh and commonly is the dominant species covering vast areas (Chabreck and Condrey 1979:26).

Grain-size curves for several samples from this transgressive deposit are shown in Figure 5-8. The samples from the transgressive zone include SP3-1-F#13, SP3-1-C#2 and SP3-1-A#1. Only the coarse fraction from these samples was analyzed in this location, though complete grain-size curves for the transgressive zone were obtained from other locales. Two of the curves (Samples SP3-1-F#13 and SP3-1-A#1) indicate that larger-than-silt-size particles (greater than 4 phi) comprise about one half of the sample. The large particles in these samples are sand and shell, the latter consisting of fragments as well as whole valves. As expected, the identified shell is primarily *Rangia cuneata*. The other sample from this facies, SP3-1-C#2, is composed primarily of silts and clays and contains only a small percentage of sand-sized particles. The differences in these samples reflect the variability and disturbed nature of the transgressive deposit as a whole.

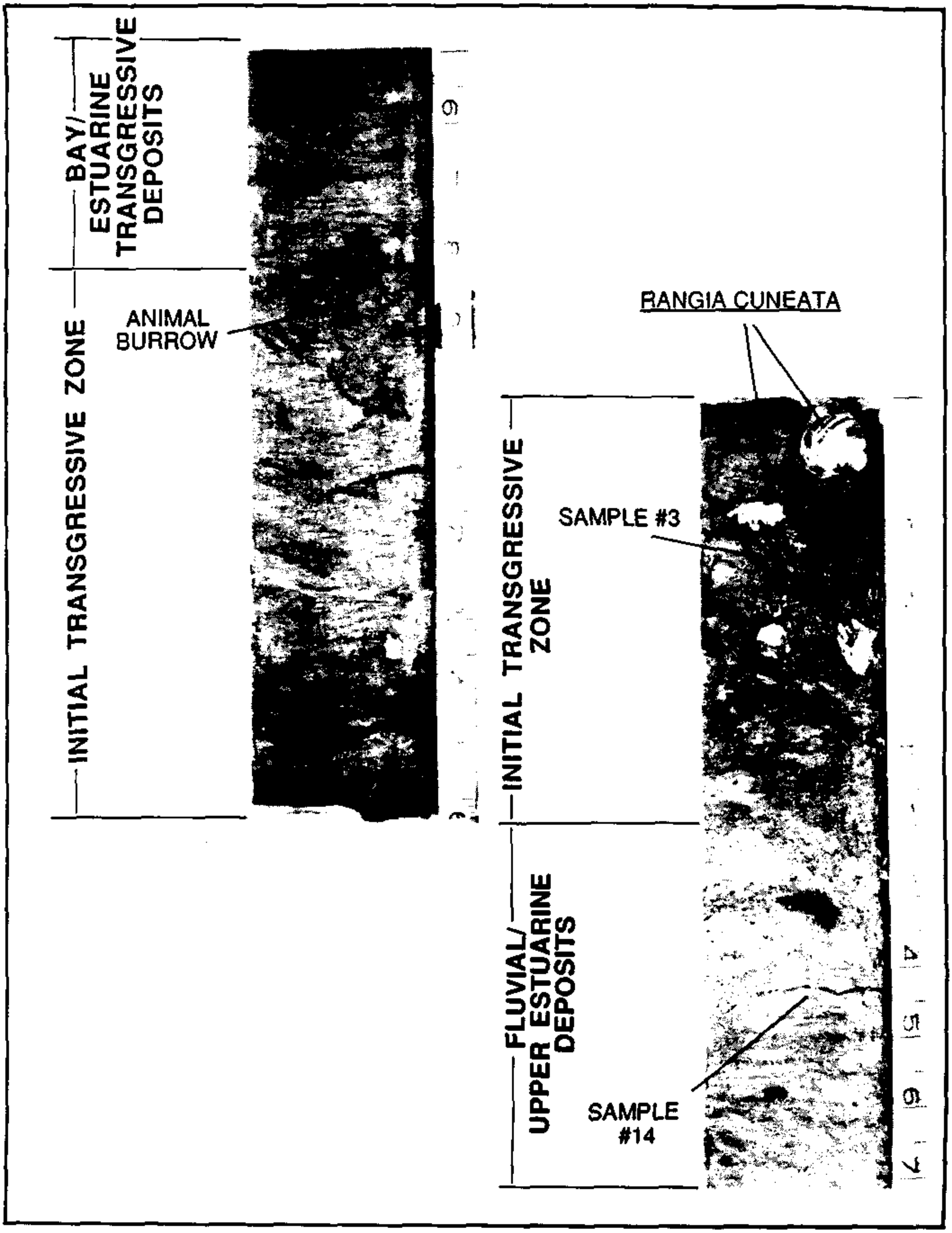


Figure 5-9. Initial bay/estuarine trangressive zone in Core 1-F, Sabine Pass 3.

Table 5-1. Seeds Identified in Core Samples.

Core and Sample Number	Seeds		Comments
SP3-1-C #2	8	Cladium jamaicense (Sawgrass)	Found in fresh to slightly brackish marsh.
SP3-1-D1 #3	1	Cladium jamaicense	Found in fresh to slightly brackish marsh.
SP6-2-B #1	1	Potamogeton sp. (Pondweed)	Found primarily in fresh water environments.
SP6-2-B #2	1	Scirpus sp.	Dependent upon species, Scirpus can be found in fresh, brackish or saline marshes.
	1	Unidentified seed	
SP6-2-C #1	2	Scirpus validus	Found in fresh to brackish marshes.
	13	Scirpus olneyi	
SP6-2-C #2	1	Scirpus validus (Softstem Bulrush)	This assemblage of primarily Scirpus seeds suggests a brackish to strongly brackish marsh.
	1	Scirpus robustus (Saltmarsh Bulrush)	
	54	Scirpus olneyi (Three-cornered grass)	
	1	Cladium jamaicense	
	2	Scirpus sp.	
SP6-4-C #4	1	Rhynchospora corniculata (Beakrush)	Seeds from this sample include upland, marsh fringe and fresh to brackish marsh types. The setting suggested is an elevated landform adjacent to a fresh to slightly brackish marsh or a sequence including those settings.
	13	Carex sp. (Sedge)	
	10	Polygonum hydropiperoides (Smartweed)	
	6	Unidentified (possibly Polygonum halves)	
	4	Unidentified (possibly Carex sp.)	
	12	Scirpus olneyi	
	20	Cladium jamaicense	
	3	Unidentified	
	2	Rubus sp. (Blackberry, raspberry, etc.)	
	1	Sambucus sp. (Elderberry)	
SP9-2-A #1	31	Lagerstroemia indica (Crepe myrtle)	Contaminated sample.

Table 5-1. Concluded.

SP9-2-A #1	12	*Scirpus olneyi*	Found in fresh to brackish marshes.
SP9-2-A #2	10 1	*Scirpus olneyi* Unidentified	Found in fresh to brackish marshes.
SP9-2-F #1	2 4	*Scirpus validus* *Scirpus olneyi*	Found in fresh to brackish marshes.
SP9-2-I #1	3 3 1	*Scirpus validus* *Scirpus olneyi* *Scirpus* sp.	Found in fresh to brackish marshes.
SP18-1-C #1	1	*Scirpus olneyi*	Found in fresh to brackish marshes.
HI49-2-B #4	1	*Scirpus olneyi*	Found in fresh to brackish marshes.
HI49-3-E #1	7	*Scirpus olneyi*	Found in fresh to brackish marshes.

This deposit is interpreted as an initial transgressive facies equivalent to the "basal transgression deposits" mapped in the Chenier plain and offshore area of Louisiana just east of the Sabine River study area (Byrne et al. 1959:248). This deposit seems to represent the leading edge of the transgressive front which crossed the area as sea level rose. The common occurrence of *Rangia* suggests areas of open, brackish water, plus an adequate substrate and rates of sedimentation sufficiently low to permit their growth. The minimal wear seen on the *Rangia* shell further suggests a low energy environment. The environment envisioned for this facies is one of shallow lakes, lagoons, and/or restricted embayments interspersed with areas of brackish to almost fresh marsh. As a whole, the unit is characterized as a bay/estuarine environment (Figure 5-3). While the disturbed nature of this deposit is partially related to animal burrowing, some of it was the result of localized shoreline erosion produced by lake, lagoon or bay expansion.

This initial transgression facies was found in all five of the areas cored. Normally it was continuous along a line of cores, but in a few cases it was localized. This zone is of critical importance in this study since it marks the boundary above which archaeological deposits are considered unlikely to occur. With few exceptions, we anticipate that archaeological deposits are to be found either in or below this unit.

A radiocarbon date of 7880 ± 90 B.P. (UGa-5426) was obtained from *Rangia* shell in this unit in Core 1-F (Figure 5-3). Other radiocarbon dates from the study area farther down the valley suggest an age range for the unit's formation about 8400 to 7800 B.P. The thin vertical and wide horizontal distribution of the deposit, coupled with the available dates, seem to suggest formation over a period of rapid sea level rise.

Immediately above the initial transgression deposit is a facies of very fine textured, massive clays containing very small amounts of silt and sand. A grain-size curve from this deposit is shown for Sample SP3-1-F#11 in Figure 5-8. Thin, parallel color laminations and very thin (less than 0.5 cm) sand laminations occur; however, the deposit is essentially homogeneous. The basic color of the matrix is dark gray (7.5YR 4/0). Organic pieces and flecks as well as thin laminae of organics occur. Shells are rare while the foraminifera assemblage taken from Samples 10 and 11 in Core 1-F (Figure 5-3) reveals a dominance of *Elphidium excavatum* and an abundance of *Ammonia parkinsoniana* (form *tepida*). This suggests moderate salinities (an increase over that from the lower deposits) and possibly indicates a deeper and more restricted subaqueous environment (Appendix A).

This facies is identified as bay/estuarine in Figure 5-3, and is interpreted as transgressive bay or estuarine fill, deposited as sea level was rising and filling the valley. The thickness of the deposit, its homogeneity, and the lack of burrowing and lack of shell all suggest relatively rapid sedimentation and possibly a rapid rate of sea level rise. This deposit generally equates with the Gulf-bottom silty clay identified off southwestern Louisiana by Byrne et al. (1959:248-253).

A thin, organic clay lens rests above this bay/estuarine clay, and represents an organic detrital lag or possibly a saline marsh development (Figure 5-10). Abundant organic flecks, stem, root and root fibers occur, and some animal burrowing is evident. Pollen types in this deposit are dominated by grasses (*Gramineae*). Upland species are present (e.g. *Pinus*, *Liquidambar*, *Quercus*, *Cheno/Am*, etc.), obviously having been transported into the deposit from elsewhere (Appendix B). *Elphidium* sp. is the dominant foraminifera genus in this unit. *E. delicatulum* and *E. excavatum* are the most common species, indicating moderate salinities and a possible shallowing of the water, events which would be expected in a marsh environment.

Another homogenous, gray (7.5YR 4/0) clay unit rests above this organic zone. Its structure and lithology are similar to that underlying the organics; however, the foraminifera assemblage suggests a decrease in salinity (Appendix A). The assemblage is dominated by *Ammotium salsum* and *Ammonia parkinsoniana*, while *Ephidium* sp. (cf. *E. delicatulum*) is present in significant quantities.

Resting above this clay deposit is a second organic clay stratum containing fragments of wood, roots, stems, etc., and exhibiting root and animal burrows. Two radiocarbon samples from this unit provide dates of 7035 ± 105 B.P. (UGa-5425) and 7415 ± 100 B.P. (UGa-5355). A grain-size curve for this stratum is shown for Sample SP3-1-F#7 in Figure 5-8. The curve is identical to that of the underlying bay/estuarine clay facies, and consists primarily of clay and a small amount of silt-sized particles. Foraminifera are absent in the sample from this deposit (Sample 7, Core 1-F, Figure 5-3), indicating a freshwater environment and, possibly, subaerial exposure. The pollen from this stratum, somewhat surprisingly, suggests more of a fluvial woodland than a marsh setting. The presence of large flecks of charred material in the pollen samples from this deposit may indicate in situ burning, implying subaerial exposure of the deposit itself or the presence of exposed land nearby.

The upper organic clay lens and the underlying clay stratum provide indications of a shift from a saline to a freshwater environment within a relatively short time span, probably less than 400 years. This change can be attributed to an actual drop in sea

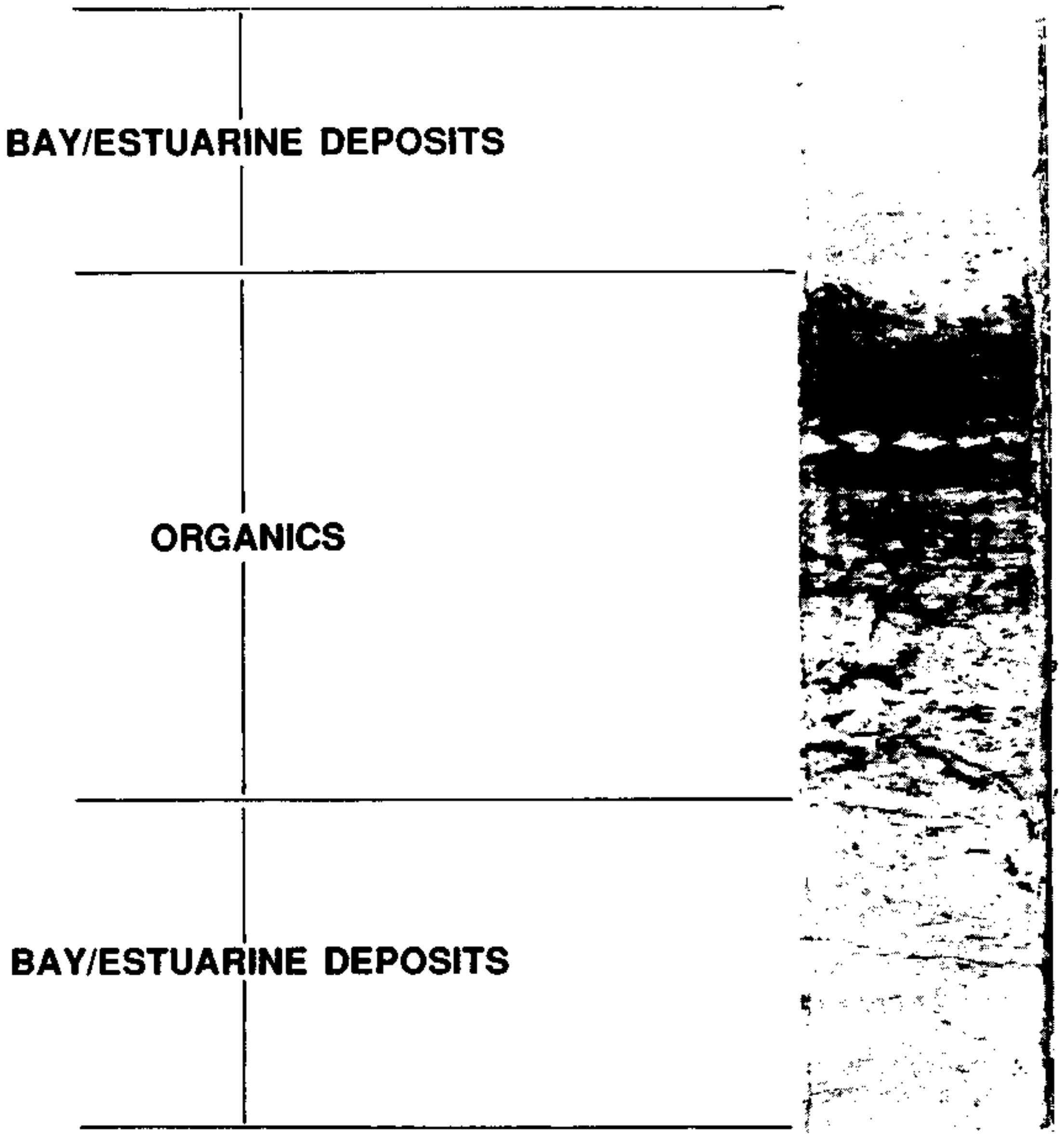


Figure 5-10. Organic stratum in Sabine Pass 3 identified as saline marsh deposit or organic detritus, Core 1-D1.

level; however, if this were the mechanism we would anticipate the drop to be expressed in other nearby areas, such as Sabine Pass 6, about 3 mi away, or Sabine Pass 9, about 6 mi away. In vibracores from these areas, however, no evidence of a shift from saline to freshwater conditions in the stratigraphic column was found. This argues that the change seen in Sabine Pass 3 is more likely to be a localized phenomenon not related to eustatic sea level change. A more reasonable explanation is that the possible freshwater deposits are related to an influx of water and sediments resulting from the shift of a Sabine River channel into the vicinity of the Sabine Pass 3 area. Movements in the river could have produced the depositional and marsh-development pattern seen there, as well as in many other locales within the changing estuary. It is noted also that the organic clay lens is not well developed and, like the deeper organic clay facies, may represent organic detritus deposited under slack-water conditions. The rather distinct differences between the foraminifera from the two organic lenses would seem to mitigate against their being similar detrital deposits; however, this cannot be entirely ruled out.

A thin lens of oyster (Crassostrea virginica) rests upon the freshwater organic clay deposit in the western one-third of the section, principally where it slopes into the former Sabine Valley. The oyster deposit was contacted in two cores, Numbers 1-E and 1-F (Figure 5-3). Parker (1960:310) notes that oysters are found in enclosed coastal waters where salinities are normally below sea water values of 34 to 36 parts per thousand. In particular, they thrive, often in reefs, in lagoons, bays and interdistributaries. However, extremely low salinities can kill oysters and they cease normal growth during periods of high salinity. Foraminifera from the oyster deposit (SP3-1-F#6, Figure 5-3) are dominated by Ammotium salsum, while Ammonia parkinsoniana (form typica) occurs in significant quantities. These types are found in estuarine environments where salinity values are less than those of the open Gulf. This is compatible with the presence and growth of oyster.

The occurrence of the oyster immediately above the interpreted freshwater deposit signals an increase in salinity, interpreted here as a combined result of sea level rise and loss of freshwater influx due to a shifting of the Sabine River channel.

Above the oyster is a thick, homogeneous deposit of soft, dark gray (7.5YR 4/0), massive, clay to silty clay. Parallel color and texture laminations occur uncommonly as do thin (less than 0.5 cm) organic streaks and organic flecks. In the upper portion of this deposit are found animal burrows and marine shell fragments. Burrows are commonly sand filled. The bulk of the deposit is fine grained, as indicated by the grain-size curve for Sample SP3-1-F#5 shown in Figure 5-8.

Foraminifera in this stratum consist primarily of Ammonia parkinsoniana and E. excavatum, types suggesting moderate salinities. This massive clay deposit is interpreted as bay/estuarine sediments, possibly grading into an open Gulf setting in the upper portion (Figure 5-3). The massiveness of the deposit and the rareness of organic or faunal (i.e. shell) accumulation are seen as indicative of relatively rapid rates of sedimentation.

The uppermost facies in the section is a soft to fluid, dark grayish brown (2.5Y 4/2) heavily burrowed clay and silty clay. Sand pockets and filled burrows are abundant, and marine shell is common. The grain-size curve of Sample SP3-1-F#4 (Figure 5-8) is from this stratum. The larger particles (larger than 4 phi) are sand grains as well as shell fragments. This stratum grades into the underlying bay/estuarine clays. Foraminifera species indicate an increase in salinity over the underlying deposits, but are still suggestive of some brackish-water influence (Appendix A). Shellfish species identified are marine types and include the nut clam (*Nucalana* sp.), incongruous ark (*Anadara braciliana*), other unidentified arks (*Anadara* sp.), Atlantic Moon snail (*Polinices duplicatus*), wentletraps (*Epitoniidae*), and donax (*Donax* sp. probably *varrabilis*). In his study of macro-invertebrates in the northern Gulf of Mexico, Parker (1960) notes that this faunal assemblage is generally characteristic of nearshore Gulf settings, ranging from inlet-influenced conditions to the intermediate shelf zone of 12 to 40 fathoms. This uppermost facies, thus, represents offshore Gulf bottom deposits now being laid down in a nearshore, shallow, open marine environment. It was evident in every vibracore taken.

As noted earlier, our assessment of core recovery indicated a loss of sediment in the upper portions of the cores. We were unable to determine whether the loss was occurring in the uppermost, offshore Gulf bottom deposits or the immediately underlying bay/estuarine deposits. Because of this indetermination, it was impossible to place with accuracy the depth of the boundary between these two units. It was decided to represent the thickness of the offshore Gulf bottom as it actually appeared in the cores, which necessitated increasing the amount of bay/estuarine deposits. Therefore, as shown in Figure 5-3 and other core interpretation illustrations, the offshore bay bottom deposit may, in fact, be thicker than illustrated, while the upper bay/estuarine facies may be thinner.

Archaeological Site Potential

The preliminary geological interpretation of the Sabine Pass 3 area indicates that human occupation is most likely to have occurred on the Prairie/Beaumont Terrace adjacent to the Sabine River valley. This surface has been disturbed to some extent by rising sea level. The remnant signature of this rise is in the form of the initial transgression zone. Archaeological deposits would have been impacted, disturbed and scattered by this transgression, but it is unlikely that the low-energy erosion would have completely obliterated archaeological remains. The occurrence of organic lenses and strata within or immediately below the transgression zone elsewhere in the study area is seen as supportive of this assumption of minimized disturbance. Apparently, in some areas local topography and other conditions were such that transgressive, and possibly pretransgressive, organic deposits have been preserved. The date of this transgression was at about 7880 B.P., and indicates that occupation of the area would have to have been before that time. After transgression, sedimentation and sea level rise continued, blanketing the formerly exposed land surface and placing it below the effects of wave-front erosion. The evidence for a decrease in salinity and the formation of a fresh marsh between 7415 B.P. and 7035 B.P. is interpreted as an influx of fresh water and sediments resulting from a shift in the river outlet, rather than a drop in sea level. While the fresh and brackish marshes and estuary environments were conducive to human exploitation, there are no landform features identified in the stratigraphic column above the Prairie Beaumont Terrace surface that would have supported settlement. In light of this, the analysis of samples in the search for archaeological remains concentrated on the initial transgression zone and its contact with underlying strata.

Analytical Approach

The analysis and interpretation of samples followed the approach presented in Gagliano et al. (1982) and essentially involved the geochemical and particle content assessment of samples. That study, relying on 21 samples from Gulf coastal archaeological sites and 10 samples from nonculturally influenced landforms, indicated that the geochemical content and the particle content derived from point counts of specific size fractions could reliably distinguish between the two sample sets. The rationale for that approach was that, even in the absence of distinguishable artifacts, the residue of cultural activities would be preserved in site sediments.

Using the chi-square statistic on the point-count data, Gagliano et al. (1982:104) found that the simple presence or absence of various components in the various size fractions was significantly different between the on-site and off-site samples used. Table 5-2 presents information on these components and their distributions across size fractions relative to significance. The earlier study indicated that the presence of Rangia shell in the -1 phi fraction was a significant marker for distinguishing between sites and nonsites. The data also indicated that the components of bone, teeth and scales; charred material (i.e., charred organic material, usually vegetal); and the combination of bone and charred material, were significant as discriminators.

Table 5-2. Chi-square Test for Significance of Differences between On-site and Off-site Samples Based on Presence/Absence of Various Components at Various Pan Sizes (Source: Gagliano et al. 1982:Table 4-6).

COMPONENT	FRACTION				
	-1.0	0.25	2.0	2.75	PAN
CLASTICS					
LAND SNAILS					
RANGIA SHELL	▨				
MARINE SHELL					
OYSTER SHELL					
SHELL, FRAGMENTARY				▨	
BONE, TEETH, SCALES	▨		▨	▨	
VEGETAL MATERIAL, FRAGMENTARY					▨
CHARRED MATERIAL		▨			
BONE AND CHARRED MATERIAL	▨	▨	▨	▨	
BAKED CLAY					
FLAKE					

▨ *Indicates significant at $p \leq 0.05$.*

Using those components determined to be significant by the chi-square analysis, Gagliano et al. (1982:Table 4-7) developed a quantitative measure of the "likelihood" that a given sample would be from a site when the particular component or components was present or absent. These results are presented in Table 5-3. Of interest here are the components for the -1 phi and the 0.25 phi fractions, the two largest-sized fractions and the ones equivalent to the size fractions examined in the present analysis. The presence of bone or bone and charred material within either fraction was a strong indicator of an archaeological site.

Table 5-3. Likelihood that Sample is Site Derived based on Presence/Absence of Various Components (Source: Gagliano et al. 1982: Table 4-7).

FRACTION AND COMPONENT	PERCENTAGE	
	COMPONENT PRESENT	COMPONENT ABSENT
10 FRACTION		
RANGIA SHELL	76%	29%
BONE, TEETH, SCALES	100%	19%
BONE AND CHARRED MATERIAL	100%	29%
20 FRACTION		
CHARRED MATERIAL	69%	13%
BONE AND CHARRED MATERIAL	88%	20%
60 FRACTION		
BONE, TEETH, SCALES	80%	19%
BONE AND CHARRED MATERIAL	89%	17%
100 FRACTION		
SHELL, FRAGMENTARY	72%	25%
BONE, TEETH, SCALES	69%	14%
BONE AND CHARRED MATERIAL	81%	15%

That earlier study identified two components of interest which, while found only in the site samples, occurred so rarely as to be nonsignificant. These are land snails and "flakes" (stone). Land snails are certainly useful in distinguishing terrestrial from marine environments and might also be expected to be found in an archaeological midden because of the decaying organic matter on which they feed. Even though flakes were found only in archaeological contexts, they occurred so rarely that they were not a significant discriminator between archaeological and noncultural deposits. Essentially, the conclusion was reached that the chance of picking up lithics in a core-sized sample from a site is extremely small (Gagliano et al. 1982:101). This latter conclusion may, of course, be applicable to the northern Gulf coast area where stone is relatively scarce, but it is not necessarily pertinent in other areas.

Ceramics and "baked clay" particles also were found only in site samples in the previous study. As noted earlier, the latest possible date for the occurrence of a site in the Sabine Pass 3 area is estimated to be about 7880 B.P., well before ceramics are known to have been in use. The latest possible dates projected for sites in the rest of the study area are also all preceramic. Ceramics, then, are not anticipated to occur in buried sites within the study area. However, it is anticipated that burnt or baked clay from hearths or fire pits can occur. None, however, was identified in the collected samples.

While the study by Gagliano et al. (1982) provides a basis for the analytical approach used here, there are some limitations which need to be considered. One shortcoming of that study is that the sample of sites and nonsites used does not encompass the range of variability actually extant in the two domains. The off-site samples do not, for example, include several important settings which most likely exist on the OCS, in particular, natural Rangia beds and buried organic (marsh and swamp) deposits.

The on-site sample used seems to be more inclusive. As has been noted several times, however, it is currently impossible to retrodict with assurable accuracy any pre-7000 B.P. coastal subsistence practices and thus specific site content. We do assume that site contents in the study area would incorporate some of the characteristics of post-7,000 B.P. coastal sites in the region (i.e., they would contain estuarine shellfish remains of Rangia or Crassostrea) and/or characteristics of the pre-7000 B.P. sites of the southeastern Texas area (e.g., contain lithics and possibly bone materials). Both of these types of sites were included in the sample used in the study by Gagliano et al.

Point-Count Analysis

The data from seven samples that were selected for point-count analysis from the Sabine Pass 3 area are shown in Tables 5-4 and 5-5. All of the counts have been converted to counts per kilogram to enable comparison. The locations of these samples are shown in Figure 5-3. Two of the samples (SP3-1-A#1, SP3-1-C#2) came from the transgressive zone at its contact with the Prairie/Beaumont surface, while three samples (SP3-1-D1#2, SP3-1-E#2 and SP3-1-F#13) came from the initial transgressive zone in the Sabine Valley. Another sample (SP3-1-E#1) came from the oyster shell deposit identified in the area, and the final sample (SP3-1-F#14) was taken from the fluvial/upper estuarine deposits identified in the Sabine River valley.

The major components in the -1 phi fraction consist of various types of shell. Those that can be identified are brackish-water types such as Rangia, barnacles, ribbed mussel and oyster (Table 5-4). No marine species were identified. The only sample without brackish-water shell is SP3-1-F#4, the sample from the identified fluvial/upper estuarine facies.

Also found in the -1 phi fraction of several of the samples are calcium carbonate concretions. These normally appear as whitish to gray, irregularly shaped, globular amorphous masses. In the Sabine Pass 3 area the largest of these was about 3 cm long. These carbonate concretions, formed of calcite ($CaCO_3$) and siderite ($FeCO_3$), have been reported in the literature from various sedimentary environments. Coleman (1966) notes that they commonly occur in salt- and brackish-marsh deposits and are less abundant in fresh-marsh sediments. Coleman et al. (1964) attribute the formation of these concretions to tidal fluctuations that periodically exposed and inundated low-lying marsh. Stevenson and Emery (1958) suggest that sediment trapping by plants can build a marsh above the effects of tides, providing the conditions needed for concretionary growth. Krinitzsky and Smith (1969:54), relying on extensive core data

Table 5-4. **Point Counts for Sabine Pass 3 Area: - 1 Phi Fraction Expressed in Particles per Kilogram.**

	SAMPLES						
COMPONENT	SP3-1-A#1	SP3-1-C#2	SP3-1-D1#3	SP3-1-E#1	SP3-1-E#2	SP3-1-F#13	SP3-1-F#14
Marine shell							
Oyster shell	89	15		252			
Mussel shell	201			112			
Barnacle/brackish species	268	44	4	364	15	5	
Rangia sp. shell	123	22	308			36	
Unidentified shell	56	37	16	91	10	18	
Iron nodule/pyrite							
Clastic/clastic concretion			15			87	40
Carbonate concretion	22	15	1346		627		
Vegetal material			187				
Charred vegetal material	33	44	12		10		
Seed							
Bone							
Charred bone							
Crustacean exoskeleton				7			
Stone					10		
Landsnails							
Other							

from the Atchafalaya Basin in Louisiana, argue that carbonate nodules can form and are often common, in freshwater lake sediments; however, they rarely occur in swamp environments. In a more recent study of the lower Atchafalaya Basin, Britsch et al. (1985:23) state that calcium concretions are abundant in backswamp deposits. In his study of Holocene sediments of the Galveston Bay area, Rehkemper (1969) indicates the occurrence of calcareous nodules in fluvial, marsh and natural levee subfacies and, in particular, their presence in concentrations at Holocene-Pleistocene contacts.

As can be seen in Tables 5-4 and 5-5, calcium carbonate concretions are identified in the initial transgression zone only. Elsewhere in the study area, carbonate concretions were found in similar settings and, as recognized above, seem to be concentrated at the Pleistocene-Holocene contact. Nelson and Bray (1970:55) noted the same phenomena and argue that the nodules are derived from the Prairie/Beaumont. Aten (1983:134) has equated the formation of calcium carbonate nodules with periods of decreased rainfall and suggests they can be used as indicators of past precipitation

Table 5-5. Point Counts for Sabine Pass 3 Area: 0 Phi Fraction Expressed in Particles per Kilogram.

	SAMPLES						
COMPONENT	SP3-1-A#1	SP3-1-C#2	SP3-1-D1#3	SP3-1-E#1	SP3-1-E#2	SP3-1-F#13	SP3-1-F#14
Marine shell							
Oyster shell	67	15					
Mussel shell	491	22		364			
Barnacle/brackish species	579	59		420		38	
Rangia sp. shell							
Unidentified shell	1362	155	608	12264	20	175	17
Iron nodule/pyrite							
Clastic/clastic concretion	223	22	296			202	120
Carbonate concretion			2588		1696		
Vegetal material		89	1000			14	
Charred vegetal material	167	422	156	168	68	9	6
Seed		59	16				
Bone							
Charred bone							
Crustacean exoskeleton	11						
Stone							
Landsnails						5	
Other							

patterns. Based on the available core data mentioned above, it appears that carbonate concretions can, and often do, form in very wet situations (i.e., in marshes and lake beds). It seems reasonable to suggest, therefore, that until future research assesses the exact nature of carbonate nodule formation in different environments, they cannot be considered specific indicators of paleoclimatic conditions. Their concentration in the initial transgressive facies indicates that they occur as lag derived either from eroded Holocene marsh or swamp deposits or from the eroded surface of the underlying Pleistocene formations.

One aspect of the occurrence of these concretions is particularly pertinent to the archaeological concerns of this study. In point-count samples from Sabine Pass 3 several "micro-flakes" or "microchunks" were initially identified. Under the microscope these appeared to be a fine-grained limestone-like material exhibiting corticular weathering and conchoidal-like fractures. However, it was later determined that these pieces represented flakes and shatter derived from calcium carbonate concretions, which are often quite dense and hard. When dealing with extremely small fragments, as is the case here, great care has to be taken in not confusing stone and concretion fragments.

Two pieces of stone (which equate to 10 pieces when converted to counts per kilogram) were identified in the -1 phi fraction of sample SP3-1-E#2. These are flattened, subrectangular and smoothed. All of the edges are rounded. The largest of the two pieces is 6 mm long, 5 mm wide and 1 mm thick. Both pieces have a tan cortex and a white interior and appear to be a quartzite-like material. These appear to be naturally deposited and there is no indication in their shape to suggest that they are cultural in nature. The composition of the 0 phi fractions are similar to the -1 phi fractions. None of the samples contained items that could be definitely identified as archaeological in origin.

Discriminant Analysis

Discriminant analysis was used in an effort to objectively assess whether a sample was or was not an archaeological deposit. Discriminant analysis is a quantitative technique for statistically characterizing the differences between two or more groups based on a set of variables. The "mathematical objective" of discriminant analysis is "to weight and linearly combine the discriminating variables in some fashion so that the groups are forced to be as statistically distinct as possible" (Klecka 1975:435). The combinations of weighted variables, which maximize the separation of the groups, are known as discriminant functions. The selection of the groups and the variables to be used in discriminant analysis are defined by the specific research situation.

Discriminant analysis provides several useful tools for interpreting data, including statistical tests for measuring the success with which the selected variables discriminate between groups. This aspect of discriminant analysis is similar in many ways to factor analysis and multiple regression (Klecka 1975:436). An additional use of discriminant analysis is as a classification technique. Once satisfactory discriminating variables have been identified, these can be used to classify new cases with unknown membership. It is this feature of discriminant analysis which can prove useful in the classification of samples from unknown sources. It is in this classification mode that the technique was used in the present study.

The discriminant analysis was performed using the program DISCRIMINANT from the Statistical Package for the Social Sciences (SPSS) (SPSS Inc. 1983). This program allows for the use of either quantitative or qualitative (presence/absence) data and provides for the selection of one of several discriminating algorithms and interpretative statistics.

The variables selected for use in analysis were those which the previous study by Gagliano et al. 1982 had indicated were the most useful for discriminating between sites and nonsites. These variables are: (1) Rangia shell, (2) unidentified shell, (3) vegetal material, (4) charred vegetal material, and (5) bone (includes teeth and scales).

The approach used in the classification analysis was to establish two groups, one of "known" members and the other of "unknown" membership, and then allow the discriminant analysis to reclassify the cases into one of the two groups on the basis of the five variables. The known group consisted of four site samples selected from the Gagliano et al. (1982) study. The samples used were from a range of sites from landform settings correlating as closely as possible with those identified in the locations selected for coring. One is from 16 SB 52, the Shotgun Shell site, a small

Woodland and Mississippi period Rangia shell midden located atop a subsided natural levee in the marshes of St. Bernard Parish in southeastern Louisiana. Two samples are from a stratified earth and shell midden at 16 SJ 2, the Lower Vacherie (Shellhill Plantation) site, a Woodland and Mississippi period locale situated on a crevasse off the Mississippi River in St. James Parish, Louisiana. One of the samples is from a primarily freshwater shell layer at the site, while the other is from a zone of compacted bone, mostly fish. The fourth known sample is from the Cedarland Plantation site (22 HA 506), a Late Archaic oyster shell and earth midden situated on a relict Pleistocene-age formation adjacent to the marsh near the mouth of the Pearl River in southern Mississippi.

The "unknown" group consisted of two off-site, or natural formation samples from the Gagliano et al. (1982) study, plus the samples selected for analysis from the vibracores. The two offsite samples were from a Pleistocene ridge near the Jackson Landing site (22 HA 500) and from the Prairie/Beaumont Terrace, near the Bayou Blue site (16 AL 1) in southwestern Louisiana. Both samples are listed simply by the site numbers on the figures. They were placed in the unknown category only to be used as a gauge in assessing the grouping of the samples from the vibracores. They were not actually needed in assessing how the vibracore samples grouped relative to the four known site samples.

Both stepwise and direct discriminant analysis methods were performed on the data. The direct method forces the complete set of variables into the analysis while the stepwise method enters individual variables dependent upon the algorithms (i.e., stepwise method) selected. It was found that, in terms of classification, the results of the two methods were not significantly different.

Discriminant analysis was run on each set of data using both quantitative data (counts) and qualitative (presence/absence) data. The results of both analyses are presented, since, as is noted below, differences in the classification did occur. Figures 5-11 and 5-12 present the results of analysis on the -1 phi fraction. When actual counts are used, one of the site samples (site 22 HA 506 in Group 1) is placed with Group 2, the unknown and off-site group. Even though this sample is statistically placed within the other group, as can be seen in the all-group histogram, spatially there is no overlap between the two groups. Why this site is placed close to the nonsite groups is not entirely evident. The histogram is developed based on the canonical discriminant functions, which indicate that the most powerful variable in the analysis includes bone teeth and scales, followed in order by Rangia shell, unidentified shell, vegetal materia and charred vegetal material. The fact that none of the vibracore samples is groupe with the known sites suggests that none represents an archaeological deposit.

Figure 5-12 presents the results of analysis using presence/absence data. In this analysis, one vibracore sample, SP3-1-D1#3, is grouped with the known site samples. This grouping is due to the identification of "vegetal material" in the sample. Despite this grouping, in light of a total lack of other evidence indicating the sample could be cultural, we feel that the grouping is spurious and not indicative of an archaeological deposit.

The results of discriminant analysis on the 0 phi fractions are presented in Figures 5-13 and 5-14. No offshore samples were reclassified into the site samples on the basis of quantitative data, however, one of the sites has been reclassified (Figure 5-13). The reasons for this are not totally clear but it seems to be because of the large quantity of unidentified shell in the site sample. In Figure 5-14 it can be seen that one of the known offsite samples, 16 AL 1 (a Pleistocene terrace sample), is reclassified into the site group. The all-groups histogram in Figure 5-14 shows, however, that there is no overlap between the two groups and that they remain spatially distinct.

```
CASE              ACTUAL      HIGHEST PROBABILITY      2ND HIGHEST      DISCRIMINANT
SEQNUM            GROUP       GROUP P(D/G) P(G/D)      GROUP P(G/D)      SCORES...

16SB52              1              0.9438 0.9999        2 0.0001        3.1463
16SJ2#1             1            1 0.1736 1.0000        2 0.0000        4.3759
16SJ2#2             1            1 0.2498 1.0000        2 0.0000        4.2268
22HA506             1 **         2 0.0547 0.8951        1 0.1049        0.5545
22HA500             2            2 0.4658 1.0000        1 0.0000       -2.0964
16AL1               2            2 0.8585 1.0000        1 0.0000       -1.5453
SP3-1-A#1           2            2 0.4176 0.9992        1 0.0008       -0.5564
SP3-1-C#2           2            2 0.6469 0.9998        1 0.0002       -0.9090
SP3-1-D#3           2            2 0.7872 0.9999        1 0.0001       -1.0970
SP3-1-E#1           2            2 0.8578 1.0000        1 0.0000       -1.5462
SP3-1-E#2           2            2 0.9051 1.0000        1 0.0000       -1.4863
SP3-1-F#13          2            2 0.9121 1.0000        1 0.0000       -1.4397
SP3-1-F#14          2            2 0.7948 1.0000        1 0.0000       -1.6271
```

```
                                    ALL-GROUPS STACKED HISTOGRAM
                                  CANONICAL DISCRIMINANT FUNCTION 1

        4 +                                                                                +
          I                                                                                I
          I                                                                                I
F         I                                                                                I
R       3 +                                2                                               +
E         I                                2                                               I
Q         I                                2                                               I
U         I                                2                                               I
E       2 +                                22 2                                            +
N         I                                22 2                                            I
C         I                                22 2                                            I
Y         I                                22 2                                            I
        1 +                              2 22 2 2     1            1    11                 +
          I                              2 22 2 2     1            1    11                 I
          I                              2 22 2 2     1            1    11                 I
          I                              2 22 2 2     1            1    11                 I
           X---------+---------+---------+---------+---------+---------+---------+---------X
          OUT     -6.0      -4.0      -2.0        .0       2.0       4.0       6.0         OUT
   CLASS   2222222222222222222222222222222222222222222222111111111111111111111111111111111111
 CENTROIDS                                    2                    1
```

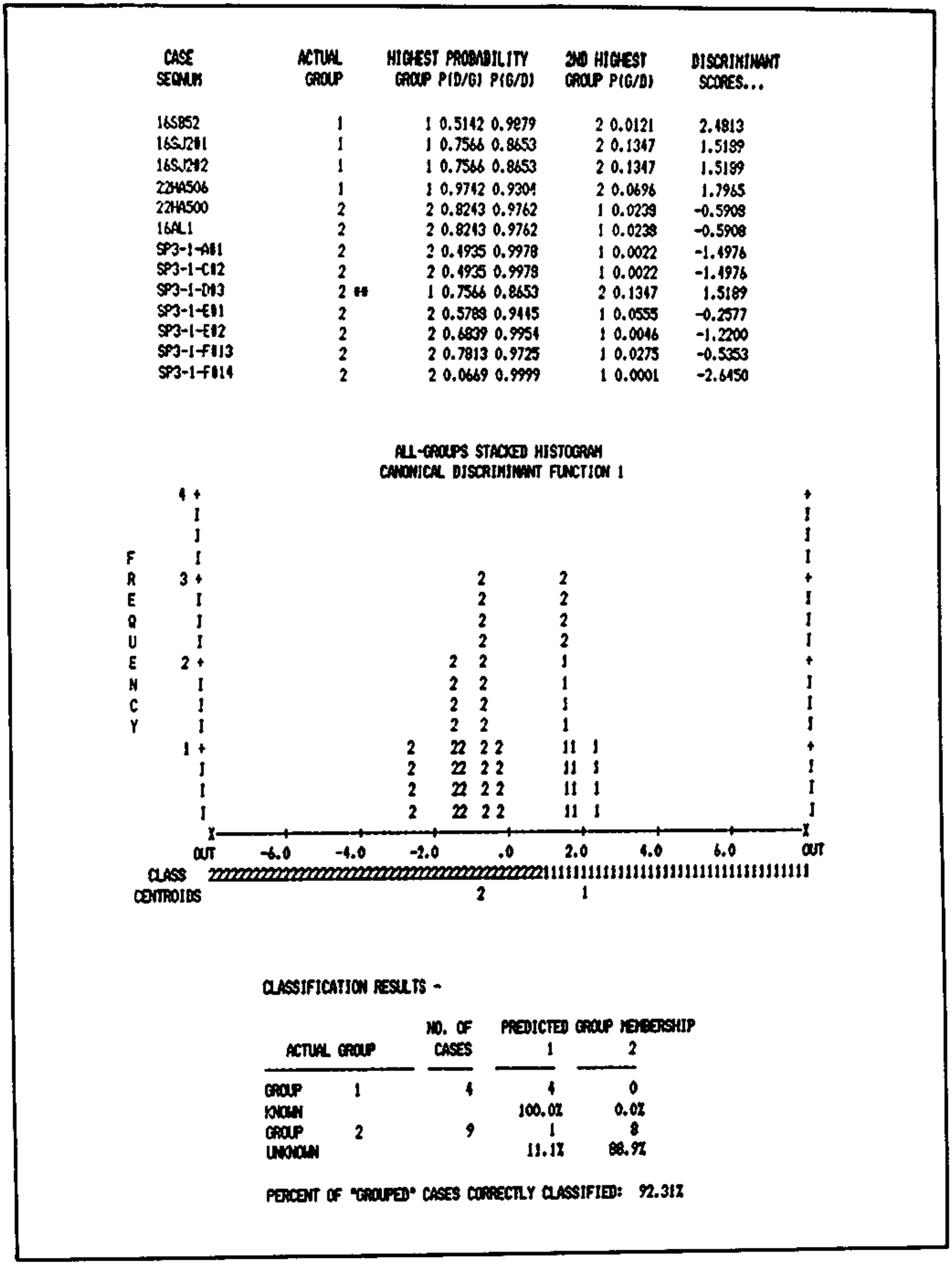
```
CLASSIFICATION RESULTS -

                           NO. OF     PREDICTED GROUP MEMBERSHIP
   ACTUAL GROUP            CASES          1          2
 --------------------      ------     -------    -------

 GROUP       1                4          3          1
 KNOWN                                 75.0%      25.0%
 GROUP       2                9          0          9
 UNKNOWN                                0.0%     100.0%

 PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED:  92.31%
```

Figure 5-11. Results of discriminant analysis on quantitative data, -1 phi fractions, Sabine Pass 3 area.



```
CASE          ACTUAL     HIGHEST PROBABILITY    2ND HIGHEST     DISCRIMINANT
SEQNUM        GROUP      GROUP P(D/G) P(G/D)    GROUP P(G/D)    SCORES...

16S852          1          1 0.5142 0.9279       2 0.0121        2.4813
16SJ2#1         1          1 0.7566 0.8653       2 0.1347        1.5189
16SJ2#2         1          1 0.7566 0.8653       2 0.1347        1.5189
22HA506         1          1 0.9742 0.9304       2 0.0696        1.7965
22HA500         2          2 0.8243 0.9762       1 0.0239       -0.5908
16AL1           2          2 0.8243 0.9762       1 0.0238       -0.5908
SP3-1-A#1       2          2 0.4935 0.9978       1 0.0022       -1.4976
SP3-1-C#2       2          2 0.4935 0.9978       1 0.0022       -1.4976
SP3-1-D#3       2 **       1 0.7566 0.8653       2 0.1347        1.5189
SP3-1-E#1       2          2 0.5789 0.9445       1 0.0555       -0.2577
SP3-1-E#2       2          2 0.6839 0.9954       1 0.0046       -1.2200
SP3-1-F#13      2          2 0.7813 0.9725       1 0.0275       -0.5353
SP3-1-F#14      2          2 0.0669 0.9999       1 0.0001       -2.6450
```

```
                                    ALL-GROUPS STACKED HISTOGRAM
                                  CANONICAL DISCRIMINANT FUNCTION 1
        4 +                                                                                +
          I                                                                                I
          I                                                                                I
 F        I                                                                                I
 R      3 +                                    2          2                                +
 E        I                                    2          2                                I
 Q        I                                    2          2                                I
 U        I                                    2          2                                I
 E      2 +                                2   2          1                                +
 N        I                                2   2          1                                I
 C        I                                2   2          1                                I
 Y        I                                2   2          1                                I
        1 +                           2    22  2 2        11   1                           +
          I                           2    22  2 2        11   1                           I
          I                           2    22  2 2        11   1                           I
          I                           2    22  2 2        11   1                           I
           X---------+---------+---------+---------+---------+---------+---------+---------X
          OUT      -6.0      -4.0      -2.0       .0        2.0       4.0       6.0       OUT
   CLASS   222222222222222222222222222222222222222222222111111111111111111111111111111111111
 CENTROIDS                                     2             1
```

```
          CLASSIFICATION RESULTS -

                                 NO. OF     PREDICTED GROUP MEMBERSHIP
             ACTUAL GROUP        CASES           1             2
          -------------------    ------     ---------     ---------
          GROUP       1              4           4             0
          KNOWN                               100.0%          0.0%
          GROUP       2              9           1             8
          UNKNOWN                              11.1%         88.9%

          PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED:  92.31%
```

Figure 5-12. Results of discriminant analysis on qualitative data, -1 phi fractions, Sabine Pass 3 area.

```
CASE            ACTUAL     HIGHEST PROBABILITY    2ND HIGHEST    DISCRIMINANT
SEQNUM          GROUP      GROUP P(D/G) P(G/D)    GROUP P(G/D)   SCORES...

16SB52             1 **        2 0.5075 0.9389       1 0.0611      -0.1779
16SJ201            1           1 0.0183 0.9999       2 0.0001       4.2510
16SJ202            1           1 0.9019 0.9629       2 0.0371       2.0146
22HA506            1           1 0.6791 0.8570       2 0.1430       1.4777
22HA500            2           2 0.9977 0.9894       1 0.0106      -0.8377
16AL1              2           2 0.7942 0.9787       1 0.0213      -0.5797
SP3-1-A01          2           2 0.8712 0.9932       1 0.0068      -1.0028
SP3-1-C02          2           2 0.4104 0.9989       1 0.0011      -1.6638
SP3-1-D03          2           2 0.8404 0.9819       1 0.0181      -0.6392
SP3-1-E01          2           2 0.9267 0.9918       1 0.0082      -0.9326
SP3-1-E02          2           2 0.9250 0.9864       1 0.0136      -0.7465
SP3-1-F013         2           2 0.7964 0.9789       1 0.0211      -0.5826
SP3-1-F014         2           2 0.7947 0.9788       1 0.0212      -0.5804
```

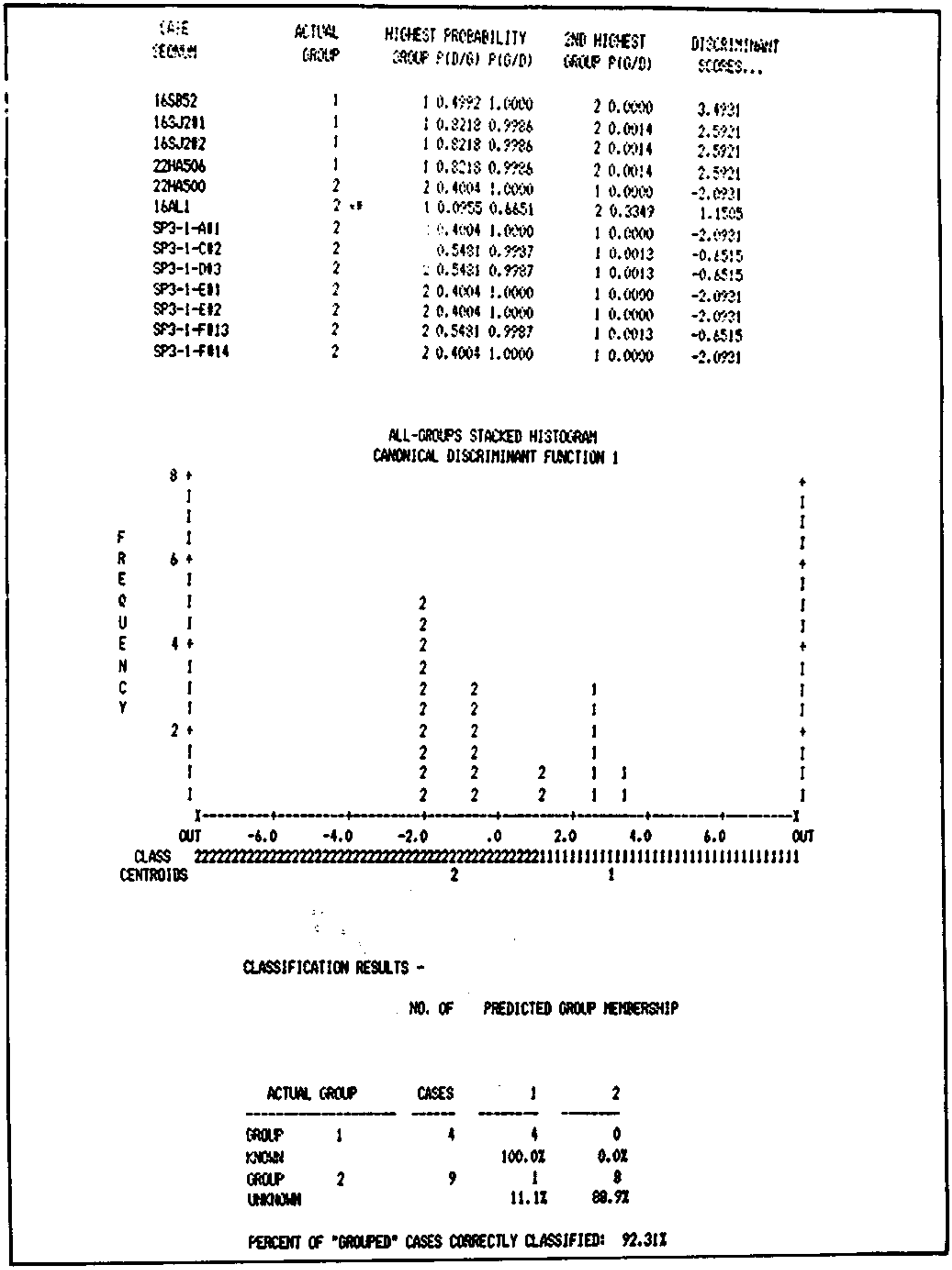
```
                                  ALL-GROUPS STACKED HISTOGRAM
                                CANONICAL DISCRIMINANT FUNCTION 1
       4 +                                    2                                          +
         I                                    2                                          I
         I                                    2                                          I
F        I                                    2                                          I
R      3 +                                    2                                          +
E        I                                    2                                          I
Q        I                                    2                                          I
U        I                                    2                                          I
E      2 +                                  222                                          +
N        I                                  222                                          I
C        I                                  222                                          I
Y        I                                  222                                          I
       1 +                               2  222 1       1  1          1                  +
         I                               2  222 1       1  1          1                  I
         I                               2  222 1       1  1          1                  I
         I                               2  222 1       1  1          1                  I
         I---------+---------+---------+---------+---------+---------+---------+---------I
         OUT     -6.0      -4.0      -2.0       .0        2.0       4.0       6.0      OUT
CLASS    222222222222222222222222222222222222222222222111111111111111111111111111111111111
CENTROIDS                                    2             1
```

```
CLASSIFICATION RESULTS -

                            NO. OF    PREDICTED GROUP MEMBERSHIP
   ACTUAL GROUP             CASES          1            2
 ----------------------    ------      --------     --------
 GROUP         1              4            3            1
 KNOWN                                  75.0%        25.0%
 GROUP         2              9            0            9
 UNKNOWN                                 0.0%       100.0%

 PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED:  92.31%
```

Figure 5-13. Results of discriminant analysis on quantitative data, 0 phi fractions, Sabine Pass 3 area.



```
 CASE           ACTUAL      HIGHEST PROBABILITY     2ND HIGHEST     DISCRIMINANT
 SEQNUM         GROUP       GROUP P(D/G) P(G/D)     GROUP P(G/D)    SCORES...

 16SB52           1             1 0.4992 1.0000       2 0.0000       3.4931
 16SJ2#1          1             1 0.8218 0.9986       2 0.0014       2.5921
 16SJ2#2          1             1 0.8218 0.9986       2 0.0014       2.5921
 22HA506          1             1 0.8218 0.9986       2 0.0014       2.5921
 22HA500          2             2 0.4004 1.0000       1 0.0000      -2.0931
 16AL1            2 **          1 0.0955 0.6651       2 0.3349       1.1505
 SP3-1-A#1        2             2 0.4004 1.0000       1 0.0000      -2.0931
 SP3-1-C#2        2               0.5431 0.9987       1 0.0013      -0.6515
 SP3-1-D#3        2             2 0.5431 0.9987       1 0.0013      -0.6515
 SP3-1-E#1        2             2 0.4004 1.0000       1 0.0000      -2.0931
 SP3-1-E#2        2             2 0.4004 1.0000       1 0.0000      -2.0931
 SP3-1-F#13       2             2 0.5431 0.9987       1 0.0013      -0.6515
 SP3-1-F#14       2             2 0.4004 1.0000       1 0.0000      -2.0931


                             ALL-GROUPS STACKED HISTOGRAM
                           CANONICAL DISCRIMINANT FUNCTION 1
        8 +                                                                               +
          I                                                                               I
          I                                                                               I
F         I                                                                               I
R       6 +                                                                               +
E         I                                                                               I
Q         I                             2                                                 I
U         I                             2                                                 I
E       4 +                             2                                                 +
N         I                             2                                                 I
C         I                             2      2               1                          I
Y         I                             2      2               1                          I
        2 +                             2      2               1                          +
          I                             2      2               1                          I
          I                             2      2        2      1   1                      I
          I                             2      2        2      1   1                      I
          X---------+---------+---------+---------+---------+---------+---------+---------X
         OUT      -6.0      -4.0      -2.0       .0       2.0       4.0       6.0       OUT
   CLASS  222222222222222222222222222222222222222222222211111111111111111111111111111111111
CENTROIDS                                    2                    1


                   CLASSIFICATION RESULTS -

                                   NO. OF     PREDICTED GROUP MEMBERSHIP


                 ACTUAL GROUP      CASES          1           2
                 --------------    ------      --------    --------
                 GROUP      1        4            4           0
                 KNOWN                         100.0%        0.0%
                 GROUP      2        9            1           8
                 UNKNOWN                        11.1%       88.9%

                 PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED:  92.31%
```

Figure 5-14. Results of discriminant analysis on qualitative data, 0 phi fractions, Sabine Pass 3 area.

One offshore sample (SP3-1-D1#3) was, on the basis of the -1 phi discriminant analysis, reclassified into the site group. This sample is from the initial transgressive zone at the edge of the Prairie/Beaumont drop-off into the Sabine Valley. This locale is one of those where we would anticipate finding evidence of cultural activity. However, as noted, this sample is classified as a site primarily on the basis of the occurrence of "vegetal material" which, in the absence of other constituents, is not seen as a strong, positive indicator that the sample is archaeological in origin.

Geochemical Analysis

Only two samples from the Sabine Pass 3 area were included in the geochemical analysis. As noted, the geochemical analysis was primarily intended to be a final assessment of a sample once other indicators suggested it may be archaeological. Additionally, the analysis would aid in characterizing the chemical character of various buried deposits.

The two samples analyzed were SP3-1-D1#3, the one sample reclassified as a site on the point-count data, and sample SP3-1-A#1. This latter sample came from the transgressive zone above the Prairie/Beaumont surface (see Figure 5-3), which, on the basis of location, was thought to be an optimum area for site occurrence as well as an area having moderate preservation potential.

Table 5-6 presents the results of the chemical analyses on all nine of the samples selected in the study area. Also included are data from other sources considered useful for comparisons. The geochemical data from the Gagliano et al. (1982) study are provided and represents the most pertinent comparative information available. That study assessed the chemical properties of five archaeological sites and five natural landforms along the northern coast of the Gulf of Mexico. The general types of sites and landforms represented in the chemical assessment are similar to many of those expected or identified within the study area. The averages of findings from the sites and the natural landforms (off-sites) are presented in Table 5-6.

Also presented for comparative purposes in Table 5-6 are chemical data derived from studies of coastal and marine sediments in the northern Gulf region. These data relate to natural sediments, primarily from the seafloor and may, to some extent, be reflecting modern pollutants.

One of the samples from the Sabine Pass 3 area, Sample SP3-1-A#1, yielded a relatively high zinc and a low total phosphate (TP) content. Both of these parameters are expected to be higher than average in archaeological deposits. The other sample, SP3-1-D1#3, indicated a higher-than-average content for both zinc and TP, yet, as noted above, the point-count data from this sample provided no indication that it was cultural.

Why the two samples from Sabine Pass 3 yielded the highest zinc content of all samples examined is not known. When the geochemical data are viewed in conjunction with the point-count data, it is equivocal as to whether an archaeological deposit is suggested. None of the parameters examined from samples from Sabine Pass 3 provides conclusive evidence that archaeological remains were encountered.

Sabine Pass 6

Features identified during the present study within the surveyed portion of lease block Sabine Pass 6 (Figure 5-15) closely matched those recorded in the original lease-block

Table 5-6. Results of the Chemical Analysis of Nine Selected Samples.

Sample	Ca	Cu	Fe	Mg	Mn	K	Zn	PO4	TP	TKN	TOC	Priority
	Chemical Parameter											
SP3-1-A#1	678.00	22.70	11204.00	5858.00	2184.00	3995.00	88.40	4.73	532.00	2008.00	1891.00	3
SP3-1-D1#3	40.70	86.00	19294.00	1808.00	4435.00	2642.00	68.30	1.37	1344.00	340.50	13639.00	5
SP6-1-A#2	4.50	20.80	4286.50	1293.00	19.20	2580.50	15.90	0.17	832.00	1203.00	38465.00	4
SP6-1-A#3	40.70	89.20	3639.00	266.00	15.80	1022.00	42.20	3.13	412.00	303.00	1346.00	1
SP6-1-C#2	15814.00	49.70	47161.00	3463.00	604.00	4575.00	39.30	1.62	950.00	320.00	3018.00	9
SP6-2-C#2	1228.00	319.00	19240.00	2829.00	631.00	2850.00	31.20	7.48	1268.00	787.00	5508.50	7
SP6-3-B#1	23.75	31.00	19591.50	1820.00	544.50	2878.50	49.10	7.57	720.00	977.00	4074.00	6
SP6-4-C#4	27.25	15.60	10422.00	1140.00	123.50	2607.50	52.15	29.30	890.00	280.00	9509.00	8
SP9-4-B#1	19.50	40.85	14757.50	2379.00	134.50	6402.50	9.40	211.00	634.00	468.00	5037.00	2
Average	1986.27	74.98	16621.72	2317.56	965.72	3283.667	53.39	29.60	842.44	742.94	5318.78	
TBEG (a)	--	24.00	31900.00	—	560.00	—	60.00	—	—	—	—	
TBEG (b)	--	18.00	30000.00	—	783.00	—	53.00	—	—	—	—	
USGS (c)	15800.00	10.00	15100.00	7400.00	401.00	—	—	—	—	—	—	
Gagliano et al. (1982):												
Average site	--	10.00	4568.00	--	555.00	--	58.00	--	2835.00	5900.00	34760.00	
Average off-site	--	8.00	8856.00	--	990.00	--	25.00	--	698.00	5180.00	37540.00	

(a) Corpus Christi, Texas, OCS (White et al. 1983)
(b) Galveston-Houston, Texas, OCS (White et al. 1985)
(c) Northwestern Gulf of Mexico, OCS (Holmes 1973)

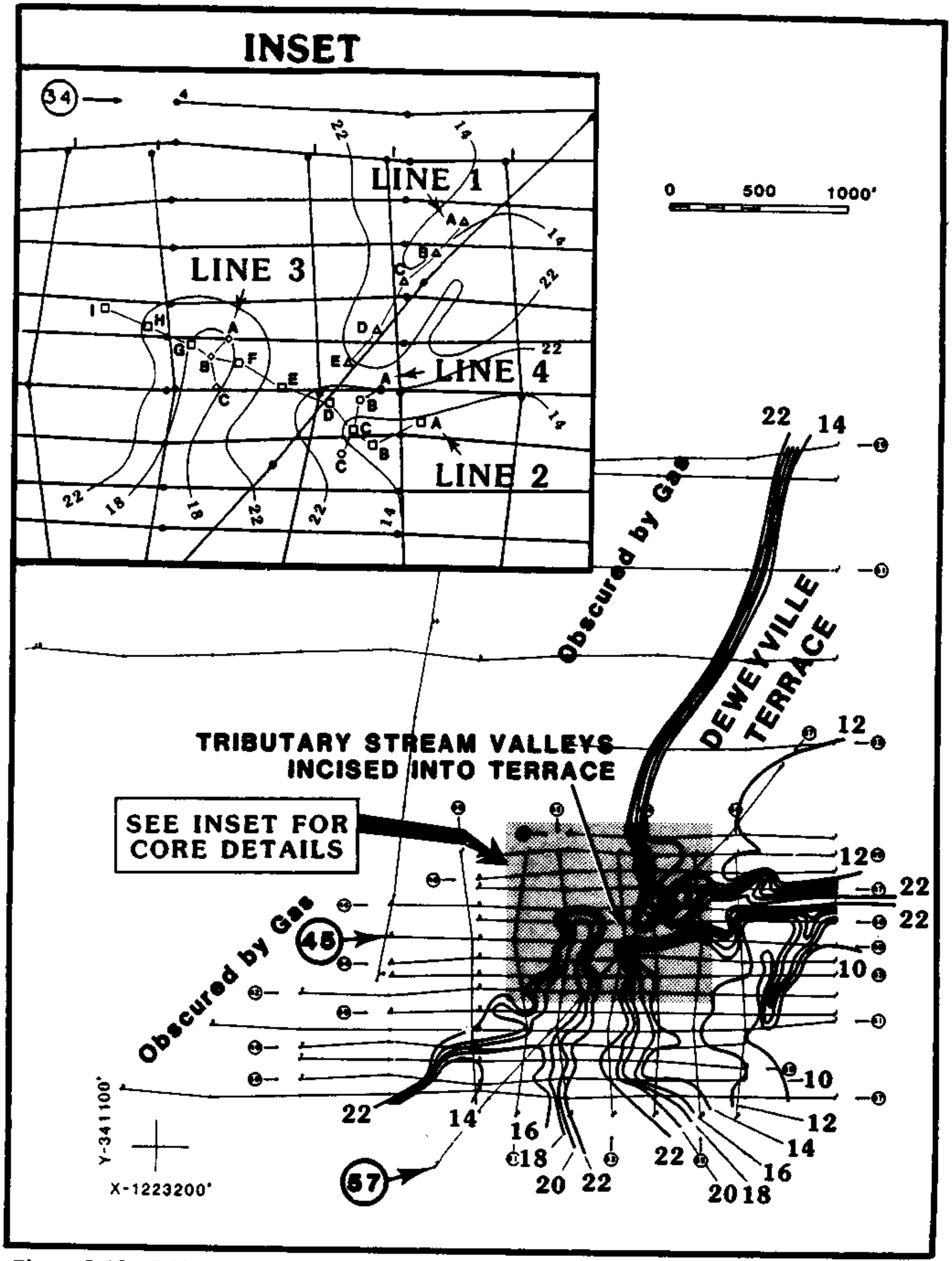


Figure 5-15. Subbottom contour map of the surveyed portion of Sabine Pass 6. Inset shows core hole locations. Contours are in feet below sea floor. Note locations of Seismic Lines 45 and 57 and, in the Inset, Vibracore Lines 1, 2, 3, and 4.

survey (see Figure 4-4). The present survey confirmed the presence of the terrace edge and located the two tributary streams. It also confirmed the lack of the lower terrace initially recorded by the lease-block survey, but whose presence was questioned during a subsequent review of the original seismic records (see Chapter IV).

The present survey also produced data which called for a revision of the terrace interpretation. Initially, the present authors agreed with the lease-block survey in identifying the terrace edge as the Prairie/Beaumont escarpment at the eastern border of the Sabine Valley. The seismic records obtained during the present study, however, reveal that the terrace formation lacks the closely spaced, multiple reflectors diagnostic of the Prairie/Beaumont, but, rather, is characterized by a single, dense, surface reflector underlain by an acoustic void. This signature was encountered elsewhere in the study area and is characteristic of surfaces which, on the basis of spatial distribution, morphology and topography, are identified as Deweyville terrace features. Figures 5-16 and 5-17 are examples of portions of Seismic Lines 45 and 57, each clearly showing this identified Deweyville signature between shot points 2 and 4.

Prior to coring, the Sabine Pass 6 area was considered the most promising of all of those examined relative to its potential for containing archaeological deposits. This potential rested in the combination of landform features found within the surveyed area. In this area, two small streams draining the Deweyville terrace join at the edge of the Holocene floodplain. Based on our assessment of potential prehistoric site distributions in the study area, this type of setting provided optimum conditions for settelement. For that reason this block was subjected to an extensive array of vibracores. This array consisted of four lines of cores, comprising a total of 19 cores. Locations of individual cores are shown in the inset in Figure 5-15.

Figures 5-16 and 5-17 present vibracores along Core Lines 1 and 2 superimposed on Seismic Lines 45 and 57. Seismic Line 45 extends from the Deweyville terrace westward into the Sabine River valley, crossing the small tributary that extends to the south. Seismic Line 57 angles across the Deweyville terrace, crossing both of the small tributaries. As can be seen in the inset for Figure 5-15, Seismic Line 57 ran northeast-southwest almost exactly along Core Line 1, while Line 45 is offset somewhat from Core Line 2. In the latter case, the core line ran from the southeast to the northwest while the seismic line ran almost due east-west. Nevertheless, the agreement between both seismic lines and the related core data is extremely close and sufficient to permit reliable interpretations of stratigraphy.

Figures 5-18 and 5-19 provide cross sections along the same two core lines, showing the present geological interpretation based on the core data. Figure 5-20 shows a similar interpretation along Core Line 4. (It should be noted that the direction of the two seismic records are reversed from the geological cross sections in Figures 5-18 and 5-19. This was unavoidable because an effort was made to present the geological cross sections looking up valley while the presentation on the seismic records is related to ship direction.) One thing that becomes apparent by a comparison of the original interpretation of the surveyed area, based on the seismic records (see Figure 5-15), with that of the geological cross sections, based primarily on the core data, is that the location of the eastern tributary channel varies. According to the core data, the channel actually is about 100 ft farther north than the location derived from the seismic records. The reason for this discrepancy is unclear at present, but a contributing factor may be found in the presence of a relatively large Rangia shell deposit which was encountered in Cores 1-C and 1-D (see Figure 5-18). The shell produced a signature similar to the Deweyville terrace and was interpreted as such. This is of some interest since the general conception is that on seismic records, shell

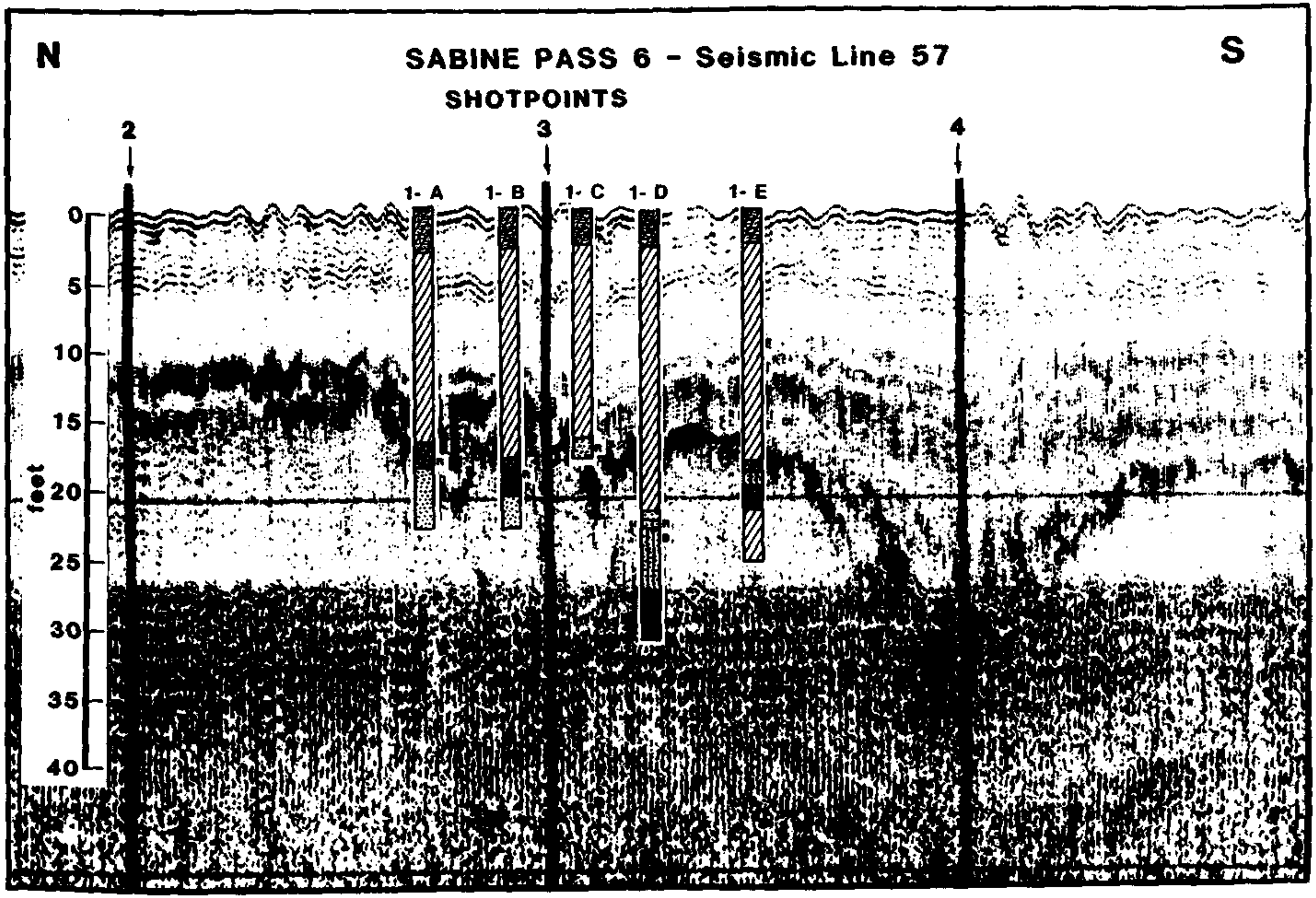


Figure 5-16. Portion of pinger record along Seismic Line 57, Sabine Pass 6 area.

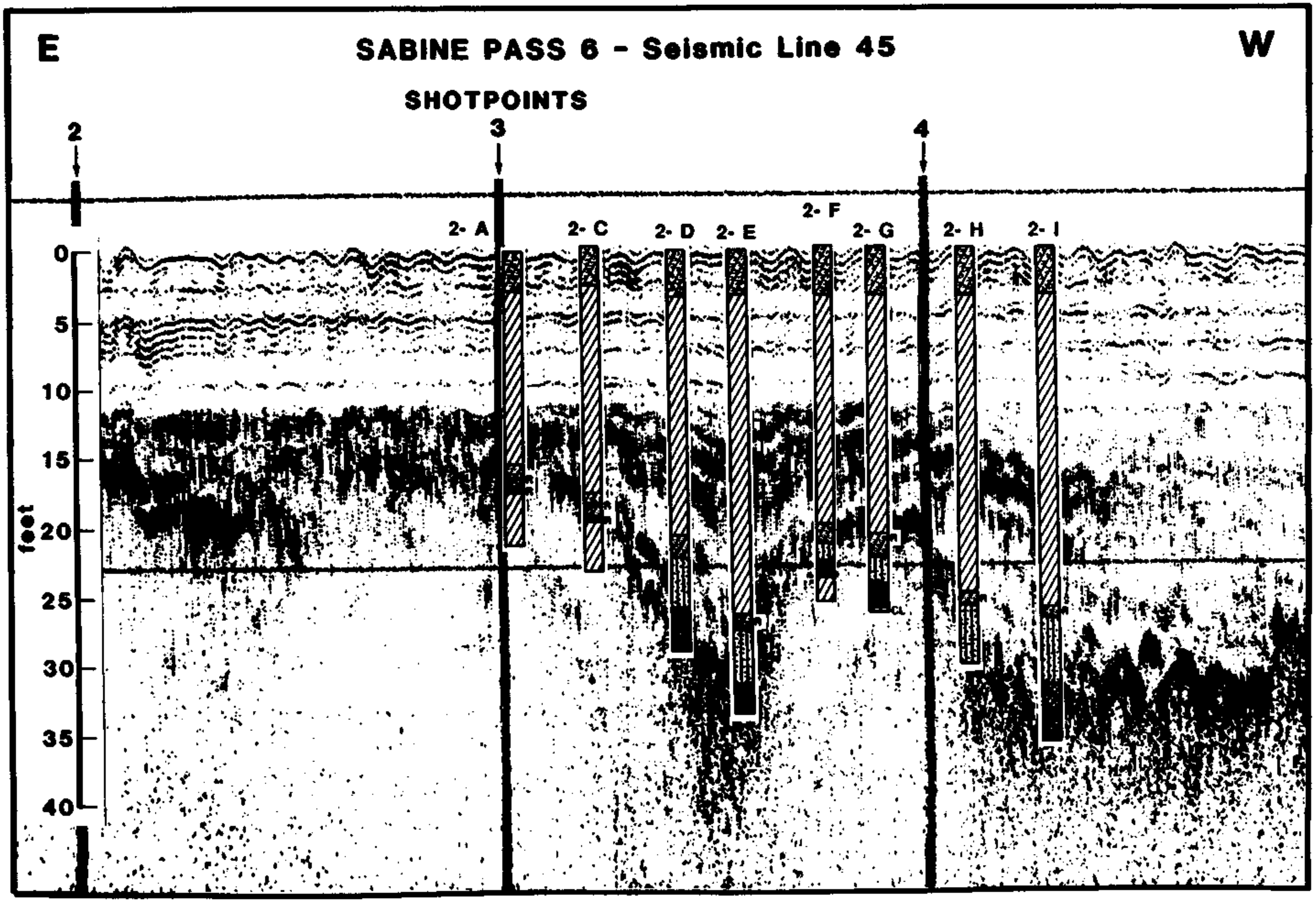


Figure 5-17. Portion of pinger record along Seismic Line 45, Sabine Pass 6 area. Note the correlation between cores and record.

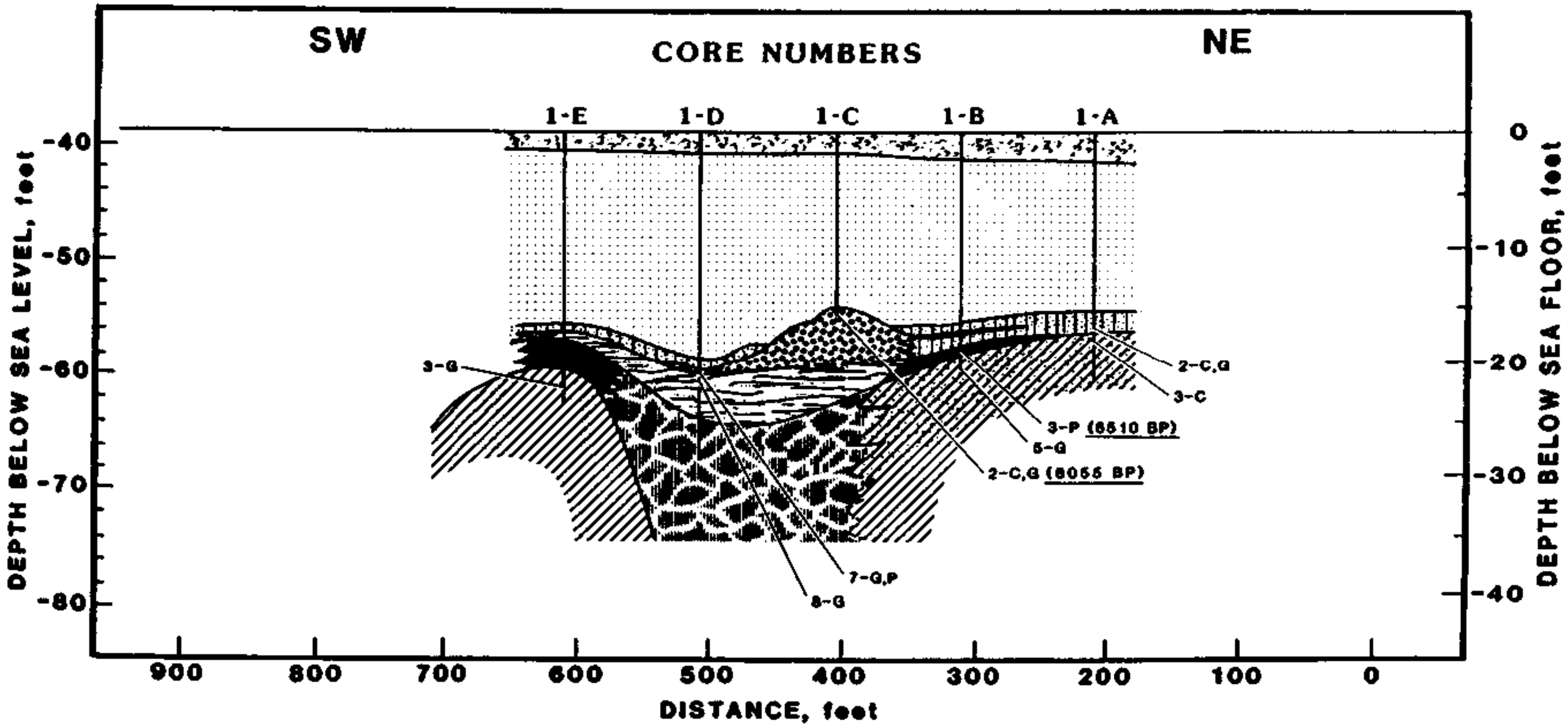


Figure 5-18. Geological interpretation of Core Line 1 in Sabine Pass 6.

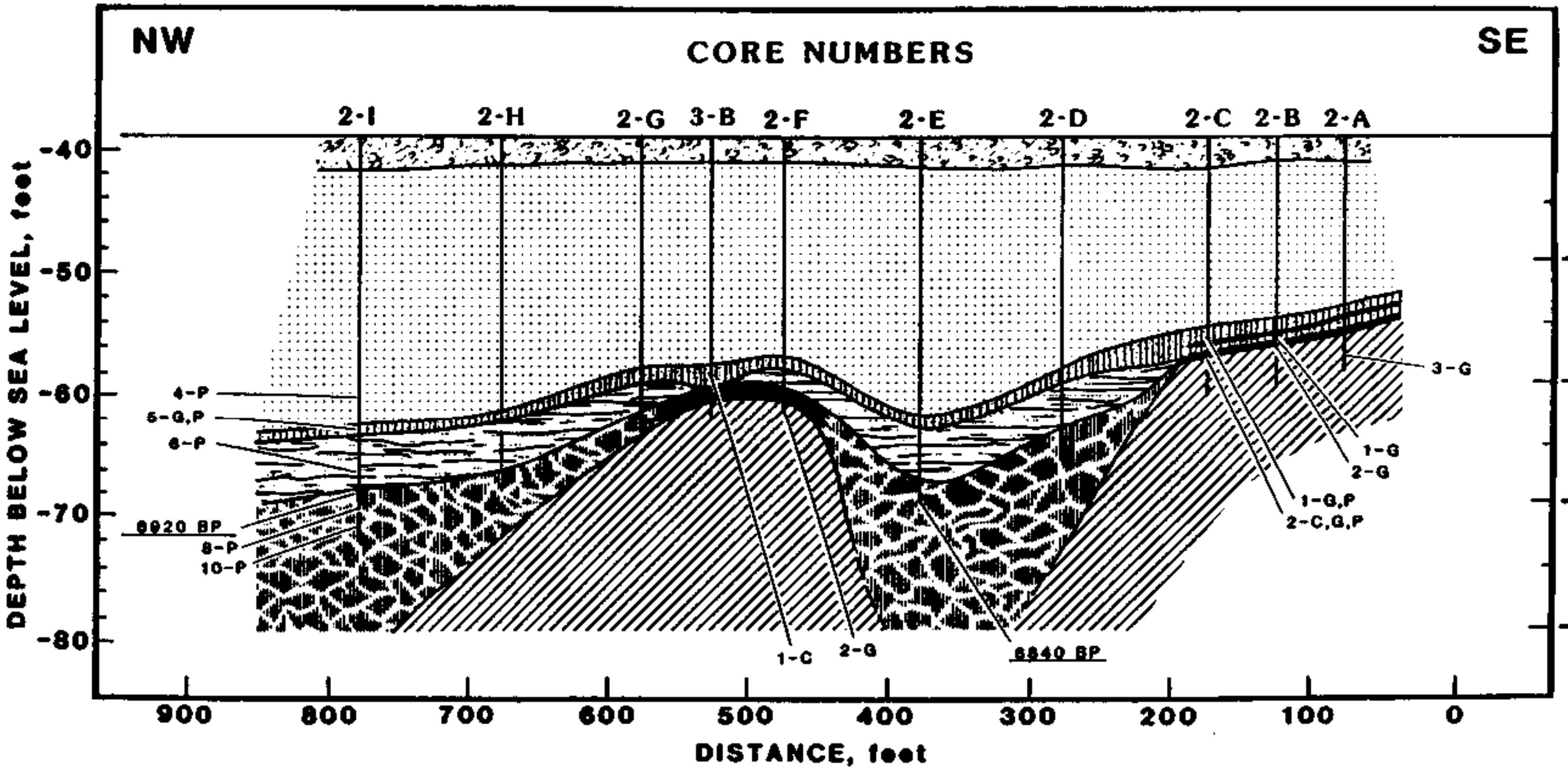


Figure 5-19. Geological interpretation of Core Line 2 in Sabine Pass 6.

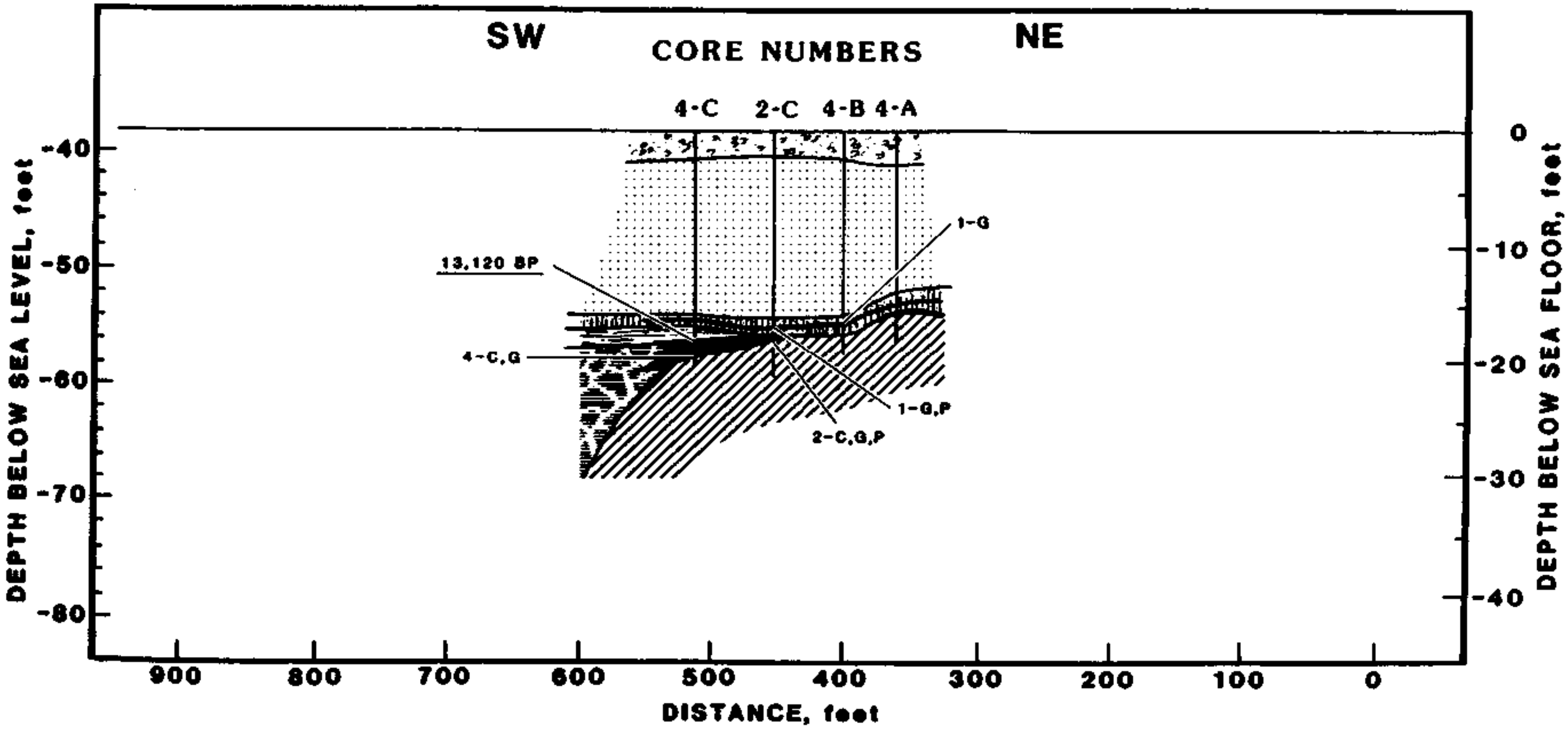


Figure 5-20. Geological interpretation of Core Line 4 in Sabine Pass 6.

features produce a distinguishable signature characterized by either a multitude of point-source diffractions or by a distinctive acoustic void (Roemer and Bryant 1977:133). No obvious point-source diffractions were noted in the area of the shell nor did the area of shell produce an acoustic void distinctive from that seen for Deweyville features in general. A similar inability to distinguish a shell deposit from a Deweyville surface was encountered in the High Island 49 area. It is obvious that, even when a seismic record is taken directly over a shell deposit, unless that deposit is quite extensive it will be difficult to identify it on the seismic records. In light of the vibracore data, it is now recognized that Core 1-C was placed at or near the north bank of the tributary channel, while Core 1-D was put down within the channel. Core 1-E, which is positioned within the channel on the inset in Figure 5-15, actually was placed across the channel on its south side.

The lowermost feature penetrated by any of the cores is interpreted as the Deweyville terrace. Along Core Line 1 it was hit by the basal portions of Cores 1-A, 1-B, and 1-E (see Figure 5-18). Cores 2-A, 2-B, 2-C, and 2-F hit it along Core Line 2, while all cores in Line 4 encountered the surface. In almost all cases the Deweyville terrace was marked by medium to thickly bedded, clays and silty clays exhibiting minimum to heavy oxidation, with colors ranging from light olive brown (2.5Y 5/6) to gray (2.5Y 5/0, 10YR 5/1) and light gray (10YR 6/1). In several cases fossilized root or worm burrow casts were found in the Deweyville (Figure 5-21). Two cores (1-A and 1-B) revealed a Deweyville deposit composed of oxidized fine sands and silty sands and thin clay seams. The sands generally were thickly bedded and gray (10YR 5/1) to light gray (10YR 6/1) in color (Figure 5-22).

While the Deweyville terraces generally have been referred to as sandy formations (see Chapter II), it should be recognized that variations exist, as in any widespread geological feature. In fact, it is likely that the southern portions of the Deweyville terrace cored in Block 6 are actually segments of channel fill within the batture of a large Deweyville channel. At least one of the small tributary channels may be the remnant of an underfit stream that once wound its way through the end of the filled Deweyville channel. Hints of this larger channel can be seen on the original lease-block survey (see Figure 4-4), and on one of our long seismic lines which crossed the southern edge of Sabine Pass 6. It appears as if the tributary channel extending to the south is the extremity of one of the obvious Deweyville channel segments identified in Sabine Pass 9, to be discussed below. While no Pleistocene-age Prairie/Beaumont surfaces were identified in this locale, the Prairie/Beaumont escarpment was identified on a long survey line about 1000 ft east of this area.

Two samples of clay portions of the Deweyville terrace were subjected to grain-size analyses (Samples SP6-1-E#3 and SP6-2-F#2) (see Figures 5-18 and 5-19). The results of these analyses are presented in Figure 5-23. Clearly there is a considerable difference between the two samples. Although only one was examined through pipette analysis, it is obvious that Sample SP6-1-E#3 consists of a significantly greater amount of sand-size particles (about 32%) than Sample No. 2 from Core 2-F (about 2%). This is a reasonable dichotomy if one considers the lower peninsula from which Sample SP6-2-F#2 came to be a portion of the batture within the filled Deweyville channel, while Sample SP6-1-E#3 is derived from the bank adjacent to the Deweyville channel. The latter would be more representative of a "typical" Deweyville surface.

The sandier segment of Deweyville terrace was examined through grain-size analysis of Samples No. 3 from Core 2-A and No. 5 from Core 1-B (see Figures 5-18 and 5-19). While these samples appear sandy, based on visual examination, the grain-size data suggest that only about 25% of the deposits consist of particles of sand size or greater (Figure 5-23). The size compositions of these seem to fall between that of the possible

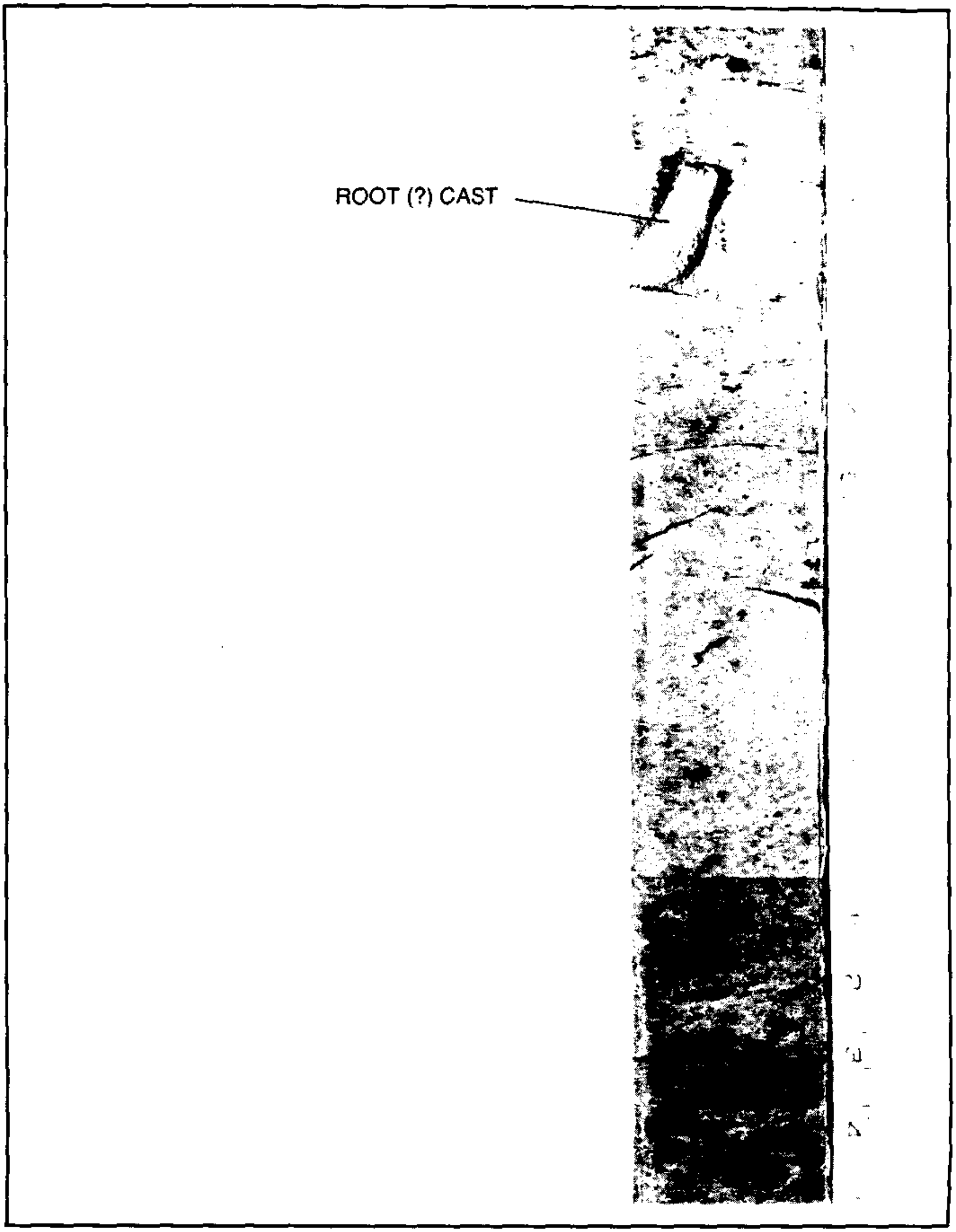


Figure 5-21. Deweyville Terrace deposits containing fossilized root (?) cast. Core 2-C, Sabine Pass 6.

Figure 5-22. Bedded sands and clays in interpreted Deweyville deposits. Core 1-A, Sabine Pass 6.

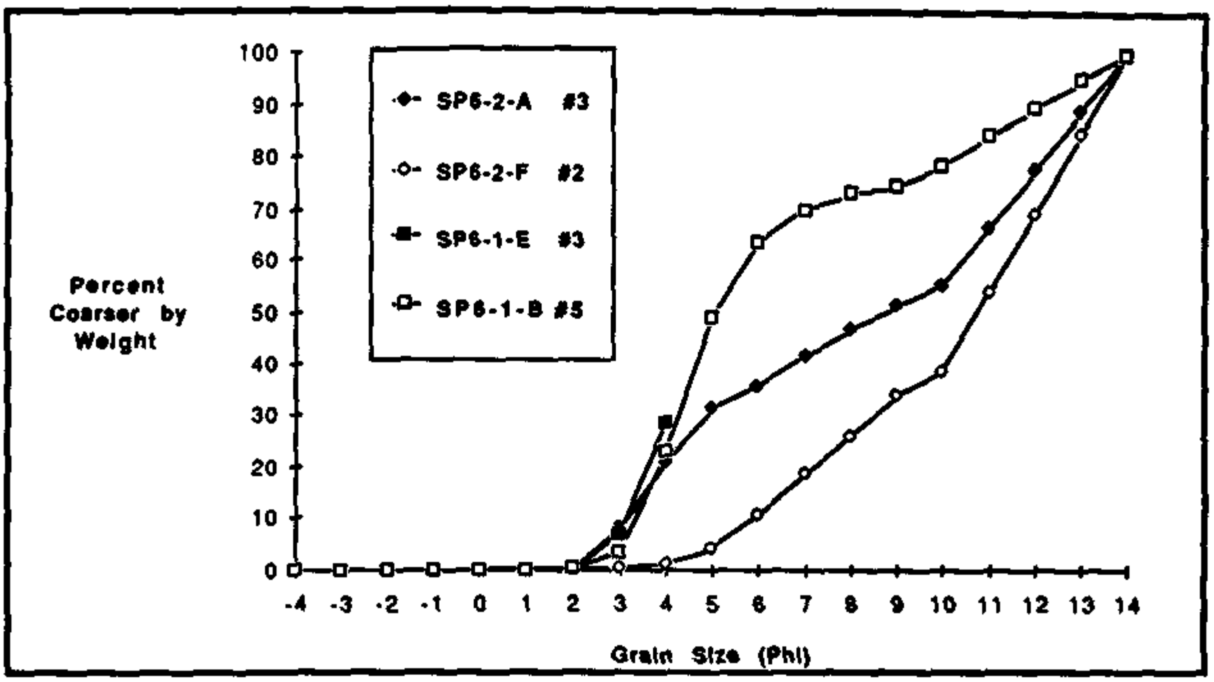


Figure 5-23. Grain-size curves for samples from identified Deweyville Terrace features in Sabine Pass 6.

clay plug (Sample SP6-2-F#2) and the sandier deposits seen north of the shell feature (Sample SP6-1-B#3). This may reflect natural levee deposits existing on the eastern side of the tributary channel. Sample SP6-2-F#2, as noted, may be from a clay plug within the batture of the Deweyville channel, and, thus, its grain-size signature is distinctly different.

Incised within the Deweyville deposits are the two smaller channels, both of which are filled with organic freshwater deposits. One of these channels was penetrated by Core 1-D as shown in Figure 5-18. The other, shown in Figure 5-19, was contacted by Cores 2-D and 2-E. Basal freshwater organics (peat) associated with the Sabine Valley proper were contacted by Cores 2-G and 2-I as shown in Figure 5-19. There appears to be little difference in the organic fill contacted in the two tributary channels and that in the Sabine Valley. All of Core 1-D is shown in Figure 5-24 to provide visual information on most of the strata identified in Sabine Pass 6.

Sample No. 10 from Core 2-I (see Figure 5-19) yielded a pollen profile suggestive of a swamp environment, although the presence of some grass pollen may argue for a nearby marsh. Sample No. 8 from the same core was barren of pollen. Dates of 8920 + 95 B.P. (UGa-5371) and 8840 ± 140 B.P. (UGa-5370) were obtained on the organic (peat) remains from Cores 2-I and 2-E, respectively (see Figure 5-19). The first of these came from fill within the Sabine Valley, while the second is on organics near the junction of the two tributary streams (see Figure 5-15, inset). These dates essentially are contemporaneous and suggest that at about 8900 B.P. this portion of the Sabine Valley was the locus of extensive stands of freshwater swamp.

A geological interpretation of Core Line 4 is presented as Figure 5-20. This line of cores extended across the peninsula formed by the junction of the two tributary streams (Inset, Figure 5-15). Core 4-C on this line fell on the eastern ridge of the southern tributary stream. Peat-like organics near the base of this core were thought

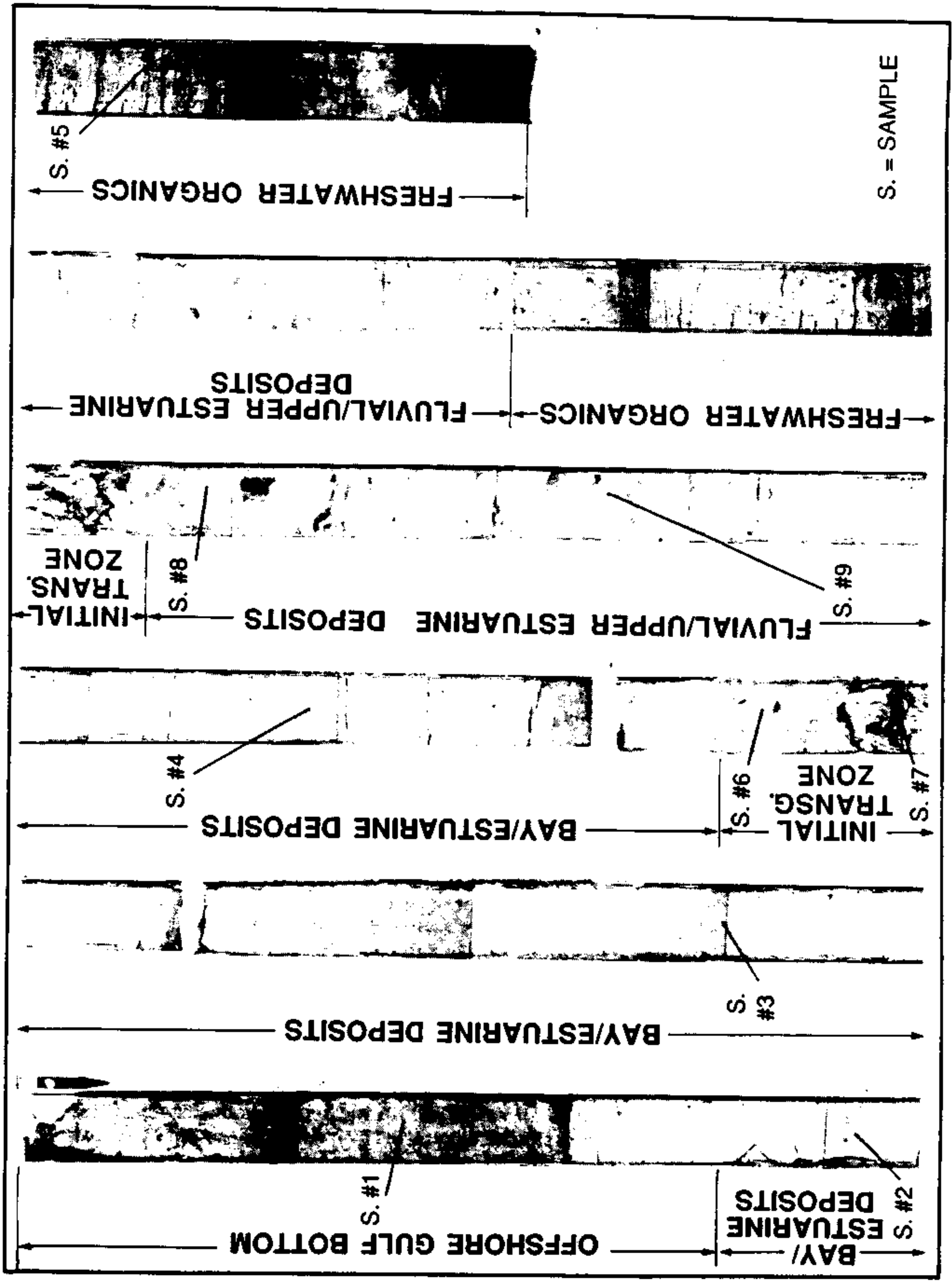


Figure 5-24. Core 1-D, Sabine Pass 6 area.

to be an extension of the organic fill of the tributary stream (Figure 5-25). However, a radiocarbon date of 13,120 ± 150 (UGa-5373) was obtained on this material, some 4280 years earlier than the date of the organic fill out in the small channel. Seeds recovered from this deposit (Sample SP6-4-C#4) include fresh to brackish marsh types (e.g., Carex sp., Scirpus olneyi and Cladium jamaicense) as well as upland types such as Rubus sp. and Sambucus sp. (see Table 5-1). Also included were numerous fragments of Rangia cuneata shell. This assemblage suggests a landform in, or adjacent to, a fresh to slightly brackish marsh.

Based on the above evidence, it seems unlikely that the date of 13,120 B.P. provides an accurate estimate of the age of the deposit. At about 13,000 years ago, all evidence (both from Nelson and Bray and Blocks 9, 18, and 49, to be discussed below) indicates that the Sabine Valley adjacent to Block 6 was the locus of a freshwater riverine system, and that estuarine marsh environments were situated much farther down the valley. It is probable, therefore, that either the date is in error, or the material dated is redeposited, having been eroded out of earlier sediments up the valley and subsequently deposited in Block 6. Since this is the only instance during the present study where a radiocarbon date disagreed to a large extent with the postulated environment from which it came, the authors favor the latter possibility. Overall, it seems likely that this deposit is equivalent to the basal organic layers to be discussed next.

One of the more widespread events recognized in the core data is the capping of much of the exposed Deweyville surfaces by several relatively thin organic and organic clay deposits. These deposits were encountered in several cores including 1-B, 2-A, 2-B, 2-C, 4-A and 4-B (Figures 5-18, 5-19, and 5-20). However, these deposits do not extend across the fill of the two tributary streams or out into the Sabine Valley to the west, suggesting that these latter areas still contained flowing bodies of water. It is difficult to interpret the environment (or environments) responsible for the deposition of these organics. They may represent a continuation of the fill sequence noted within the tributary streams and valley proper, which eventually lapped up onto the surfaces of the adjacent Deweyville terrace. In a few instances, however, they are distinctly different in visual appearance and lithology from the channel-fill deposits. For example, the latter deposits contain greater quantities of wood fragments and are more evenly bedded. Thus, the two deposits are illustrated by separate symbols in Figures 5-18, 5-19, and 5-20.

Pollen data are available on several samples from these organic deposits and provide additional support for separating these zones from the channel-fill deposits. Sample No. 3 from Core 1-B (see Figure 5-18) yielded a unique pollen profile typical of a bottomland hardwood forest (see Appendix B). The organics and associated pollen may have formed in a shallow depression atop the Deweyville terrace. A radiocarbon date of 8510 ± 95 B.P. (UGa-5372) was obtained on the organics. Pollen from Sample No. 2 in Core 2-C (see Figure 5-19) indicated a fairly extensive marsh (see Appendix B), while that from Sample No. 3, Core 3-A (not illustrated on the profiles) produced one of the largest amounts of grass pollen from any of the samples examined and almost certainly reflects a marsh environment (see Appendix B). This same sample produced a radiocarbon date of 8585 ± 95 B.P. (UGa-5374). Seeds from two of the point-count analyses of samples from these organic zones were also examined (see Table 5-1). Both are from deposits identified as marsh based on the pollen (Core 2-B, No. 2 and 2-C, No. 2). Scirpus was the dominant genus recorded, with the majority of these attributable to S. olneyi. These types suggest a brackish to strongly brackish marsh. Aside from the sample from Core 1-B, therefore, the organic deposits overlying the Deweyville probably were derived from marsh. It is likely that the deposit with the

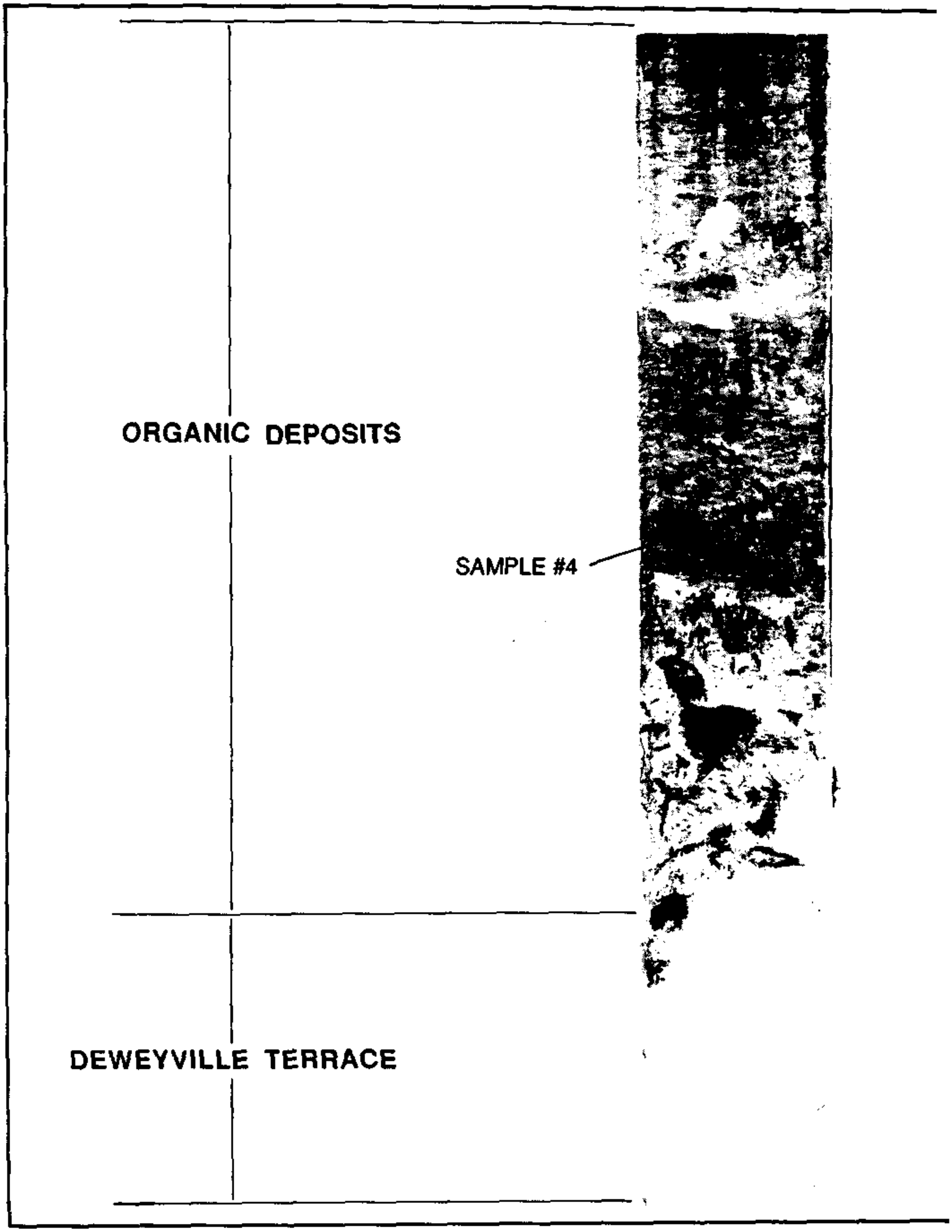


Figure 5-25. Basal deposits in Core 4-C at contact with underlying Deweyville surface, Sabine Pass 6 area.

highly questionable date of 13,120 B.P. also is from this same marsh. If so, this general capping of the area by marsh occurred about 8500 B.P. Two grain-size curves from these organic deposits, Samples SP6-2-C#1 and SP6-4-C#4, are shown in Figure 5-26.

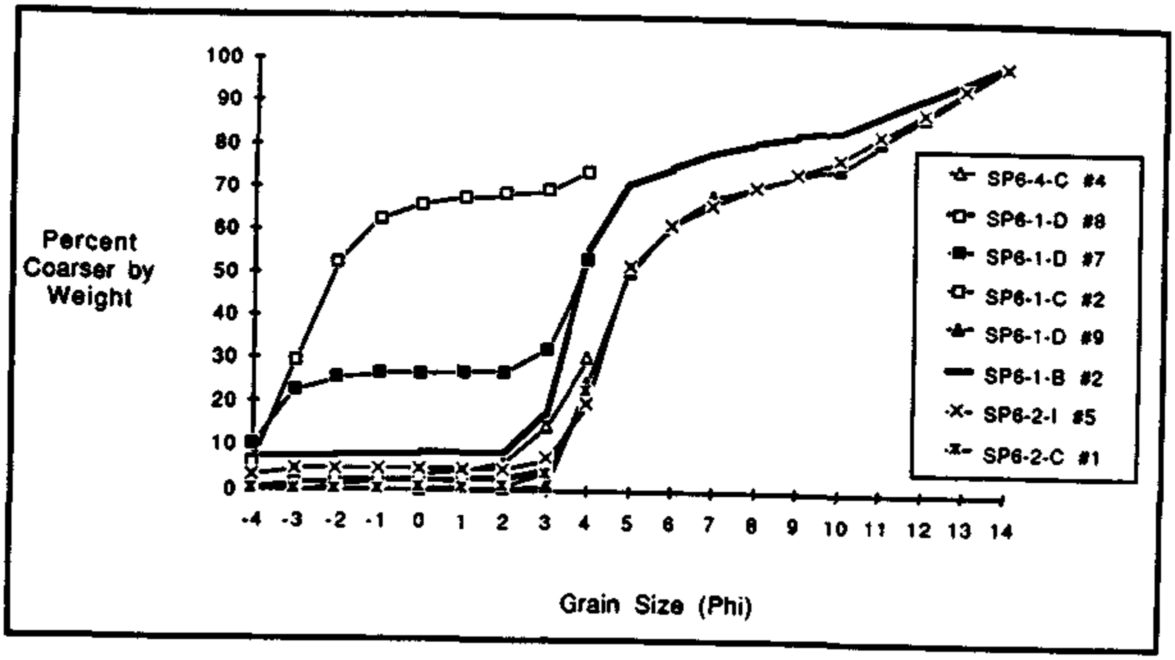


Figure 5-26. Grain-size distribution curves of selected samples from transgressive deposits and the Rangia shell feature in the Sabine Pass 6 area.

Following formation of the marsh and possible bottomland hardwood zones just discussed, much of the lower portion of the surveyed area was covered by a thin lens of fluvial or upper estuarine silts and sands. This zone is believed to be equivalent to the upper estuarine deposit noted in Sabine Pass 3 only a few miles to the north. There the deposit stratigraphically was bracketed between freshwater organics dated to 8995 B.P. and the initial transgressive zone dated to 7880 B.P. In Block 6 the deposit is bracketed by freshwater organics dated to 8920 and 8840 B.P. (and possibly the bottomland-hardwood deposit dated at 8510 B.P.) and a large Rangia shell deposit (to be discussed more fully below) dated at 8055 B.P. Judging by the radiocarbon dates, it appears that this portion of the Sabine Valley was receiving flow from a nearby Sabine River distributary channel or series of distributary channels for, at the most, 1100 to 900 years. Only one pollen sample (No. 6, Core 2-I) was processed from this deposit (see Appendix B). It had poor pollen preservation, reflecting mechanical degradation and possibly oxidation of pollen grains. Grain-size curves for this deposit, from Samples SP6-1-D#8 and SP6-1-D#9, are shown in Figure 5-26. Sample No. 8 was a coarse fraction analysis only while Sample No. 9 involved pipette analysis. This latter sample exhibits an abundance of silts and lesser amounts of clay and sand-size particles and is almost identical to the curve derived from the equivalent deposit in the Sabine Pass 3 area.

A relatively large deposit of primarily Rangia cuneata shell in a clay matrix was encountered above the upper estuarine/fluvial facies in the northern tributary channel (Figure 5-27). This deposit was encountered in Cores 1-C and 1-D as shown in Figure 5-18. The shell deposit apparently rests directly atop the estuarine sands and silts, and is partially covered by remains of the initial transgressive zone, to be reviewed next.

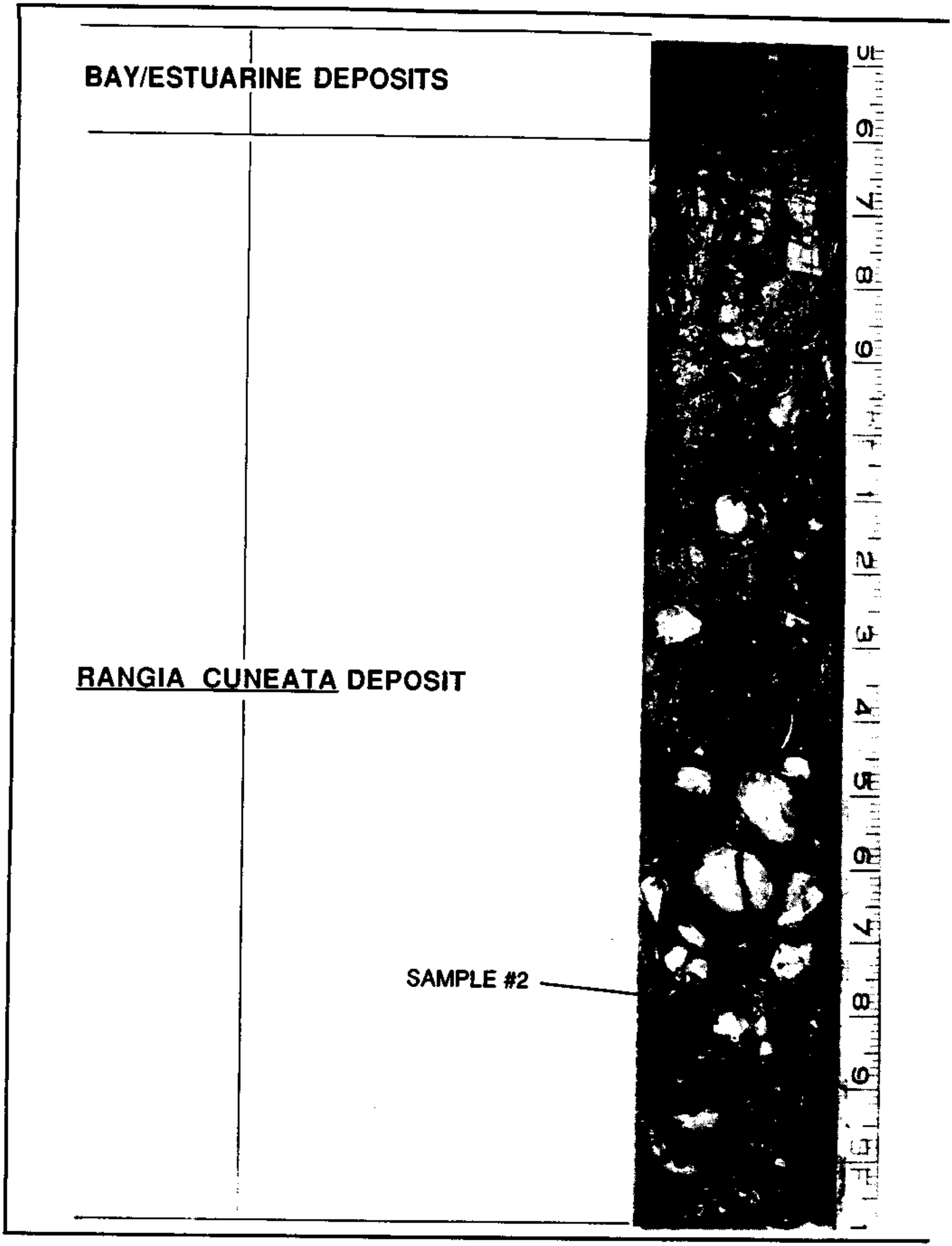


Figure 5-27. Rangia cuneata deposit encountered in Core 1-C, Sabine Pass 6 area.

The deposit is at least 150 ft wide where encountered by the vibracores. No other dimensions were obtained since, as noted earlier, the shell was not identifiable on the seismic records.

A pollen sample (SP6-1-D#7) obtained from the clay matrix of the shell deposit is of prime importance in interpreting the nature of the feature. The sample contains a relatively large percentage of well-preserved pollen, showing little damage related to water movement or redeposition. In addition, two of the key constituents of the assemblage are disturbance (Cheno/Am) and juniper (cedar) pollen (see Appendix B). Juniper is important here because it is a plant attracted to calcareous soils such as offered by a subaerially exposed shell deposit. An abundance of disturbance pollen is typical of archaeological sites in the southeastern United States. Other facies from the study area that contained Rangia shell had low juniper and Cheno/Am counts, while the condition of the pollen from such deposits tended to indicate degradation and damage from mechanical weathering. Thus, the pollen data suggest that the shell deposit was once subaerially exposed, and has remained relatively intact and undisturbed following marine transgression.

Additional samples from the shell deposit were subjected to grain-size analysis and radiocarbon dating. Grain-size analysis from the upper portion of the deposit produced a unique signature (Sample SP6-1-C#2), caused by the abundance of whole and fragmented Rangia, and showed that over 70% of the sample was comprised of particles greater than sand size (see Figure 5-26). Another sample from the flank of the shell deposit (SP6-1-D#7) exhibits a grain-size distribution slightly different than that in the center of the deposit (Figure 5-26). This sample contained few particles in the -3 phi to +3 phi size range, a reflection of the shattered nature of this flanking shell material. The sample submitted for radiocarbon dating came from the upper 2 ft of the shell deposit and consisted of fragmented Rangia shells which produced a date of 8055 ± 90 B.P. (UGa-5450).

This shell deposit is quite different from others encountered in the study area and in terms of geometry and location seems to resemble known archaeological deposits more closely than natural Rangia deposits. Elsewhere in the study area, Rangia shell was found as scattered individuals or as thin stratum primarily within the identified initial transgressive zone. A review of data from the coastal area of southwestern Louisiana and southeastern Texas indicates that thick, consolidated, almost pure Rangia shell deposits, such as the one found in Sabine Pass 6, are nonexistent or extremely rare. Cores taken from a variety of locales in the region indicate the presence of scattered Rangia in several types of brackish environments (Coleman 1966; McEwen 1969; Morton and McGowen 1983; Rehkemper 1969). Large shell reefs are not uncommonly encountered in buried deposits in coastal Louisiana and Texas. These, however, are either relict oyster reefs or beach deposits composed of reworked oyster, Rangia, and often a variety of other estuarine and marine shell species. These beach deposits also display a high sand content reflecting their deposition under high energy conditions.

Known early prehistoric archaeological deposits in coastal Texas and Louisiana often consist entirely or almost entirely of Rangia shell. While the dimensional data from the shell deposit in Sabine Pass 6 are limited, its estimated size and geometry fall within the range of that of known archaeological Rangia deposits. In addition, the earlier (Archaic) Rangia sites that have been examined in the lower Trinity River area yield very little in the way of artifactual, floral, or with the exception of Rangia, faunal material (Ambler 1973; Aten 1983). A small core sample taken from one of these middens would be unlikely to contain a distinctive, identifiable artifact. Dealing with Rangia middens of a later date, Gagliano et al. (1982) also indicated the rareness of easily identified artifacts in small core samples. The location of the shell deposit in Sabine Pass 6 (adjacent to a small stream which was a tributary to what was probably a brackish marsh at the time of occupation) is also consistent with settlement selection as indicated by known prehistoric site distributions.

Covering all previous surfaces, save the upper portion of the large shell deposit, the next identifiable deposit consists of what has been labeled the "initial transgressive zone" in the discussion of Sabine Pass 3. In almost all respects this zone is identical to that reported in Block 3, although here it contains lenses of organics (Figure 5-28). As noted above, these organics are common in transgressive deposits beneath the organics henier plain of southwest Louisiana, and there is no reason to believe that they should not occur in the present study area, as well.

Both the sandy clay and organic portions of the transgressive zone were examined for pollen and seeds, and analyzed for grain-size. Sample No. 5 from Core 2-I, from the sandy clay (see Figure 5-19), yielded pollen suggestive of a marsh (see Appendix B), while Sample No. 1 from Core 2-B (see Figure 5-19) contained one pondweed (Potamogeton sp.) seed, a primarily freshwater species (see Table 5-1). These data are in keeping with most of those found for the same zone in the other blocks sampled, implying that much of the contents of the transgressive zone is made up of reworked marsh. Only one grain-size analysis was run on the sandy clay portion of the zone. This sample, SP6-2-C#1, contained about 25% sand-size particles or larger, while a little over 70% of it was composed of particles larger than clay (Figure 5-26). This is within the general range of the grain-size distributions found for the transgressive zone in samples analyzed from other blocks.

The organic lenses within the transgressive zone were subjected to grain-size analysis and examined for pollen and seeds. The pollen data (see Appendix B) were somewhat less clear than that from the sandy clay segment, suggesting either a marsh/swamp interface or possibly a swamp. However, the seed assemblage (see Table 5-1) points to a brackish to highly brackish marsh, with identified elements of softstem bulrush (Scirpus validus), saltmarsh bulrush (Scirpus robustus), three-cornered grass (Scirpus olneyi), and sawgrass (Cladium jamaicense). Presumably, the seeds provide a more reliable indication of the environment responsible for the organic lenses within the transgressive zone than does the pollen. The grain-size curve for this organic lens is almost identical to that of the sandy clay portion of the transgressive zone (see Sample SP6-2-C#1, Figure 5-26). In this instance, however, many of the particles of sand size or greater are fragments of vegetal remains, such as stems, roots, or grass.

Above the transgressive zone is a relatively thick deposit of laminated clays which is similar, if not identical, to the same deposit discussed in Block 3. In both instances, a shallow bay or estuary is considered the environment of deposition. Because of the extensive sampling of this zone in Block 3, only one pollen sample (Core 2-I, Sample No. 4) was analyzed from Block 6. It yielded an assemblage which contained a moderate percentage of what is probably nonlocal pollen (see Appendix B). Approximately 24% consisted of pine (Pinus sp.) and 17% of oak (Quercus sp.), pollen types which may have entered the bay/estuary by means of the Sabine River or the numerous tributaries draining the uplands adjacent to the Sabine Valley.

No organic strata were identified within the massive estuarine clays as had been the case in the Sabine Pass 3 area. The lack of these facies here supports our contention that in the Sabine Pass 3 area they represent localized events of marsh development, changes in influx of freshwater, or the accumulation of organic detritus.

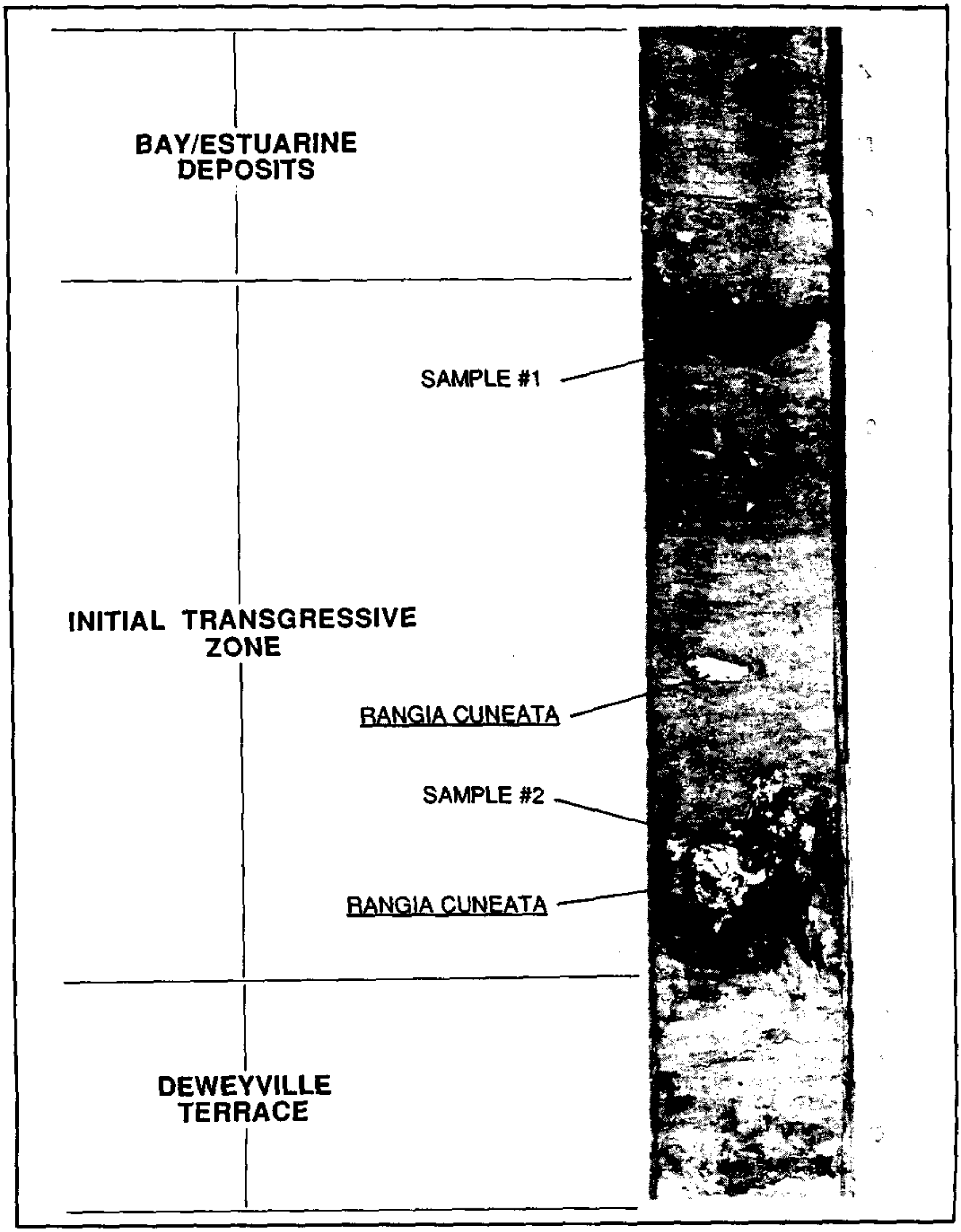


Figure 5-28. Initial transgressive zone in Core 2-C, Sabine Pass 6 area.

The uppermost stratum identified is a relatively thin zone of open marine deposits. These are identical to those noted in Block 3 and represent recent and ongoing inshore deposition.

Archeological Site Potential

The Sabine Pass 6 locale exhibits a coincidence of landforms that was considered to have the highest potential for prehistoric sites of any of the five blocks cored. The juncture of streams adjacent to, or overlooking, the main Sabine River valley presents optimum conditions for site occurrence. As in Sabine Pass 3, we anticipated that intact or minimally disturbed archaeological deposits could only occur within or below the initial transgressive zone. The one exception to this is the Rangia shell deposit which seems to project slightly above the initial transgressive facies. The occurrence of organic lenses within the initial transgressive zone is suggestive of minimal or discontinuous disturbance. Radiocarbon dates suggest that initial transgression occurred after about 8000 B.P. Following that, the area was covered by estuarine sediments. Based on our interpretation, human occupation of this area would not have been possible after 8000 B.P. Therefore, samples used in the assessment of the locale's archaeological potential were gathered primarily from the Rangia shell deposit, the initial transgressive zone, and strata immediately under the transgressive zone. As noted earlier, the Rangia shell deposit was of particular interest in that its configuration, location, pollen assemblage, and possibility of subaerial exposure, reflected similarities with known archaeological deposits.

Point-Count Analysis

Thirteen sample locations were chosen for detailed point-count analysis (Tables 5-7 and 5-8). It should be noted that in a few instances, when a specific sample yielded material suggestive of a possible archaeological site, an additional amount of material was taken from the opposite core half adjacent to the original sample. This was done in an effort to increase the sample volume and, it was hoped, produce an artifact or definite indicator of human occupation. This additional quantity of sample matrix is referred to as the "unsampled one-half" or, simply, "US".

As shown in Tables 5-7 and 5-8, several samples produced bone, some of which was carbonized or charred (of which a few pieces actually were calcined), and one sample produced stone. The concentrations of bone in these samples were higher than in any other collected. Counts were as high as 700 particles of bone per kilogram of sample. The occurrence of bone is one of the criteria identified in the Gagliano et al. (1982) study as a strong indicator of an archaeological deposit. Although minor amounts of bone occur in certain natural deposits, Coleman (1966:Table 7) does not report bone from the marsh facies he examined in coastal Louisiana. Rather, bone was found to be common only in nearshore marine facies and rare, but present, in beaches, oyster reefs, mud flats, and brackish bay deposits (Coleman 1966:Table 7). Furthermore, Coleman reports finding only fish bone. The quantity of burned and unburned bone recovered in the Sabine Pass 6, along with its concentration and variety (see below), suggests that these samples are unique.

The distribution of those cores producing bone are shown as a schematic map of the area examined in Sabine Pass 6 (Figure 5-29). Two concentrations are apparent, the Rangia shell pile and several cores around the junction of Core Lines 2 and 4. The sample containing the one bone in Core 2-H (Sample No. 2 from the fluvial/upper estuarine silts and sands) was not included in the point-count analyses since the bone from it almost certainly represents a natural inclusion in the deposit.

Table 5-7. Point Counts for Sabine Pass 6 Area: -1 Phi Fraction Expressed in Particles per Kilogram.

	SAMPLES														
COMPONENT	SP6-1-A#2	SP6-1-B#5	SP6-1-C#2	SP6-1-C#2US	SP6-1-D#7	SP6-1-D#8	SP6-2-B#1	SP6-2-B#2	SP6-2-C#1	SP6-2-C#2	SP6-2-C#2US	SP6-2-F#2	SP6-4-B#1	SP6-4-C#4	SP6-4-C#4US
Marine shell															
Oyster shell					4	76									
Mussel shell															
Barnacle/brackish species						6	4			5					
Rangia sp. shell	5		2628	1073	298	69	13	148		270	493			7	10
Unidentified shell					8		17	23						34	31
Iron nodule/pyrite											14		17		4
Clastic/clastic concretion								31			28		76		22
Carbonate concretion			32	8	34			23							24
Vegetal material			9				4					51		40	126
Charred vegetal material			68	8	8	6	26	343		47	503			1373	135
Seed							4							14	
Bone							17	16		5	23		8	75	51
Charred bone														28	10
Crustacean exoskeleton															
Stone															
Landsnails															
Other															

Table 5-8. Point Counts for Sabine Pass 6 Area: 0 Phi Fraction Expressed in Particles per Kilogram.

	SAMPLES														
COMPONENT	SP6-1-A#2	SP6-1-B#5	SP6-1-C#2	SP6-1-C#2US	SP6-1-D#7	SP6-1-D#8	SP6-2-B#1	SP6-2-B#2	SP6-2-C#1	SP6-2-C#2	SP6-2-C#2US	SP6-2-P#2	SP6-4-B#1	SP6-4-C#4	SP6-4-C#4US
Marine shell															
Oyster shell					4	63									
Mussel shell	5														
Barnacle/brackish species						19	9			42					
Rangia sp. shell	5		2612	1110	319	95	13	62		88	1391				150
Unidentified shell	59	26	36	30		189	66	156	10	562	108	17	25	136	14
Iron nodule/pyrite													25		12
Clastic/clastic concretion			108	148	59	25	31	110	10	161	136		302	163	182
Carbonate concretion					147										
Vegetal material						19	40		213			128	17	3638	682
Charred vegetal material	5		72	110	80	76	31	3042	349	286	1429		17	3951	1574
Seed		7			4		4	32	146	31	263			252	85
Bone			56	32	4	19	4		10	21	75			347	116
Charred bone				4		6	4	16	10	16	19			374	355
Crustacean exoskeleton															
Stone															4
Landsnails															
Other															

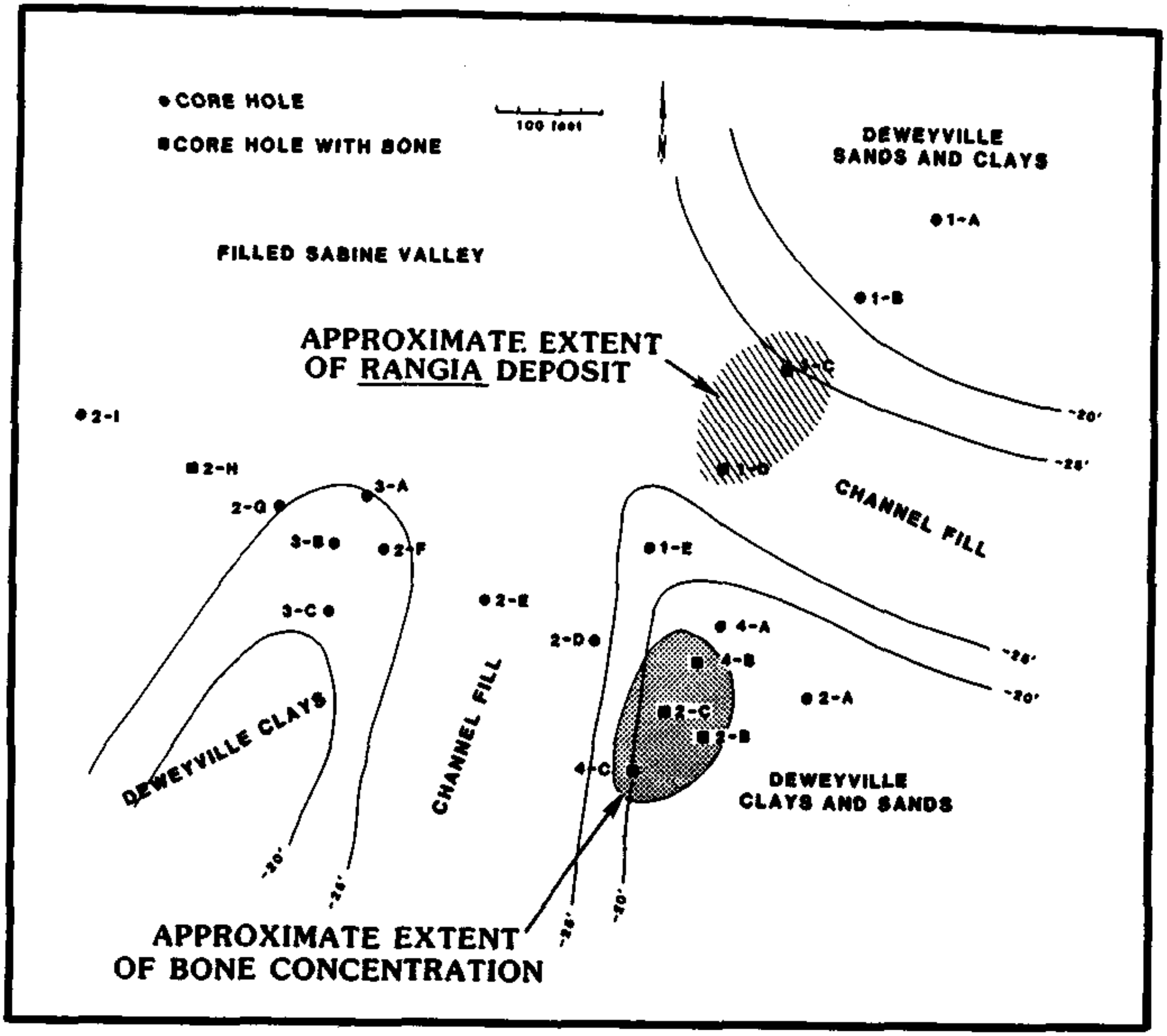


Figure 5-29. **Schematic map of cored area in Sabine Pass 6, showing bone concentration and *Rangia* shell deposit.**

In the *Rangia* deposit three samples are of interest: SP6-1-C#2; SP6-1-D#7; and SP6-1-D#8 (see Figure 5-18 and Tables 5-7 and 5-8). The first sample is from a two-foot-long section of core which penetrated the shell feature. The principal component of the sample was *Rangia cuneata* shell, including, in both the -1 phi and 0 phi fractions, over 1500 fragments (which become over 5200 when converted to counts per kilogram for the point-count tables) and at least 16 whole valves. Both the fragments and whole valves showed minimal wear suggesting, we believe, lack of reworking and redeposition. Also included in the matrix were several carbonate and clastic concretions, wood fragments, and charred vegetal matter. The 0 phi fraction of samples SP6-1-C#2 and SP6-1-C#2US contained eight bone fragments. Those which could be identified included three fish vertebrae, one fish vertebral spine, and one gar scale which may have been burned. Sample SP6-1-D#7 is from a thin lens of *Rangia* shell believed to be the southern edge of the large deposit (see Figure 5-18). Again, the principal component of the sample was *Rangia cuneata* shell. Other elements in the matrix include carbonate and clastic concretions, carbonized vegetal matter, one carbonized seed, two oyster shell fragments, and one possible fish scale.

The final sample (No. 8 from Core 1-D) is from the fluvial/upper estuarine deposit immediately underlying the *Rangia* lens examined in Sample No. 7 (see Figure 5-18). Although not a part of the shell deposit, per se, this sample apparently has been influenced to a moderate degree by elements within the *Rangia* lens. Thus, incorporated within the sample were *Rangia* and oyster shell fragments, carbonized and noncarbonized vegetal material, one barnacle, and one burned and three unburned bones. Of the latter, the three unburned bones are unidentifiable fragments, while the burned bone is probably fish.

The second area of interest is the peninsula formed by the juncture of the two small streams. Cores of interest in this area are Cores 2-B, 2-C, 4-B, and 4-C (see Figure 5-29). Here, by far the greatest quantity of bone, both burned and unburned, was located in any of the areas cored. What is unusual is the fact that the bone comes from several distinct strata both below and within the transgressive zone. Samples to be discussed include the following: 2-B, #1; 2-B, #2; 2-C, #1; 2-C, #2; 4-B, #1; and 4-C, #4 (see Figures 5-19 and 5-20 and Tables 5-7 and 5-8). These will be reviewed by apparent order of deposition.

The most prolific of these samples is that from near the bottom of Core 4-C (Samples SP6-4-C#4 and SP6-4-C#4US in Tables 5-7 and 5-8). As noted earlier, the organics encountered just above this sample, and responsible for the questionable date of 13,120 B.P., are probably from a setting adjacent to a fresh to slightly brackish marsh. As can be seen in Tables 5-7 and 5-8, the sample yielded bones and scales in both the -1 phi and 0 phi screen sizes. Included (in actual counts) are 94 unburned bones, 182 burned bones (of which eight are calcined), 52 unburned fish scales, and 12 burned fish scales. Identified elements included one vertebra from a water snake (*Natrix* sp.), one burned amphibian vertebra, one mammalian long bone fragment (possibly from a mammal the size of a squirrel or rabbit), 12 burned gar (*Lepisosteus* sp.) scales, seven unburned gar scales, one burned gar mandible, one burned fish mandible, six burned fish vertebrae, two burned fish vertebral spines, and numerous fish bones most of which are burned. Also included in the sample were carbonized and noncarbonized seeds (see Table 5-1), carbonized nut hulls, carbonized and noncarbonized vegetal matter, ferric, carbonate, and clastic concretions, several quartz grains, and two pieces of stone. One of the latter fragments is a lightly water-polished, blocky piece of gray cryptocrystaline stone. One portion contains a reddish cortex. The fragment, found in the 0 phi fraction, may represent a large sand grain; however, it is more angular and is not a clear or whitish quartz as are all of the others found in this sample. The other piece, also found in the 0 phi fraction, is a white, fine-grained, tabular cryptocrystaline stone. The edges are more angular than any of the other clastics found in the sample and seem to be minimally water worn, if at all. Both of these pieces are extremely small, with maximum dimensions of less than 3 mm. Lastly, fragments of *Rangia* shell were recovered in both size fractions. The *Rangia* in these samples consist of small, worn fragments. There is no evidence that larger pieces or possibly whole valves were encountered by the core. No oyster, mussel or other estuarine shell, other than *Rangia*, were identified in the samples from Core 4-C.

Samples 2-B, #2 and 2-C, #2 probably represent portions of the same deposit responsible for the remains in Core 4-C. As can be seen in Figure 5-20, the samples are from a thin bed of organics lying directly atop the Deweyville terrace and immediately below the initial transgressive zone. As noted earlier, this organic lens is most likely derived from a brackish to strongly brackish marsh.

Material from Sample No. 2 in Core 2-B (see Tables 5-7 and 5-8) contained a large quantity of carbonized vegetal matter, including several seeds, Rangia and unidentified shell fragments, carbonate concretions, and 11 clastic concretions of which a few appear to be fired clay. Burned and unburned bone were also present, including one burned fish bone, one unburned fish vertebra, one possible gar scale (burned), one possible bird long bone fragment (unburned), and one unburned bone fragment of possibly a small mammal or reptile. Sample No. 2 from Core 2-C was somewhat similar (see Tables 5-7 and 5-8), with the addition of several barnacle fragments, oxidized concretions, and whole Rangia valves. The latter were moderately worn and chalky to the touch. Bones were somewhat more prevalent, including (in actual counts) 23 unburned fragments, five burned pieces (of which one was calcined), and four fish scales. Identifiable elements consisted of four fish bones (two of which were burned), three gar scales (two of which were burned), one gar mandible fragment, one burned fish vertebral spine, and two mammal or bird long bone fragments.

The final series of samples (2-B, #1; 2-C, #1; and 4-B, #1) is from the thin organic lens located within the initial transgressive deposit. Based on the seeds found within the organics (see Table 5-1), and as noted above, it is likely the zone represents the remains of a brackish to strongly brackish marsh. Point counts (see Tables 5-7 and 5-8) suggest a very similar matrix to that recognized in the marsh zone situated below it, and represented in Samples 2-B, #2 and 2-C, #2. Of particular interest, again, are the bone fragments. Sample No. 1 from Core 2-B yielded one burned and two unburned fragments. Sample No. 1 from Core 2-C produced one burned and one unburned fragment, while Sample No. 1 from Core 4-B contained eight bone fragments and one gar scale. Of note in the latter sample is one mammalian long bone fragment and the fact that the gar scale may be burned.

The overall concentration of bone, including burned fish and possibly mammal or reptile, occurred only in this one area, and is related to at least two different strata. Since burned bone plus carbonized seeds and vegetal matter occur, the elements involved must have been subaerially exposed. One can envision scenarios in which marsh or forest fires might burn the floral and terrestrial faunal remains located there, but burned fish bone, particularly in the quantity encountered, is difficult to explain as a natural occurrence. If the fish were deposited atop the bank during high water, a more widespread distribution would be expected. Yet Cores 1-E, 2-A, 2-D, and 4-D, from the same area, failed to produce any bone at all.

Several explanations for the bones' presence in the different strata can be postulated. The hypothesis preferred here is that the bones found in the two different strata actually are from one parent deposit. Reworking of that deposit by transgression would account for the bones within the transgressive zone. Organics within the transgressive strata suggest that transgression was not a constant process, but stopped for infrequent periods of relatively short duration. These periods were sufficiently long, however, for the formation of the organic lenses. If this is the case, then the parent deposit must be the organic zone immediately overlying the Deweyville terrace and encountered near the base of Cores 4-C, 2-B, and 2-C. Based on the radiocarbon dates from what is believed to be the same deposit in Cores 1-B and 3-A, it is suggested that the parent material dates to about 8500 B.P.

Rangia Shell Analysis

In an effort to further assess the nature of the shell deposit in Block 6, seasonality and population estimates were obtained on whole Rangia valves from Samples SP6-1-C#2 and and SP6-1-D#7. These were compared to both natural and archaeological deposits in the Gulf coastal zone. Due to the small size of the shell components, 15 valves from Sample SP6-1-C#2 and 9 from SP6-1-D#7, the valves were combined into a single sample.

A seasonality estimation procedure was performed on the Rangia valves following the technique described by Aten (1981:179-200). The resultant histogram is presented in Figure 5-30. On the basis of a visual comparison of this histogram with those in Aten's master sequence, the closest collection period match for the Block 6 sample was mid-April. Aten has recently begun using an adaptation of a Fortran program to determine goodness-of-fit between archaeological samples and a model of natural seasonal growth patterns. Aten's (personal communication 1986) statistical analysis of the Block 6 data resulted in a poor fit or "neutral" result; that is, the season of collection could not be determined with statistical reliability. The problem appears to be in the late Rangia growth-stage category. The frequency of this category is too high. To match the histogram or data for mid-April, the frequency percentage should be on the order of 4% rather than the observed 17%. Several explanations are possible for this discrepancy: small sample size, a natural origin for the Rangia shell deposit, or an archaeological deposit representing multiple seasons of collection. Or, as discussed below, there may be problems with the assumptions underlying the procedure (Weinstein and Whelan 1986).

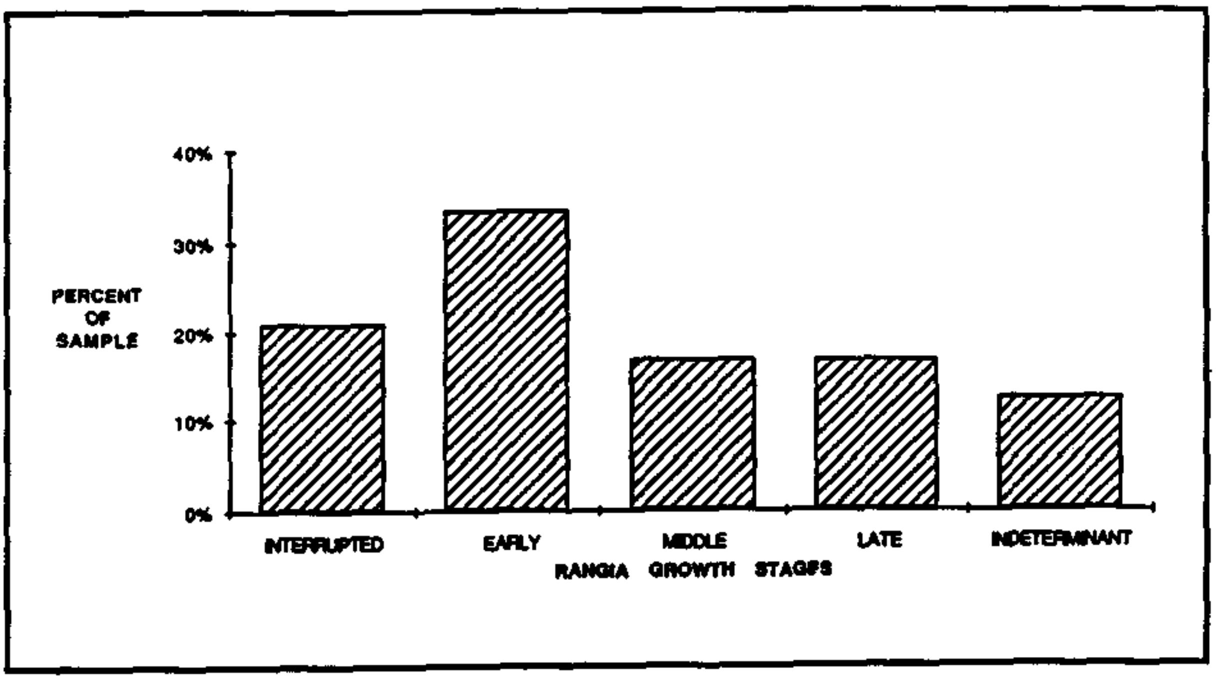


Figure 5-30. Seasonality estimate histogram for Rangia from the shell deposit encountered in Cores 1-C and 1-D.

Aten (1981:182) has assumed that all annual growth increments for a particular shell are equal. Yet, data he himself presents indicate a general decrease in the annual growth increment through time. The regularity or lack of regularity in annual growth increments is a major factor in seasonality estimation. If the annual increment is regular, for example 9 mm, then determining the growth stage at the time of collection is straightforward. An incomplete increment of less than 3 mm indicates the early season, one of 3 to 6 mm, middle, and so on. If, however, the height of the growth increment decreases each year, as it appears to do, then determining seasonality becomes much more difficult. Should the annual growth increment decrease by 23%, for example, and the last complete growth stage measures 9 mm, then the incomplete increment has a potential complete measurement of approximately 7 mm. Thus, an incomplete increment of 5 mm in width, would fall into the late category and not the middle, as would be the case if there was no decrease in annual growth height. It is possible that the analyst's subjective interpretation of the Rangia growth pattern may result in inflating the frequency of one category at the expense of another.

Previous studies have suggested that there are no distinctive population structure features that facilitate the differentiation of natural and archaeological Rangia deposits (Weinstein and Whelan 1986). Nonetheless, a population curve based on size classes was prepared for the Block 6 sample and compared with similar curves from both natural deposits (Figure 5-31) and archaeological deposits (Figure 5-23) of Rangia valves. Due to the small sample size, the population curve for the Block 6 sample is polymodal. It must also be noted that some umbo fragments, showing fresh breaks, from the sample indicate the presence in the deposit of valves in the 50-60 mm size classes.

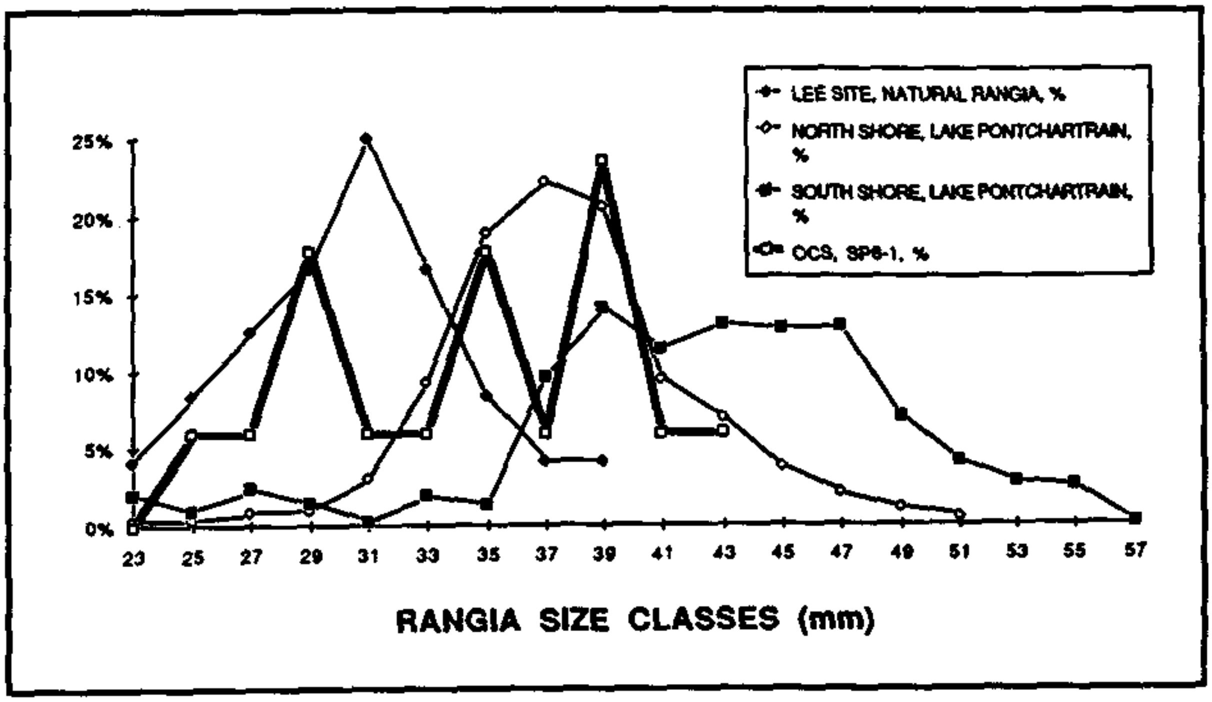


Figure 5-31. Comparison of the Sabine Pass 6 Rangia population curve with those from three natural populations.

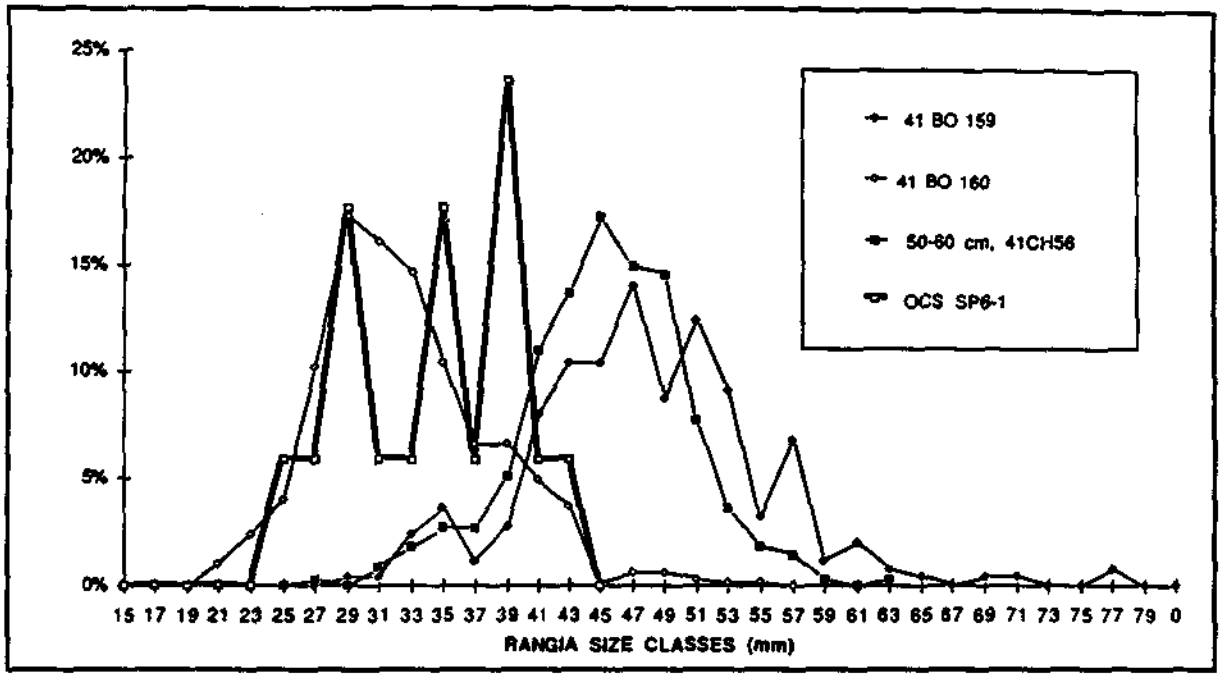


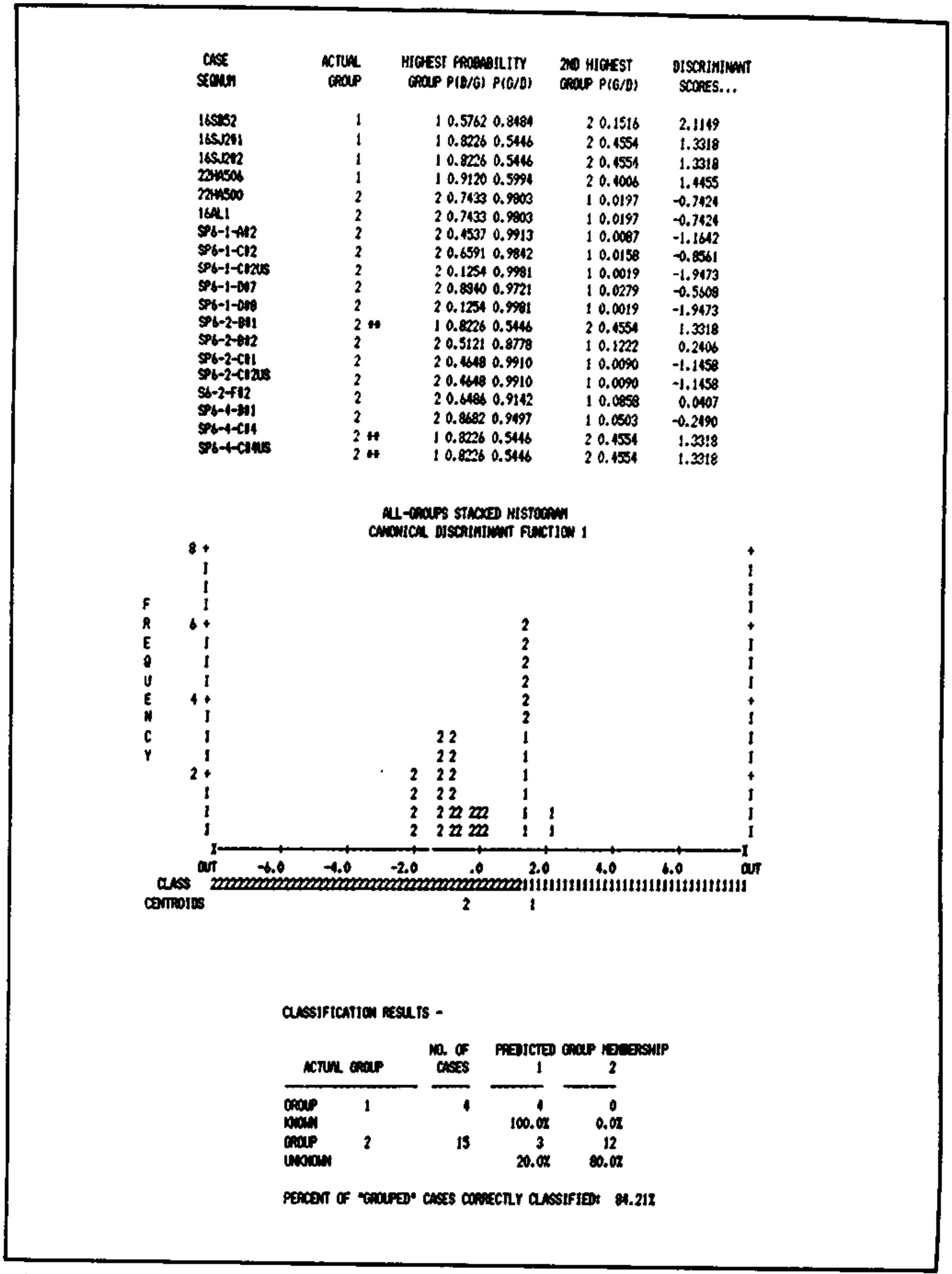
Figure 5-32. Comparison of the Sabine Pass 6 Rangia population curve with those from three prehistoric archaeological deposits.

An examination of Figures 5-31 and 5-32 shows no similarity of shape between the Block 6 sample and any of the other six samples. With regard to size range, the closest match in the natural population comparison is with the Lee site material (Figure 5-3), while the closest agreement in the archaeological deposit comparison is with the curve for 41 BO 160. These results indicate the current difficulty in distinguishing natural from archaeological Rangia using size compositions. Neither the seasonality nor population data from the Rangia deposit are definitive in indicating whether or not it is an archaeological site.

Discriminant Analysis

With recognition of the highly unique qualities of many of the samples mentioned above, the various point-count data (see Tables 5-7 and 5-8) from Block 6 were subjected to discriminant analyses, as discussed earlier under the review of Sabine Pass 3. The variables used were Rangia shell, unidentified shell, vegetal material, charred vegetal material, and bone. Figures 5-33 and 5-34 show the results of these analyses for the -1 phi and 0 phi fractions, based on the presence or absence of key elements. Figures 5-35 and 5-36 show the results of the same analysis on the -1 phi and the 0 phi fractions; but, in this case the actual counts, rather than presence or absence, were used as the basis for the analysis.

Using the -1 phi point-count data (Figures 5-33 and 5-35), it can be seen that when presence/absence criteria are considered, three samples, No. 1 from Core 2-B, and the two samples from Core 4-C, were classed as sites. All three of these samples contain the combination of Rangia shell, bone, and vegetal material. The results of the quantitative analysis of the -1 phi fraction is presented in Figure 5-35. Spatially the two groups are distinct; however, one site sample, 22 HA 506, was placed within the nonsite group because of its lack of Rangia shell.



```
CASE            ACTUAL    HIGHEST PROBABILITY   2ND HIGHEST    DISCRIMINANT
SEQNUM          GROUP     GROUP P(D/G) P(G/D)   GROUP P(G/D)   SCORES...

16S052            1           1 0.5762 0.8484      2 0.1516       2.1149
16SJ201           1           1 0.8226 0.5446      2 0.4554       1.3318
16SJ202           1           1 0.8226 0.5446      2 0.4554       1.3318
22HA506           1           1 0.9120 0.5994      2 0.4006       1.4455
22HA500           2           2 0.7433 0.9803      1 0.0197      -0.7424
16AL1             2           2 0.7433 0.9803      1 0.0197      -0.7424
SP6-1-A02         2           2 0.4537 0.9913      1 0.0087      -1.1642
SP6-1-C02         2           2 0.6591 0.9842      1 0.0158      -0.8561
SP6-1-C02US       2           2 0.1254 0.9981      1 0.0019      -1.9473
SP6-1-D07         2           2 0.8940 0.9721      1 0.0279      -0.5608
SP6-1-D08         2           2 0.1254 0.9981      1 0.0019      -1.9473
SP6-2-B01         2 **        1 0.8226 0.5446      2 0.4554       1.3318
SP6-2-B02         2           2 0.5121 0.8778      1 0.1222       0.2406
SP6-2-C01         2           2 0.4648 0.9910      1 0.0090      -1.1458
SP6-2-C02US       2           2 0.4648 0.9910      1 0.0090      -1.1458
S6-2-F02          2           2 0.6486 0.9142      1 0.0858       0.0407
SP6-4-B01         2           2 0.8682 0.9497      1 0.0503      -0.2490
SP6-4-C04         2 **        1 0.8226 0.5446      2 0.4554       1.3318
SP6-4-C04US       2 **        1 0.8226 0.5446      2 0.4554       1.3318
```

```
                          ALL-GROUPS STACKED HISTOGRAM
                        CANONICAL DISCRIMINANT FUNCTION 1
       8 +                                                                               +
         I                                                                               I
         I                                                                               I
F        I                                                                               I
R      6 +                                              2                                +
E        I                                              2                                I
Q        I                                              2                                I
U        I                                              2                                I
E      4 +                                              2                                +
N        I                                              2                                I
C        I                                 2 2          1                                I
Y        I                                 2 2          1                                I
       2 +                             2   2 2          1                                +
         I                             2   2 2          1                                I
         I                             2   2 22 222     1  1                             I
         I                             2   2 22 222     1  1                             I
         X---------+---------+---------+---------+---------+---------+---------+---------X
        OUT      -6.0      -4.0      -2.0        .0       2.0       4.0       6.0       OUT
  CLASS   2222222222222222222222222222222222222222222222111111111111111111111111111111111
CENTROIDS                                      2        1
```

```
CLASSIFICATION RESULTS -

                          NO. OF    PREDICTED GROUP MEMBERSHIP
   ACTUAL GROUP           CASES          1           2
--------------------     ------     --------    --------

GROUP       1                4           4           0
KNOWN                                100.0%        0.0%
GROUP       2               15           3          12
UNKNOWN                               20.0%       80.0%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED:  84.21%
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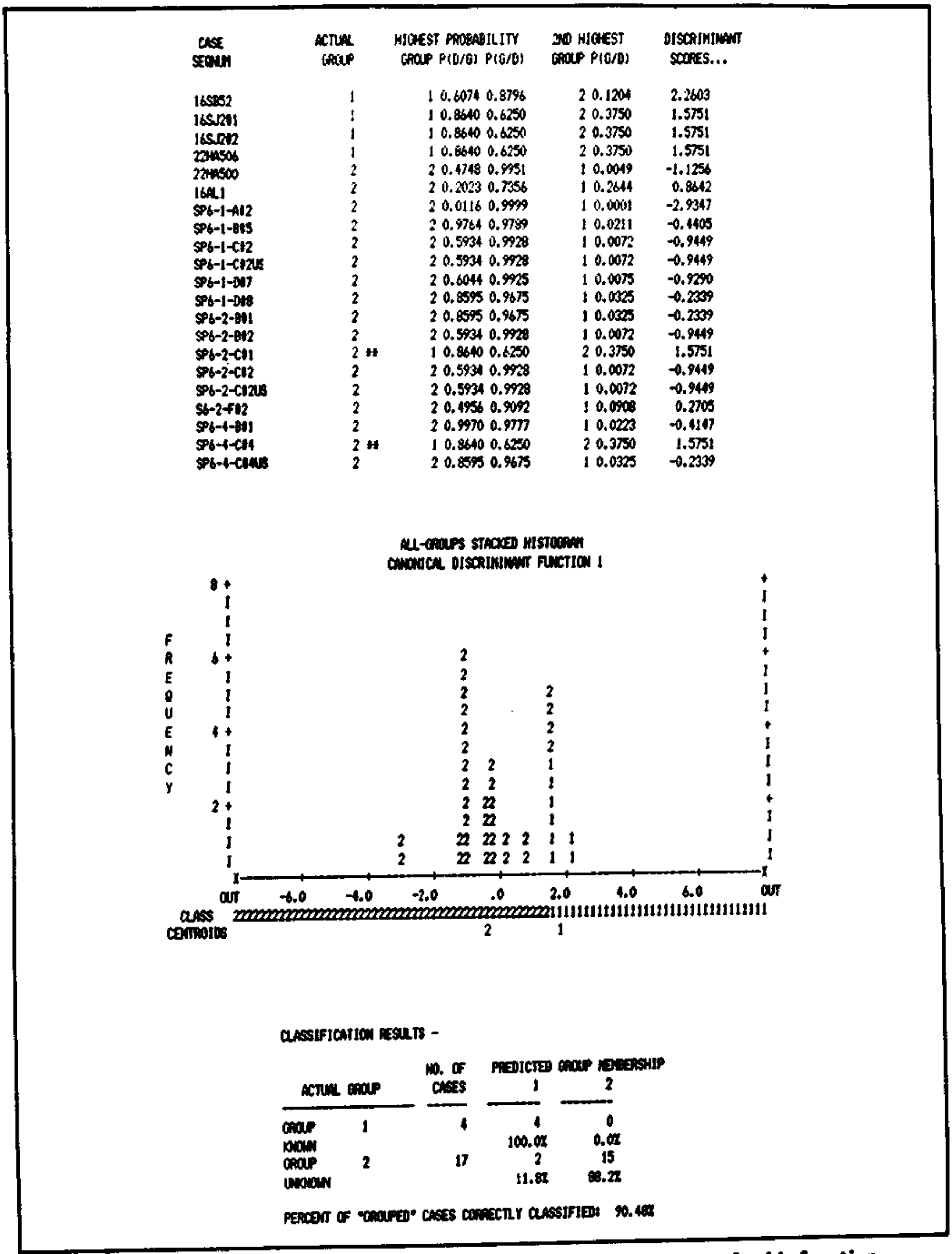
Figure 5-33. Results of discriminant analysis on qualitative data, -1 phi fraction, Sabine Pass 6 area.



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CASE         ACTUAL       HIGHEST PROBABILITY    2ND HIGHEST DISCRIMINANT
SEQNUM        GROUP       GROUP P(D/G) P(G/D)   GROUP P(G/D)   SCORES...

16SB52            1           1 0.6074 0.8796       2 0.1204     2.2603
16SJ201           1           1 0.8640 0.6250       2 0.3750     1.5751
16SJ202           1           1 0.8640 0.6250       2 0.3750     1.5751
22HA506           1           1 0.8640 0.6250       2 0.3750     1.5751
22HA500           2           2 0.4748 0.9951       1 0.0049    -1.1256
16AL1             2           2 0.2023 0.7356       1 0.2644     0.8642
SP6-1-A02         2           2 0.0116 0.9999       1 0.0001    -2.9347
SP6-1-B05         2           2 0.9764 0.9789       1 0.0211    -0.4405
SP6-1-C02         2           2 0.5934 0.9928       1 0.0072    -0.9449
SP6-1-C02US       2           2 0.5934 0.9928       1 0.0072    -0.9449
SP6-1-D07         2           2 0.6044 0.9925       1 0.0075    -0.9290
SP6-1-D08         2           2 0.8595 0.9675       1 0.0325    -0.2339
SP6-2-B01         2           2 0.8595 0.9675       1 0.0325    -0.2339
SP6-2-B02         2           2 0.5934 0.9928       1 0.0072    -0.9449
SP6-2-C01         2 **        1 0.8640 0.6250       2 0.3750     1.5751
SP6-2-C02         2           2 0.5934 0.9928       1 0.0072    -0.9449
SP6-2-C02US       2           2 0.5934 0.9928       1 0.0072    -0.9449
S6-2-F02          2           2 0.4956 0.9092       1 0.0908     0.2705
SP6-4-B01         2           2 0.9970 0.9777       1 0.0223    -0.4147
SP6-4-C04         2 **        1 0.8640 0.6250       2 0.3750     1.5751
SP6-4-C04US       2           2 0.8595 0.9675       1 0.0325    -0.2339


                                  ALL-GROUPS STACKED HISTOGRAM
                                CANONICAL DISCRIMINANT FUNCTION 1
      8 +                                                                                +
        I                                                                                I
        I                                                                                I
F       I                                                                                I
R     6 +                                   2                                            +
E       I                                   2                                            I
Q       I                                   2           2                                I
U       I                                   2           2                                I
E     4 +                                   2           2                                +
N       I                                   2           2                                I
C       I                                   2   2       1                                I
Y       I                                   2   2       1                                I
      2 +                                   2  22       1                                +
        I                                   2  22       1                                I
        I                         2        22  22 2  2  1  1                             I
        I                         2        22  22 2  2  1  1                             I
        X----------+---------+---------+---------+---------+---------+---------+---------X
       OUT       -6.0      -4.0      -2.0       .0       2.0       4.0       6.0        OUT
  CLASS  22222222222222222222222222222222222222222222222111111111111111111111111111111111
CENTROIDS                                      2          1



                    CLASSIFICATION RESULTS -

                        NO. OF   PREDICTED GROUP MEMBERSHIP
   ACTUAL GROUP          CASES            1          2
---------------------   ------   ---------- ----------
GROUP       1                4            4          0
KNOWN                                100.0%       0.0%
GROUP       2               17            2         15
UNKNOWN                               11.8%      88.2%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED:  90.48%
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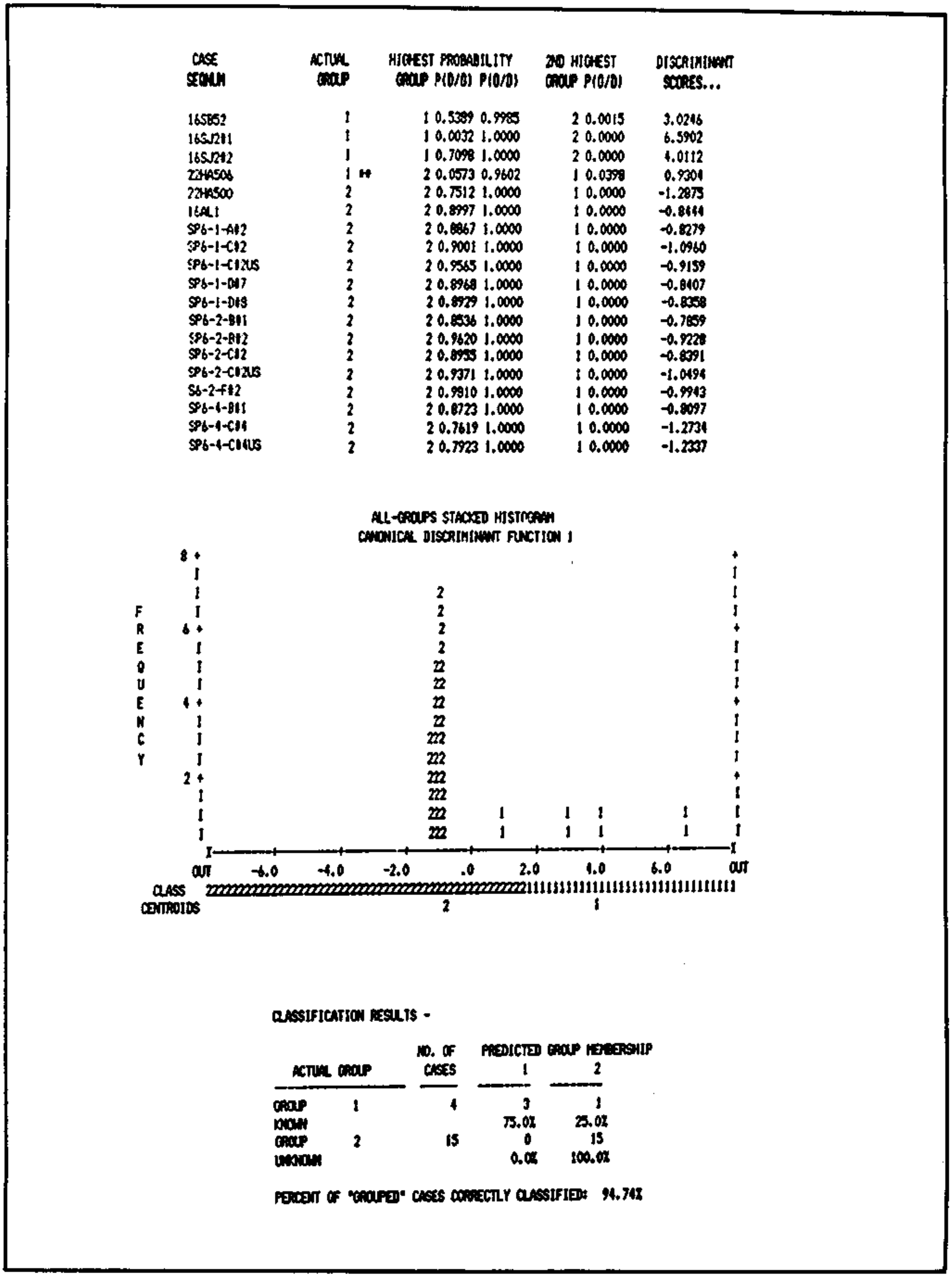
Figure 5-34. Results of discriminant analysis on qualitative data, 0 phi fraction, Sabine Pass 6 area.



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 CASE          ACTUAL      HIGHEST PROBABILITY    2ND HIGHEST     DISCRIMINANT
SEQNUM          GROUP      GROUP P(D/G) P(G/D)    GROUP P(G/D)     SCORES...

16SB52              1          1 0.5389 0.9985        2 0.0015       3.0246
16SJ2#1             1          1 0.0032 1.0000        2 0.0000       6.5902
16SJ2#2             1          1 0.7098 1.0000        2 0.0000       4.0112
22HA506             1 **       2 0.0573 0.9602        1 0.0398       0.9304
22HA500             2          2 0.7512 1.0000        1 0.0000      -1.2875
16AL1               2          2 0.8997 1.0000        1 0.0000      -0.8444
SP6-1-A#2           2          2 0.8867 1.0000        1 0.0000      -0.8279
SP6-1-C#2           2          2 0.9001 1.0000        1 0.0000      -1.0960
SP6-1-C#2US         2          2 0.9565 1.0000        1 0.0000      -0.9159
SP6-1-D#7           2          2 0.8968 1.0000        1 0.0000      -0.8407
SP6-1-D#8           2          2 0.8929 1.0000        1 0.0000      -0.8358
SP6-2-B#1           2          2 0.8536 1.0000        1 0.0000      -0.7859
SP6-2-B#2           2          2 0.9620 1.0000        1 0.0000      -0.9228
SP6-2-C#2           2          2 0.8955 1.0000        1 0.0000      -0.8391
SP6-2-C#2US         2          2 0.9371 1.0000        1 0.0000      -1.0494
S6-2-F#2            2          2 0.9810 1.0000        1 0.0000      -0.9943
SP6-4-B#1           2          2 0.8723 1.0000        1 0.0000      -0.8097
SP6-4-C#4           2          2 0.7619 1.0000        1 0.0000      -1.2734
SP6-4-C#4US         2          2 0.7923 1.0000        1 0.0000      -1.2337


                                    ALL-GROUPS STACKED HISTOGRAM
                                  CANONICAL DISCRIMINANT FUNCTION 1
         8 +                                                                               +
           I                                                                               I
           I                                  2                                            I
  F        I                                  2                                            I
  R      6 +                                  2                                            +
  E        I                                  2                                            I
  Q        I                                 22                                            I
  U        I                                 22                                            I
  E      4 +                                 22                                            +
  N        I                                 22                                            I
  C        I                                222                                            I
  Y        I                                222                                            I
         2 +                                222                                            +
           I                                222                                            I
           I                                222         1         1    1           1       I
           I                                222         1         1    1           1       I
           I---------+---------+---------+---------+---------+---------+---------+---------I
         OUT      -6.0      -4.0      -2.0        .0       2.0       4.0       6.0        OUT
   CLASS   2222222222222222222222222222222222222222222222222111111111111111111111111111111
 CENTROIDS                                     2                      1



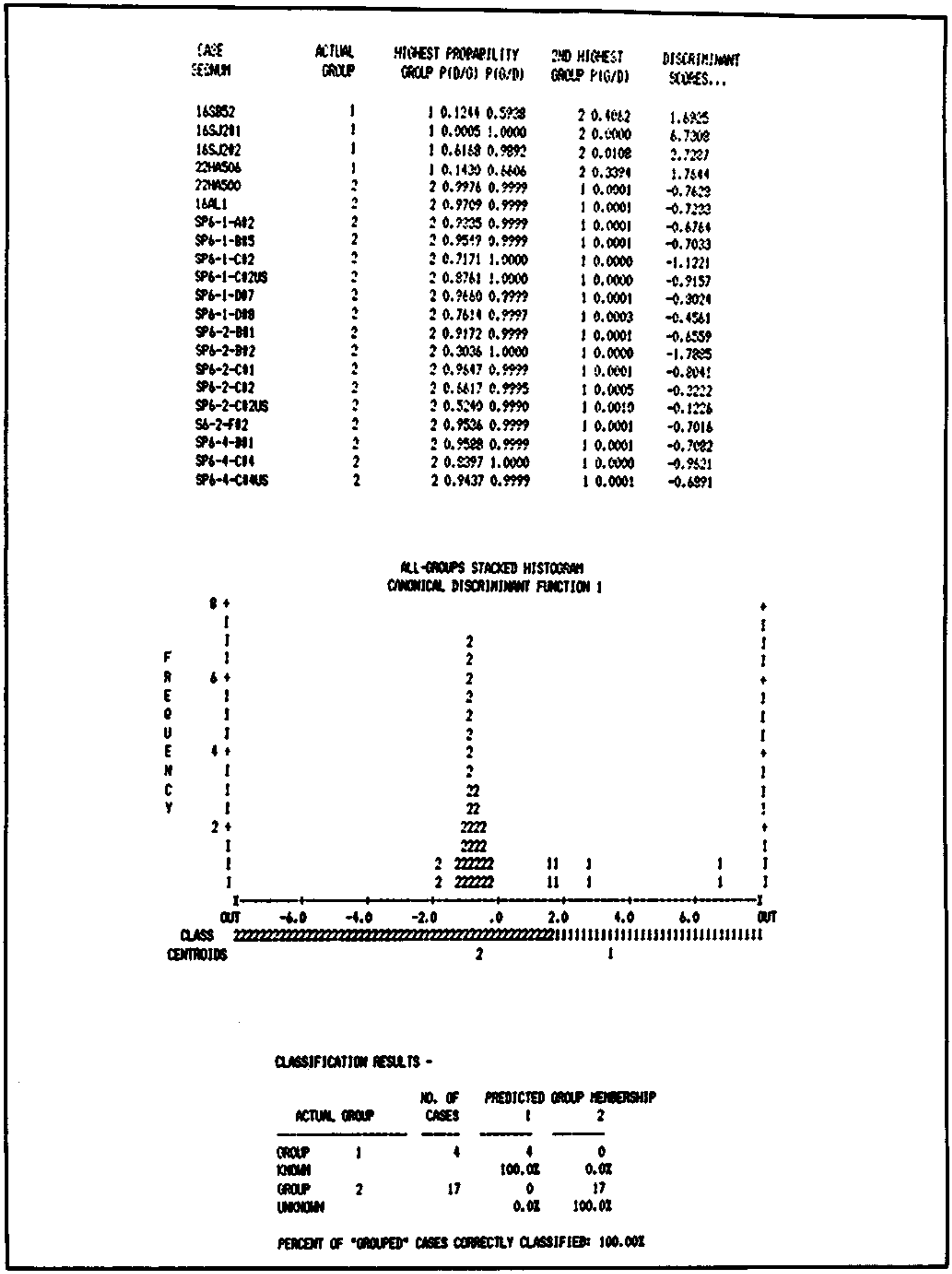
             CLASSIFICATION RESULTS -

                                 NO. OF     PREDICTED GROUP MEMBERSHIP
               ACTUAL GROUP      CASES           1            2
             ----------------    ------     ---------    ---------

             GROUP       1           4           3            1
             KNOWN                           75.0%        25.0%
             GROUP       2          15           0           15
             UNKNOWN                          0.0%       100.0%

             PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED:  94.74%
```

Figure 5-35. Results of discriminant analysis on quantitative data, -1 phi fraction, Sabine Pass 6 area.



```
CASE                ACTUAL     HIGHEST PROBABILITY    2ND HIGHEST     DISCRIMINANT
SEQNUM              GROUP     GROUP P(D/G) P(G/D)    GROUP P(G/D)     SCORES...

16S852                1           1 0.1244 0.5938      2 0.4062        1.6925
16SJ201               1           1 0.0005 1.0000      2 0.0000        6.7308
16SJ202               1           1 0.6168 0.9892      2 0.0108        2.7227
22HAS06               1           1 0.1430 0.6606      2 0.3394        1.7544
22HAS00               2           2 0.9976 0.9999      1 0.0001       -0.7623
16AL1                 2           2 0.9709 0.9999      1 0.0001       -0.7233
SP6-1-A02             2           2 0.9335 0.9999      1 0.0001       -0.6764
SP6-1-B05             2           2 0.9549 0.9999      1 0.0001       -0.7033
SP6-1-C02             2           2 0.7171 1.0000      1 0.0000       -1.1221
SP6-1-C02US           2           2 0.8761 1.0000      1 0.0000       -0.9157
SP6-1-D07             2           2 0.9660 0.9999      1 0.0001       -0.3024
SP6-1-D08             2           2 0.7634 0.9997      1 0.0003       -0.4561
SP6-2-B01             2           2 0.9172 0.9999      1 0.0001       -0.6559
SP6-2-B02             2           2 0.3036 1.0000      1 0.0000       -1.7885
SP6-2-C01             2           2 0.9647 0.9999      1 0.0001       -0.8041
SP6-2-C02             2           2 0.6617 0.9995      1 0.0005       -0.2222
SP6-2-C02US           2           2 0.5240 0.9990      1 0.0010       -0.1226
S6-2-F02              2           2 0.9536 0.9999      1 0.0001       -0.7016
SP6-4-B01             2           2 0.9528 0.9999      1 0.0001       -0.7082
SP6-4-C04             2           2 0.8397 1.0000      1 0.0000       -0.9521
SP6-4-C04US           2           2 0.9437 0.9999      1 0.0001       -0.6991


                                    ALL-GROUPS STACKED HISTOGRAM
                                  CANONICAL DISCRIMINANT FUNCTION 1
       8 +                                                                                +
         I                                                                                I
         I                                    2                                           I
F        I                                    2                                           I
R      6 +                                    2                                           +
E        I                                    2                                           I
Q        I                                    2                                           I
U        I                                    2                                           I
E      4 +                                    2                                           +
N        I                                    2                                           I
C        I                                    22                                          I
Y        I                                    22                                          I
       2 +                                   2222                                         +
         I                                   2222                                         I
         I                               2  22222         11    1                   1     I
         I                               2  22222         11    1                   1     I
          I---------+---------+---------+---------+---------+---------+---------+---------I
         OUT      -6.0      -4.0      -2.0       .0       2.0       4.0       6.0        OUT
   CLASS  222222222222222222222222222222222222222222222222111111111111111111111111111111111
CENTROIDS                                      2                   1



                 CLASSIFICATION RESULTS -

                                     NO. OF      PREDICTED GROUP MEMBERSHIP
                   ACTUAL GROUP       CASES          1            2
                 -----------------   ------     --------     --------

                 GROUP       1            4          4            0
                 KNOWN                             100.0%         0.0%
                 GROUP       2           17          0           17
                 UNKNOWN                             0.0%       100.0%

                 PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 100.00%
```

Figure 5-36. Results of discriminant analysis on quantitative data, 0 phi fraction, Sabine Pass 6 area.

The results of the 0 phi presence/absence analysis are presented in Figure 5-34. Two of the offshore samples are classified into the site group. One of them, Sample 4 from Core SP6-4-C, had also been classified as a site on the basis of the -1 phi sample.

The results of the quantitative discriminant analysis of the 0 phi fraction are presented in Figure 5-36. All samples are classified in their original group and no overlap in the spatial distribution of samples is indicated in the histogram produced. .

Overall, with the discriminant analyses of the point-count data, three offshore samples are reclassified into the known site group. These are samples SP6-2-B#1, SP6-2-C#1, SP6-4-C#4 and SP6-4-C#4US. The latter two samples come from the same location in the core. All of these samples are derived from the area of the bone concentration located on the peninsula between the two small streams draining the Deweyville surface (see Figure 5-29). These samples show a strong resemblance to archaeological deposits identified by Gagliano et al. (1982) in terms of their particular content.

Geochemical Analysis

Six samples from the Sabine Pass 6 locale were analyzed for their geochemical properties (see Table 5-6). This represented the largest number of geochemical samples examined at any of the selected areas. Sabine Pass 6 was the only one of the areas cored which produced reliable indications of archaeological deposits and it was hoped that the larger number of geochemical samples would aid in distinguishing and characterizing the presumed archaeological sediments.

Three of the samples were selected from those features which most resembled archaeological deposits. These consisted of two samples from the organic, bone producing strata overlying the Deweyville terrace (Samples SP6-2-0#2 and SP6-4-C#4) and one from the Rangia deposit (Sample SP6-1-C#2). One sample (SP6-1-A#3) was taken from within the identified Deweyville deposits in a location presumed least likely to have contained archaeological remains. This sample was intended to provide chemical information on a natural deposit upon which archaeological sites are expected to be found. The two remaining samples (SP6-1-A#2 and SP6-3-B#1) were selected from nonorganic portions of the transgressive zone.

The geochemical results are not definitive in delineating that any of the samples are, or are not, from an archaeological deposit. However, some trends are apparent in the geochemical data which seem to correlate with assumptions about the chemical character of archaeological sediments (see Table 5-6). Total phosphates (TP) was one of the chemical parameters that showed a correlation with the ranking of samples relative to archaeological potential (Appendix C). Interestingly, sample SP6-1-A#3, the sample from the almost assuredly noncultural Deweyville feature, contained the lowest TP concentration of any sample examined (412 ppm). The sample from the Rangia shell deposit (SP6-1-C#2), which was the feature considered most likely to be cultural, contained higher than average TP concentration (950 ppm), as did the two samples from the bone concentration area (samples SP6-2-C#2 and SP6-4-C#4). The two samples from the transgressive deposit (samples SP6-1-A#2 and SP6-3-B#1) contained slightly lower than average TP concentrations (see Table 5-6).

All of the TP concentrations for these samples are much lower than the average of 2835 ppm obtained from onshore coastal sites examined by Gagliano et al. (1982). However, except for the one obvious nonsite sample, all are above the average of 698 ppm exhibited by the offsite contral samples in that study.

The other chemical parameters examined in the Sabine Pass 6 samples show a great deal of variability and do not appear to correlate highly with our assumption about archaeological potential. With the possible exception of total phosphates, the chemical data is ambiguous in terms of indicating which sample may be cultural. Too little is currently known about both the chemical variability extant in submerged natural deposits and the impact of inundation and burial on the chemical constituents of archaeological deposits.

Reliance on the model developed by Gagliano et al. (1982) and on known attributes of coastal sites, suggests that two areas of possible archaeological deposits were encountered in the Sabine Pass 6 lease block. These were the Rangia shell deposit and the various organic strata at the juncture of Core lines 2 and 4. The point-count and pollen data suggest that the Rangia deposit may have been subaerially exposed at deposition. The geometry and location of the deposit and its shell content are more similar to known archaeological deposits than to known natural features. In addition, the radiocarbon date obtained for the shell deposit of about 8000 B.P. is consistent with our interpretation of the geology of the area and with the possibility of the shell deposit being an archaeological site.

The strata containing the large quantity of bone also exhibit characteristics of known archaeological deposits. This is particularly evident in the variety of bone recovered and in the presence of calcined bone. It seems probable that the particular content encountered in these deposits would be an unlikely or extremely rare occurrence in nature.

It is presently impossible to quantify the probability that the two areas in Sabine Pass 6 are archaeological deposits. It is reasonable to state, however, that they more closely resemble archaeological deposits than known natural deposits.

Sabine Pass 9

The seismic data collected for this block during the present study basically duplicated the features identified in the original lease block and pipeline surveys. Our present geological interpretation of these features differs dramatically, however, from that first suggested (see Chapter IV). What had been considered initially to have been the eastern valley wall, coupled with Holocene floodplain deposits to the west, was found to be a single depositional terrace that can be equated with the Deweyville.

Figures 5-37 and 5-38 illustrate the northern and southern halves, respectively, of the area surveyed for the present study. As with the previous blocks, contours are in feet below the seafloor. The most obvious features noted are three large, filled channel segments, measuring approximately 1000 ft across, which together suggest a well-developed Deweyville floodplain. Included in this floodplain is an area of relatively small east-west-trending ridges and swales at the northern edge of the survey area. These may represent examples of a Deweyville-age point-bar feature. At the extreme southern end of the area surveyed, a deep channel was detected. This channel is filled with organics that have obscured the seismic signals, and most likely represents the northern edge of the drowned Calcasieu River valley near where it joined the Sabine River valley.

The area selected for coring was near the center of the surveyed area, along the south bank of one of the large, Deweyville channels. Originally, the coring strategy called for four lines of cores to be placed in this area, with two of the lines positioned at the

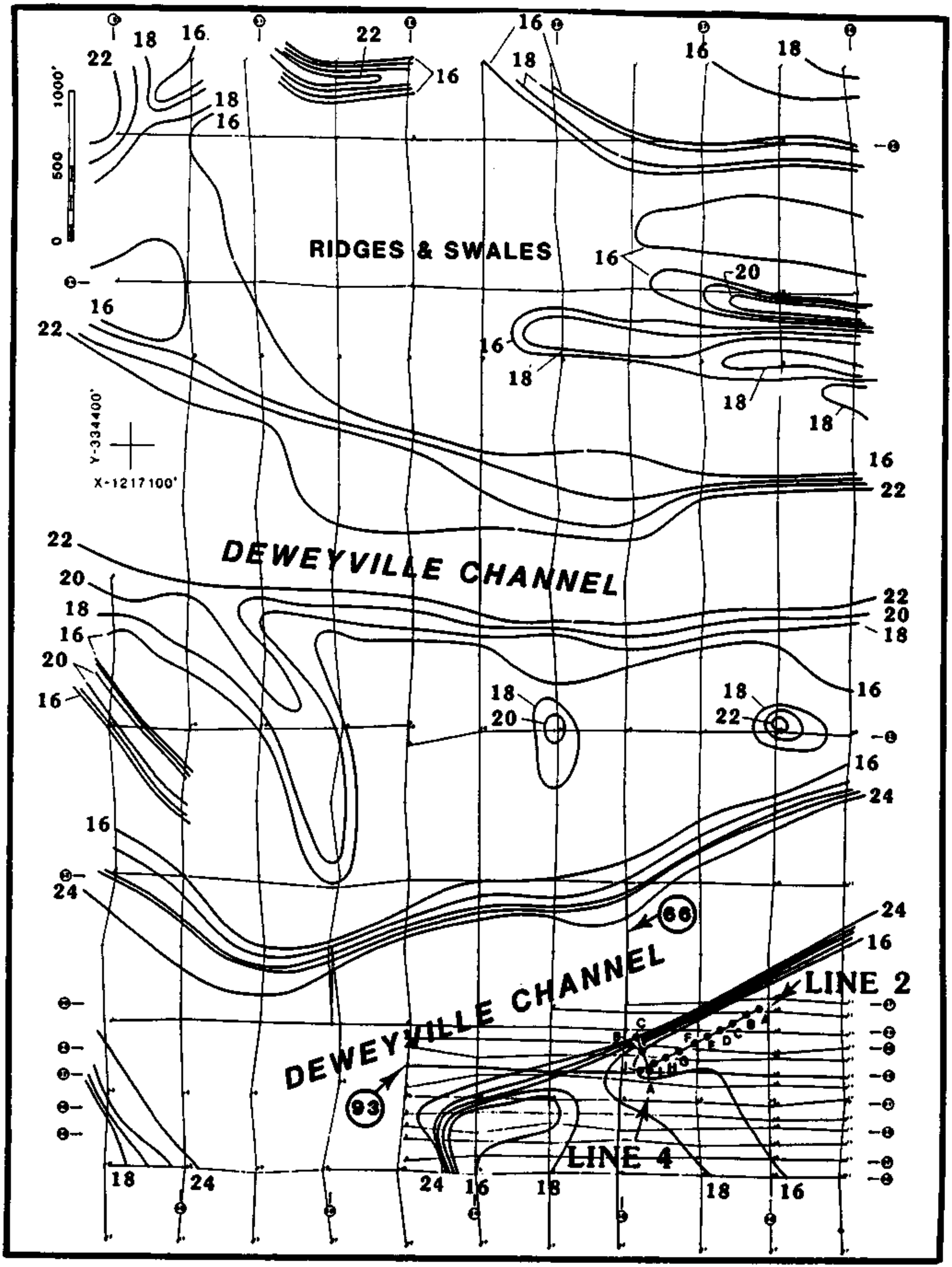


Figure 5-37. Contour map of the northern portion of the Sabine Pass 9 survey area, showing contours atop the Deweyville surface. Contour intervals are in feet below the mud line. Note locations of Seismic Lines 66 and 93 and Vibracore Lines 2 and 4.

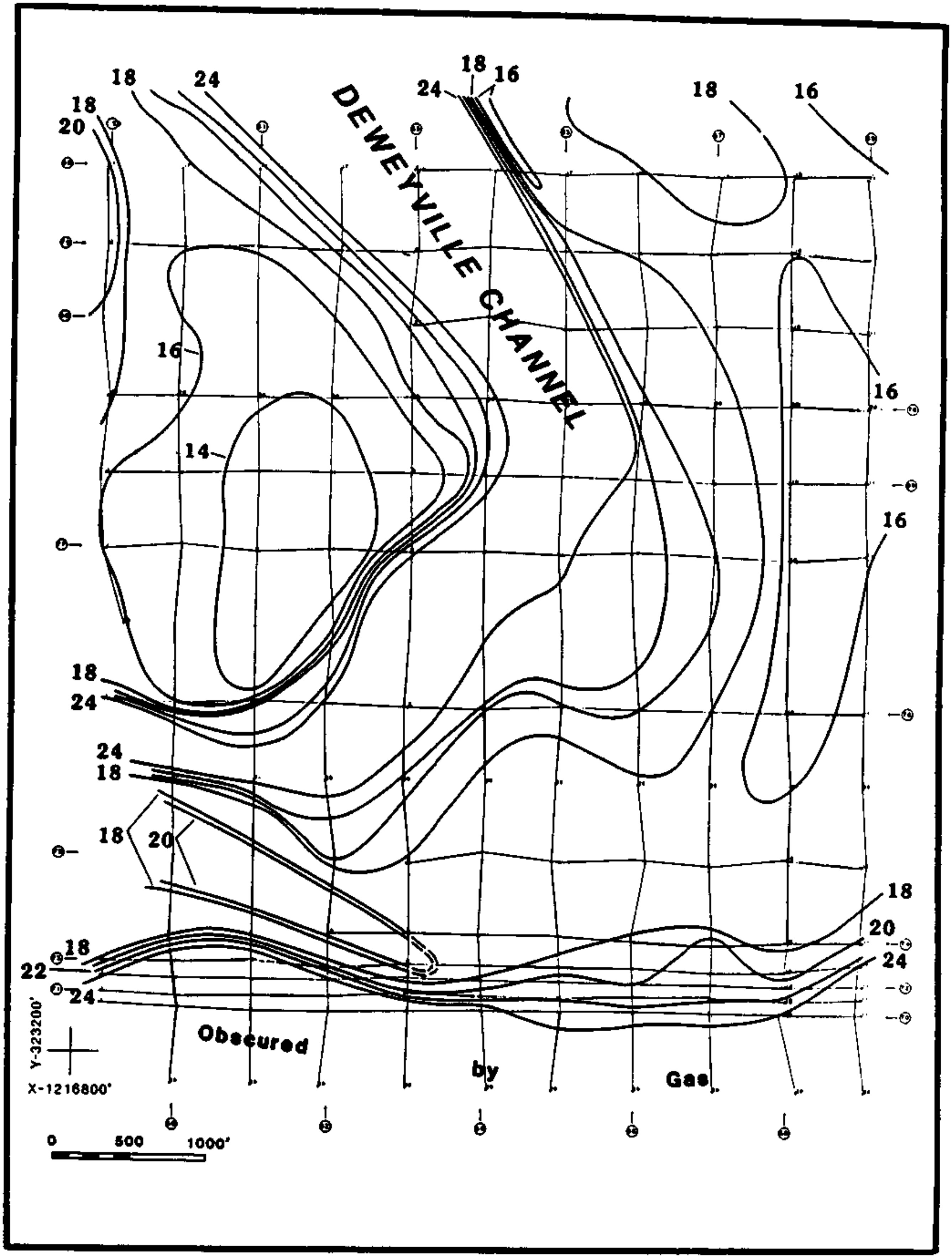


Figure 5-38. Contour map of the southern portion of the Sabine Pass 9 survey area.

junction of the above-mentioned channel with another Deweyville channel trending in a southeasterly direction from that point. This strategy had to be altered, however, as a gas pipeline traversed the area, and coring could not be performed within about 500 ft of the line. Thus, only two lines of cores (Lines 2 and 4) were taken. One line (No. 2) included 10 cores and ran parallel to the channel edge, while the other (No. 4), including three cores, was placed perpendicular to the first and ran down into the channel.

Based upon terrestrial site analogy, it was felt that the area selected for coring would have been a likely place for habitation, particularly at a time when the Deweyville channel would have been a relict feature supporting either an oxbow lake or filled swamp and possible underfit streams. Unfortunately, the highest probability location could not be cored due to the presence of the gas pipeline at the juncture of the two channels.

As noted in the previous chapter, Nelson and Bray's (1970) model of sea-level rise would have placed the survey area adjacent to a riverine environment prior to 9600 B.P. Between 9600 and 6050 B.P. the area changed to an estuary or lagoon. After 6050 B.P. the area was inundated. This suggested the possibility of encountering remains attributable to the Paleo-Indian through Middle Archaic periods.

Figures 5-39 and 5-40 illustrate selected seismic lines which ran roughly parallel to the two coring lines. Core positions have been added. The major reflector, identified at depths below the seafloor of between about 15 and 20 ft, initially was identified as the top of the Deweyville surface, and this basically is substantiated by the coring data. The Deweyville channel along which the cores were placed can be seen as a depression in the northern portion of Figure 5-39. Organic channel fill appears as the typical dark "gas" signature at a depth of about 34 ft, obscuring deeper features. Core 4-C penetrated the upper levels of channel fill. The dark feature angling down from about 30 ft below the surface at Shot Point 15 in Figure 5-39 presumably represents a point-bar accretionary feature.

Covering the Deweyville floodplain deposits is a relatively thick (ca. 10 to 15 ft) section of thin, parallel reflectors which have been noted previously in Sabine Pass Blocks 3 and 6 and identified as transgressive bay or estuarine fill. Within the upper 4 to 5 ft of the record is a zone of dark, thin reflectors marking modern nearshore marine deposits.

A geological interpretation of the core lines, based on a combination of core and seismic data, is presented in Figures 5-41 and 5-42. The basal Deweyville surface was penetrated by all cores, except Core 4-C. The Deweyville consisted of a somewhat undulating deposit of either heavily oxidized, stiff, grayish brown (2.5Y 5/2) clay, or horizontally bedded, medium and coarse, light brownish gray (2.5Y 6/2) to grayish brown (2.5Y 5/2) sand. Sample No. 3 from Core 2-A and No. 2 from Core 2-D were subjected to grain-size analyses, the results of which are shown in Figure 5-43. Although Sample No. 3 came from the clay portion of the Deweyville surface, this sample was coarser than those samples taken from probable organic and bay/estuary contexts (Core 4-C, Sample Nos. 8 and 4, respectively), and finer than those samples from the initial transgressive deposit (defined earlier in the discussion on Sabine Pass 3) as obtained by Sample No. 1 in Core 2-A and No. 2 in Core 2-C (see Figure 5-41). Sample No. 2 from Core 2-D came from the sandy portion of the Deweyville surface, and its grain-size curve indicates a well-sorted deposit of silt-sized particles (see Figure 5-43). The section along Core Line 2, as shown in Figure 5-41, has the appearance of a typical point bar or similar fluvial accretionary feature. This is not

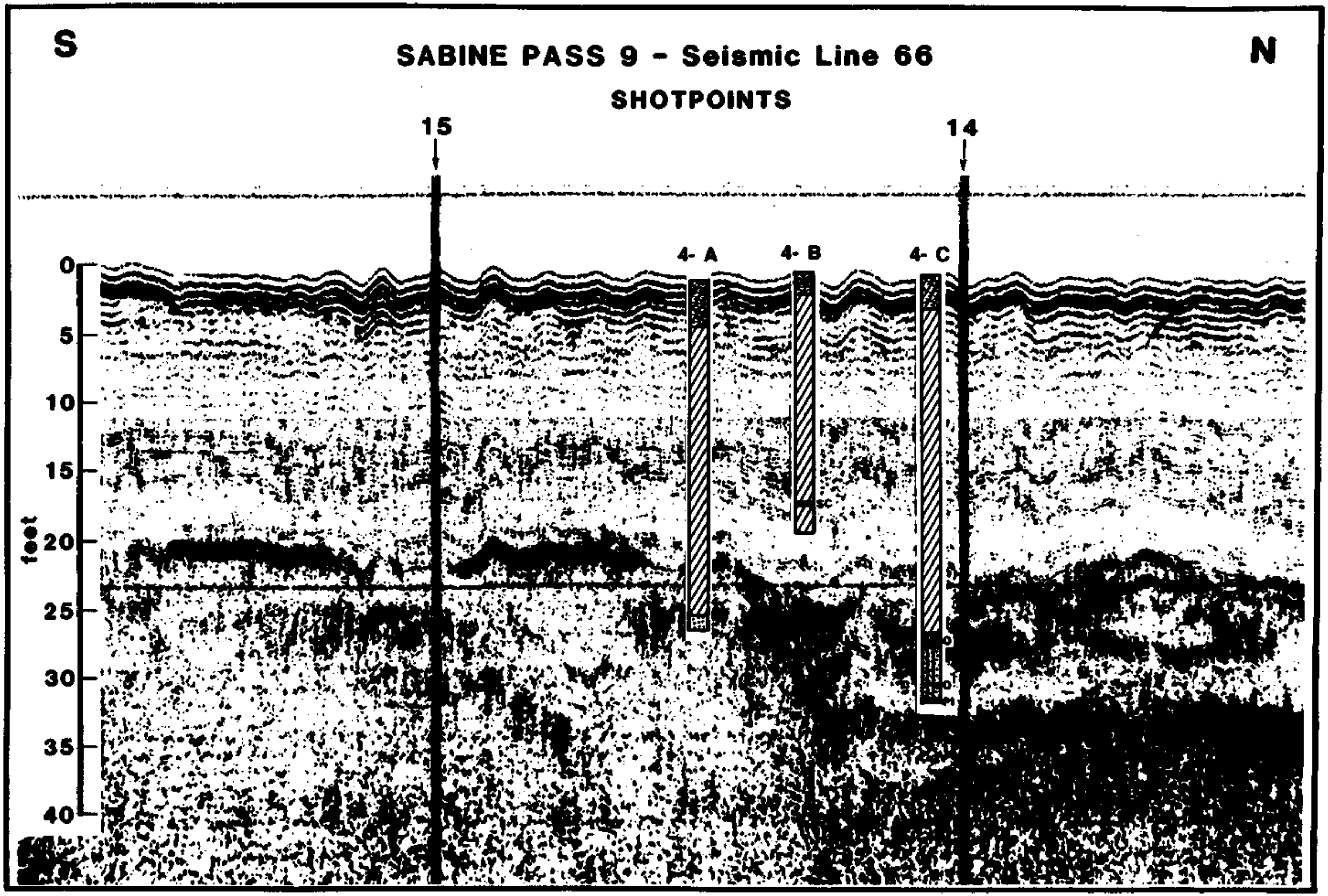


Figure 5–39. Portion of Seismic Line 66, Sabine Pass 9 area showing drop-off into filled Deweyville channel at right. Cores have been added to show comparison of the strata.

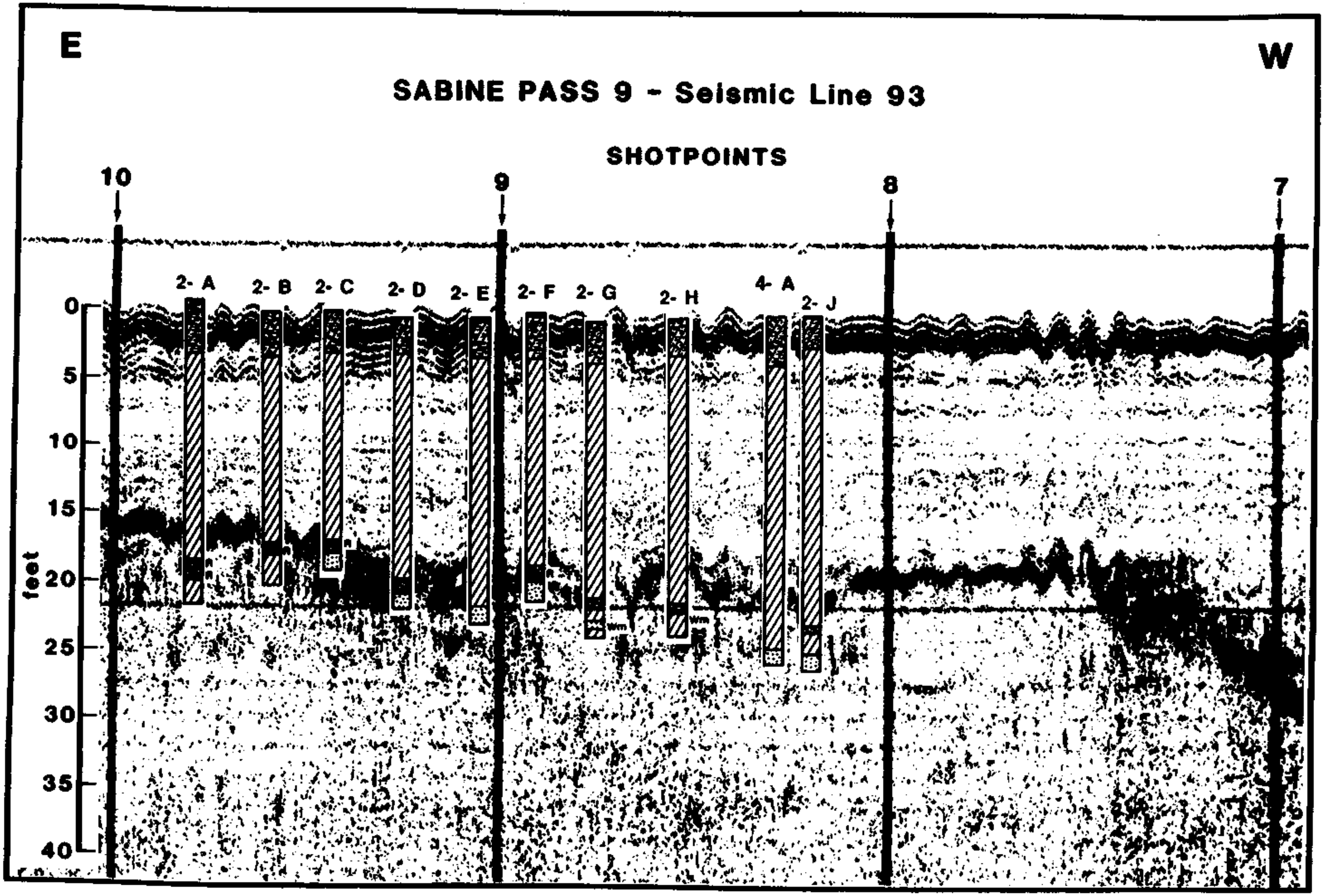


Figure 5-40. Portion of pinger record along Seismic Line 93, Sabine Pass 9 area, showing Deweyville surface. Cores have been added to show comparison of the strata.

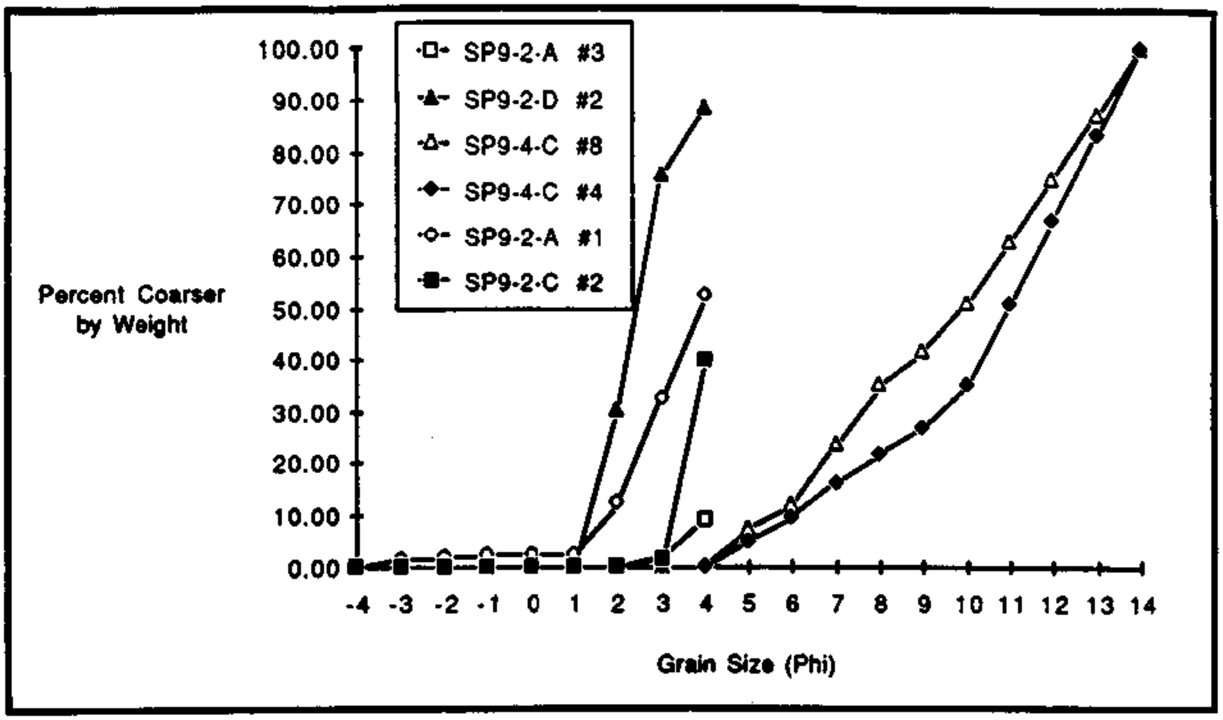


Figure 5–43. Results of grain-size analysis of samples from Sabine Pass 9 area.

unreasonable considering we are sampling the surface of an identified floodplain.

The filled Deweyville channel was encountered only in Core 4-C, and this became the control core for the block. Thus, pollen, grain-size, and foraminifera studies were performed on samples from this core. The lowest channel fill encountered in Core 4-C consisted of thinly bedded clays and peat. Sample No. 9 from this deposit was examined for both foraminifera and pollen (see Appendices A and B). The sample was barren of both, although it did contain large charcoal particles. These data together suggest a freshwater deposit, although no seeds were found to enable more specific environmental identification. A radiocarbon date on the peaty organics yielded a date of 9045 ± 95 B.P. (UGa-5423). This is in close agreement with dates from other freshwater deposits in Sabine Pass Blocks 3 and 6. Since this date is from the fill of what we feel is reliably identified as a Deweyville channel, it provides a terminus ante quem for this particular channel. The channel would have been abandoned for some unknown period of time prior to when the dated feature was deposited.

Atop the freshwater deposits within the channel was a zone of bedded silts, sands, and clays representing fluvial or upper estuarine fill. This zone contained one thin organic lens within it and was capped by another. The fluvial deposits were sampled for foraminifera (Sample No. 7), but only a few were noted (see Appendix A). The assemblage was dominated by Ammotium salsum, suggesting a shallow water, estuarine environment. The lower organic lens was subjected to grain-size and hydrometer analysis (Sample No. 8), and the results are plotted on Figure 5–43. An entirely clay and silt-size sample is indicated. The upper organic zone in the channel was sampled for pollen. Only 18 grains could be counted, all of them badly weathered (see Appendix B). The degraded nature of the pollen suggests an environment subjected to periods of alternating wet and dry conditions.

Capping both the Deweyville surface and the channel fill deposits was an extensive zone of disturbed, sandy clay, heavily burrowed, and containing scattered Rangia shell. Noted earlier in the discussion on Sabine Pass 3, this almost ubiquitous deposit is considered the signature for initial transgression. It was identified in all cores but 2-E and 4-A. A pollen sample from within the transgressive zone in Core 2-B contained abundant grains characteristic of a marsh environment or an open body of water adjacent to a marsh. This pollen was not seriously eroded or degraded possibly indicating that it was deposited slightly after initial transgression or that, as noted earlier, localized segments of relatively undisturbed deposits exist within the transgression zone (see Appendix B). A foraminifera sample (Core 4-C, No. 5) from the same deposit produced an assemblage similar to that found in the fluvial/upper estuarine zone located just below it in the same core, thus indicating little change in salinity (see Appendix A).

This zone also yielded several samples which contained identifiable seeds (see Table 5-1). These samples (Core 2-A, Nos. 1 and 2; Core 2-F, No. 1; and Core 2-I, No. 1) are dominated by three-corner grass (Scirpus olneyi), although bulrush (Scirpus validus) appears in lesser quantity. The one crepe myrtle (Lagerstroemia indica) seed can only be attributed to accidental contamination during either the core-cutting or grain-size analyses since this species is native only to the old world and is prevalent as an ornamental at CEI's laboratory in Baton Rouge. The Scirpus seeds indicate a deposit composed primarily of reworked brackish to fresh marsh.

Above the initial transgressive deposit rests a massive, homogenous deposit of thinly bedded, dark gray (2.5Y 4/0) clays. This deposit is identical to those of Sabine Pass Blocks 3 and 6, and is considered to be bay or estuarine fill. Four samples (Nos. 1, 2, 3, and 4) within Core 4-C were examined in regard to foraminifera content. The assemblage (see Appendix A) for all samples was dominated by Elphidium excavatum and Ammonia parkinsoniana, suggesting relatively high salinity.

At and within a few feet of the sea floor, all of the cores encountered what is identified as a nearshore marine deposit, as noted in the discussion of the previous blocks. The zone contained numerous marine shells was heavily burrowed, and consisted of grayish brown (2.5Y 5/2) to dark grayish brown (2.5Y 4/2) sands and clays. Several of the cores contained lumps of stiff, oxidized gray clay within the upper nearshore marine deposit. Initially unexplainable, it was eventually determined that the oxidized clay had been derived from the dredging of a ship channel located several thousand feet to the northeast.

Archaeological Site Potential

Although the areas chosen for coring were considered high probability locales for prehistoric sites, none of the cores encountered clear cases of either earth or shell middens. Only a thin deposit of Rangia shell incorporated within the initial transgressive zone, and encountered in Core 2-A, could be considered similar to a shell midden or, more properly, to the lag remains of a former midden. Nevertheless, several samples were subjected to point-count and discriminant analyses in an effort to identify possible sites.

Point-Count Analysis

The results of point-count analyses for the 0 phi and -1 phi fractions are presented in Tables 5-9 and 5-10. There is some variability in the shell content of those samples derived from the Deweyville surface and initial transgressive zone. This corresponds to the variability in the transgressive zone seen elsewhere. The only identified shell types in the samples are Rangia and barnacle (Balanus sp.), suggesting brackish conditions. Bone was recovered in the 0 phi fractions of two samples, SP9-2-A#2 and SP9-2-C#2 (Table 5-10). These bones consist of one fish scale and one fish vertebra from the first sample and one unidentified fragment from the second.

Table 5-9. Point Counts for Sabine Pass 9 Area: -1 Phi Fraction Expressed in Particles per Kilogram.

	SAMPLES						
COMPONENT	SP9-2-A#1	SP9-2-A#2	SP9-2-A#3	SP9-2-C#2	SP9-2-F#1	SP9-2-I#1	SP9-4-C#8
Marine shell							
Oyster shell							
Mussel shell							
Barnacle/brackish species							
Rangia sp. shell	266	77			108		
Unidentified shell							
Iron nodule/pyrite							
Clastic/clastic concretion			10				
Carbonate concretion							
Vegetal material					58	14	
Charred vegetal material	7				33		10
Seed	7						
Bone							
Charred bone							
Crustacean exoskeleton							
Stone							
Landsnails							
Other		14					

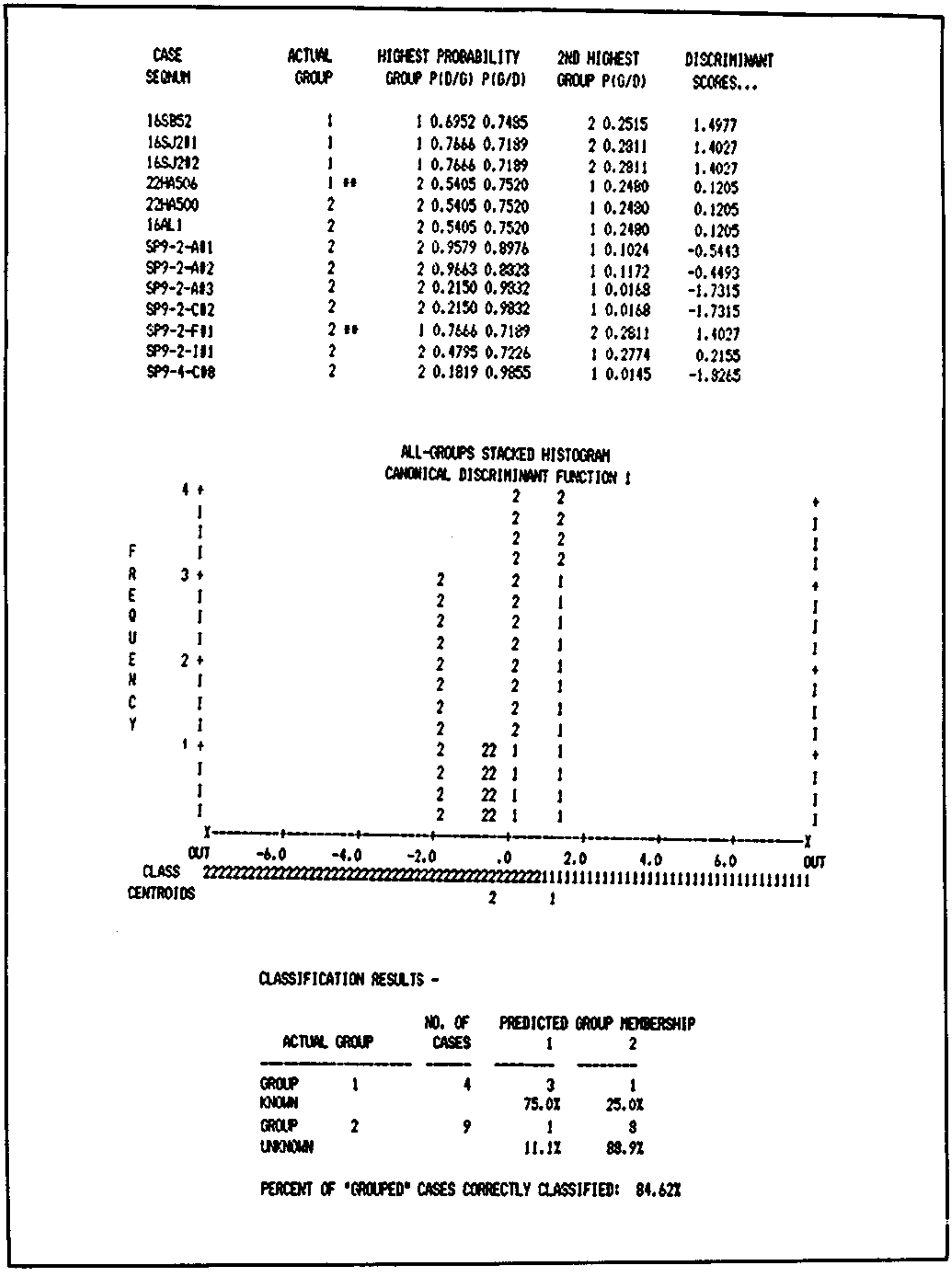
Several samples from the Sabine Pass 9 area contained Rangia shell, charred vegetal material or bone, which, as has been noted, are common constituents of coastal archaeological sites. However, it is also true that the presence of Rangia, Balanus and fish bone is expected in natural estuarine deposits. In this instance, the point-count criteria are ambiguous and do not permit distinction between estuarine and archaeological deposits. Further refinement in criteria is needed to distinguish these two sedimentary settings.

Table 5-10. Point Counts for Sabine Pass 9 Area: 0 Phi Fraction Expressed in Particles per Kilogram.

COMPONENT	SP9-2-A#1	SP9-2-A#2	SP9-2-A#3	SP9-2-C#2	SP9-2-F#1	SP9-2-I#1	SP9-4-C#8
Marine shell							
Oyster shell							
Mussel shell							
Barnacle/brackish species					116	54	
Rangia sp. shell	569	287					
Unidentified shell			5	5	199	68	10
Iron nodule/pyrite	7						
Clastic/clastic concretion	29	63	5		8		10
Carbonate concretion							
Vegetal material	58	21			440	258	10
Charred vegetal material	137	42	10	10	315	299	140
Seed	86	70			42	95	
Bone		14		5			
Charred bone							
Crustacean exoskeleton							
Stone							
Landsnails							
Other	7	7			25		

Discriminant Analysis

The data derived from the point-count analysis were subjected to discriminant analysis. Only in one case was an offshore sample placed in the known site group. In this instance, the -1 phi fraction of Sample No. 1 from Core 2-F was classified as a site on the basis of presence/absence data (Figure 5-44). This sample was reclassified on the basis of the presence of Rangia shells, charred vegetal matter and noncharred vegetal matter, a combination of elements lacking in the other offshore samples. These elements in combination were recognized as site indicators in the Gagliano et al. (1982) study; however, in the present study they have been found together in samples, which, on the basis of other characteristics, are interpreted as natural deposits. In light of this, it is concluded that the presence of archaeological remains cannot be demonstrated in the point-count data from Sabine Pass 9.



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 CASE          ACTUAL      HIGHEST PROBABILITY    2ND HIGHEST     DISCRIMINANT
SEQNUM          GROUP       GROUP P(D/G) P(G/D)   GROUP P(G/D)      SCORES...

16SB52            1             1 0.6952 0.7485      2 0.2515       1.4977
16SJ2#1           1             1 0.7666 0.7189      2 0.2811       1.4027
16SJ2#2           1             1 0.7666 0.7189      2 0.2811       1.4027
22HA506           1 **          2 0.5405 0.7520      1 0.2480       0.1205
22HA500           2             2 0.5405 0.7520      1 0.2480       0.1205
16AL1             2             2 0.5405 0.7520      1 0.2480       0.1205
SP9-2-A#1         2             2 0.9579 0.8976      1 0.1024      -0.5443
SP9-2-A#2         2             2 0.9663 0.8323      1 0.1172      -0.4493
SP9-2-A#3         2             2 0.2150 0.9832      1 0.0168      -1.7315
SP9-2-C#2         2             2 0.2150 0.9832      1 0.0168      -1.7315
SP9-2-F#1         2 **          1 0.7666 0.7189      2 0.2811       1.4027
SP9-2-I#1         2             2 0.4795 0.7226      1 0.2774       0.2155
SP9-4-C#8         2             2 0.1819 0.9855      1 0.0145      -1.9265


                                  ALL-GROUPS STACKED HISTOGRAM
                                CANONICAL DISCRIMINANT FUNCTION 1
        4 +                                        2     2                                +
          I                                        2     2                                I
          I                                        2     2                                I
F         I                                        2     2                                I
R       3 +                              2         2     1                                +
E         I                              2         2     1                                I
Q         I                              2         2     1                                I
U         I                              2         2     1                                I
E       2 +                              2         2     1                                +
N         I                              2         2     1                                I
C         I                              2         2     1                                I
Y         I                              2         2     1                                I
        1 +                              2     22  1     1                                +
          I                              2     22  1     1                                I
          I                              2     22  1     1                                I
          I                              2     22  1     1                                I
          X---------+---------+---------+---------+---------+---------+---------+---------X
        OUT       -6.0      -4.0      -2.0        .0        2.0       4.0       6.0       OUT
  CLASS   222222222222222222222222222222222222222222222111111111111111111111111111111111111
CENTROIDS                                       2       1


                    CLASSIFICATION RESULTS -

                                        NO. OF     PREDICTED GROUP MEMBERSHIP
                     ACTUAL GROUP       CASES          1              2
                   ---------------     ------      --------       --------
                   GROUP      1             4          3              1
                   KNOWN                            75.0%          25.0%
                   GROUP      2             9          1              8
                   UNKNOWN                          11.1%          88.9%

                   PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED:  84.62%
```

Figure 5-44. Results of discriminant analysis on qualitative data, -1 phi fraction, Sabine Pass 9 area.

Geochemical Analysis

One sample (SP9-4-B#1) from the transgressive zone overlying Deweyville natural levee deposits immediately adjacent to a Deweyville channel was examined for its chemical constituents (see Table 5-6). This sample was analyzed primarily to expand the data on the chemical content of deposits which were deemed most likely to contain archaeological sites. One distinguishing characteristic of this sample was a low zinc and a high potassium content. Again it is presumed that these values are reflections of the range of variability which can be expected to occur in submerged natural deposits.

Sabine Pass 18

Seismic data obtained from this block confirmed the presence of the large channel located below and east of the higher, late Pleistocene terrace which covers much of the western portion of the survey area (Figure 5-45). The channel is interpreted as a filled Deweyville feature while the terrace is considered Prairie/Beaumont. The Deweyville channel measures approximately 800 to 1000 ft across and is situated west of a relatively well-defined Deweyville point bar (identified as Deweyville terrace on Figure 5-45). In the northeast corner of the survey area several seismic lines picked up evidence of another Deweyville channel which had been truncated by, and filled with sediment from, the more prominent channel. West of the main Deweyville channel and south of the Prairie/Beaumont Terrace occurs another relatively flat area which has been identified as a terrace similar to the Deweyville terrace east of the large channel.

Three lines of cores were placed in this block. Line 1, composed of nine cores, ran in a north-south direction along the eastern slope of the Prairie/Beaumont Terrace, overlooking the large Deweyville channel. Based on the terrestrial site-locational information presented earlier, this was deemed to be a high probability locale for prehistoric occupation. The second line consisted of only two cores placed on the Deweyville point bar east of the large, filled channel. Line 3, also of two cores, ran eastward from core 1-D down into the Deweyville channel.

Figures 5-46 and 5-47 illustrate representative seismic lines located west and east of the Deweyville channel. Figure 5-46 is taken from that portion of Seismic Line 23 which crosses the eastern edge of the Prairie/Beaumont Terrace and the western side of the filled Deweyville channel. As can be seen by the undulating reflector, it was a rough day when the data were collected, with seas running 5 to 6 ft. Nevertheless, the slope of the Prairie/Beaumont is readily identifiable, along with the drop-off into the Deweyville channel. Core 1-D and the two cores on Line 3 have been added to the figure for comparison of the various strata, although the actual core locations were about 180 ft to the south of Line 23.

Figure 5-47 is from a segment of Line 19 where the line crosses the western edge of the identified Deweyville point bar. The point bar initially was identified as the relatively thick reflector appearing between about 25 and 35 ft below the mud line. Cores in this area later showed that this reflection was caused by a thick bed of organics overlying the actual Deweyville surface. As with Figure 5-46, the Line 2 cores have been added to Figure 5-47 for comparison of the seismic and coring data, although the cores' actual locations were about 420 ft north of Line 19.

The geological interpretation of the survey area, based both on core and seismic data, is presented in Figure 5-48. This shows a section from the Prairie/Beaumont Terrace

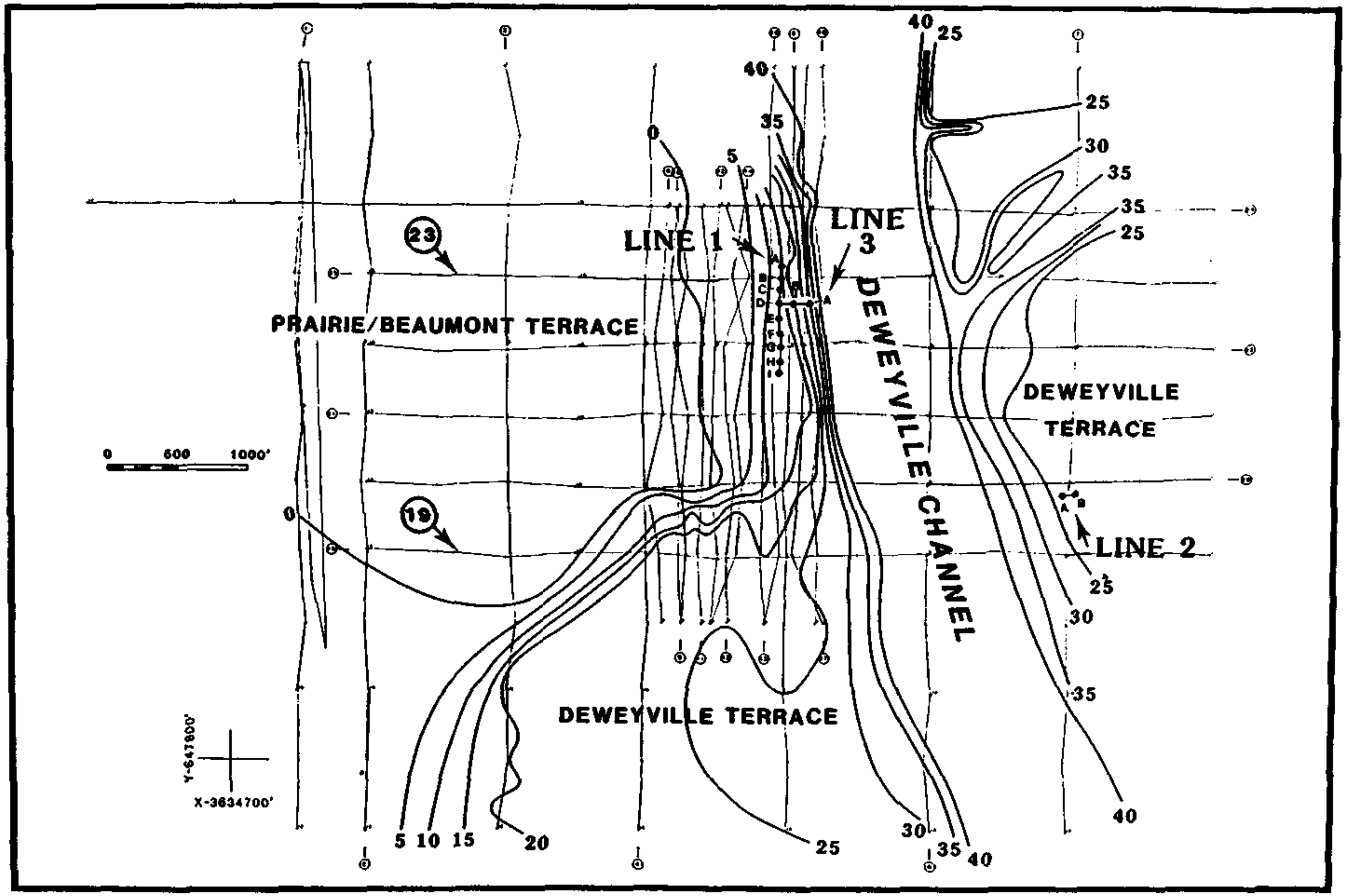


Figure 5-45. Subbottom contour map of the area surveyed in Sabine Pass 18. Note locations of Seismic Lines 19 and 23 and Vibracore Lines 1, 2, and 3.

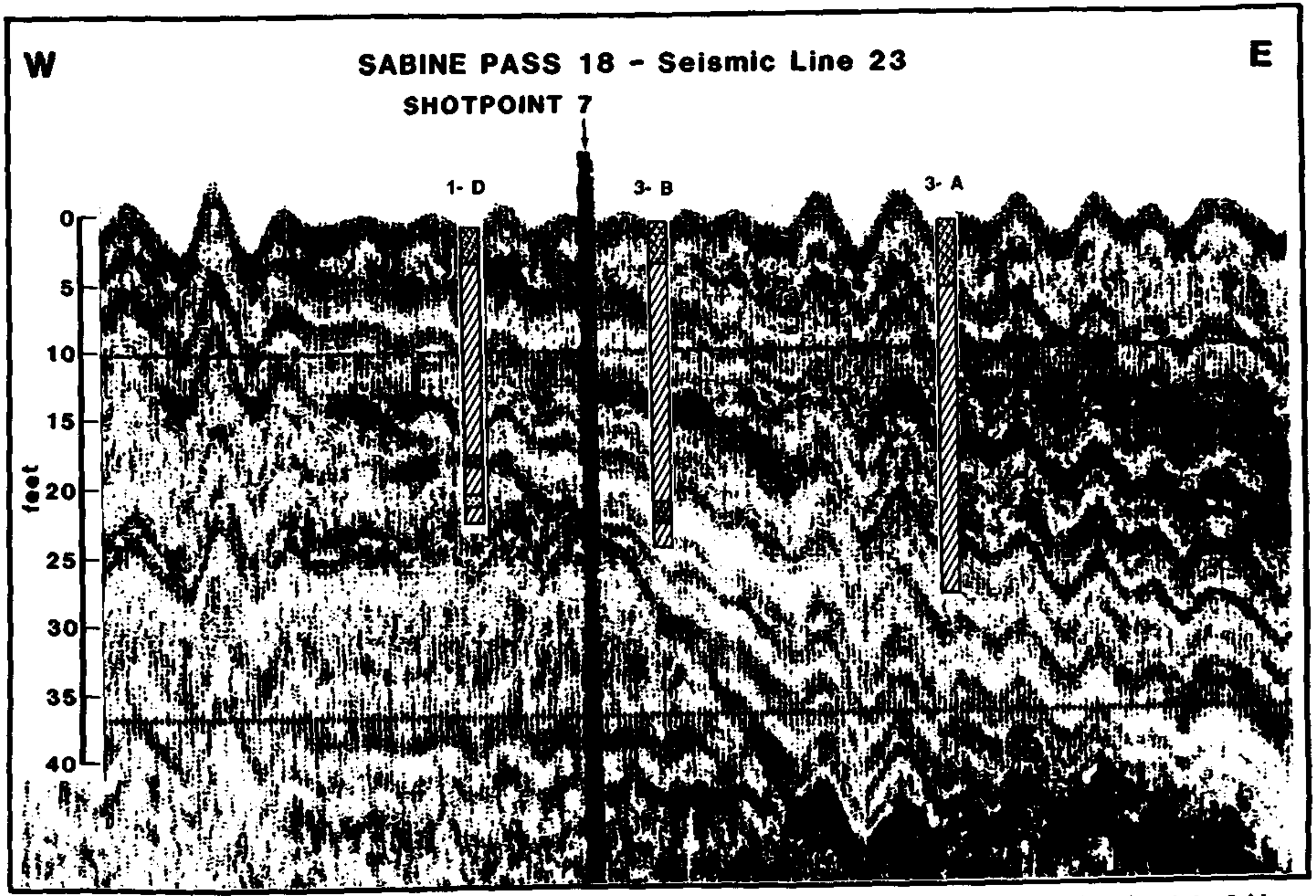


Figure 5–46. Example of a portion of Seismic Line 23, showing the Prairie/Beaumont Terrace to the left (west) and the Sabine Valley to the right. The dark reflector at a depth of about 40 feet below the seafloor in the Sabine Valley is interpreted as organic fill in a Deweyville channel.

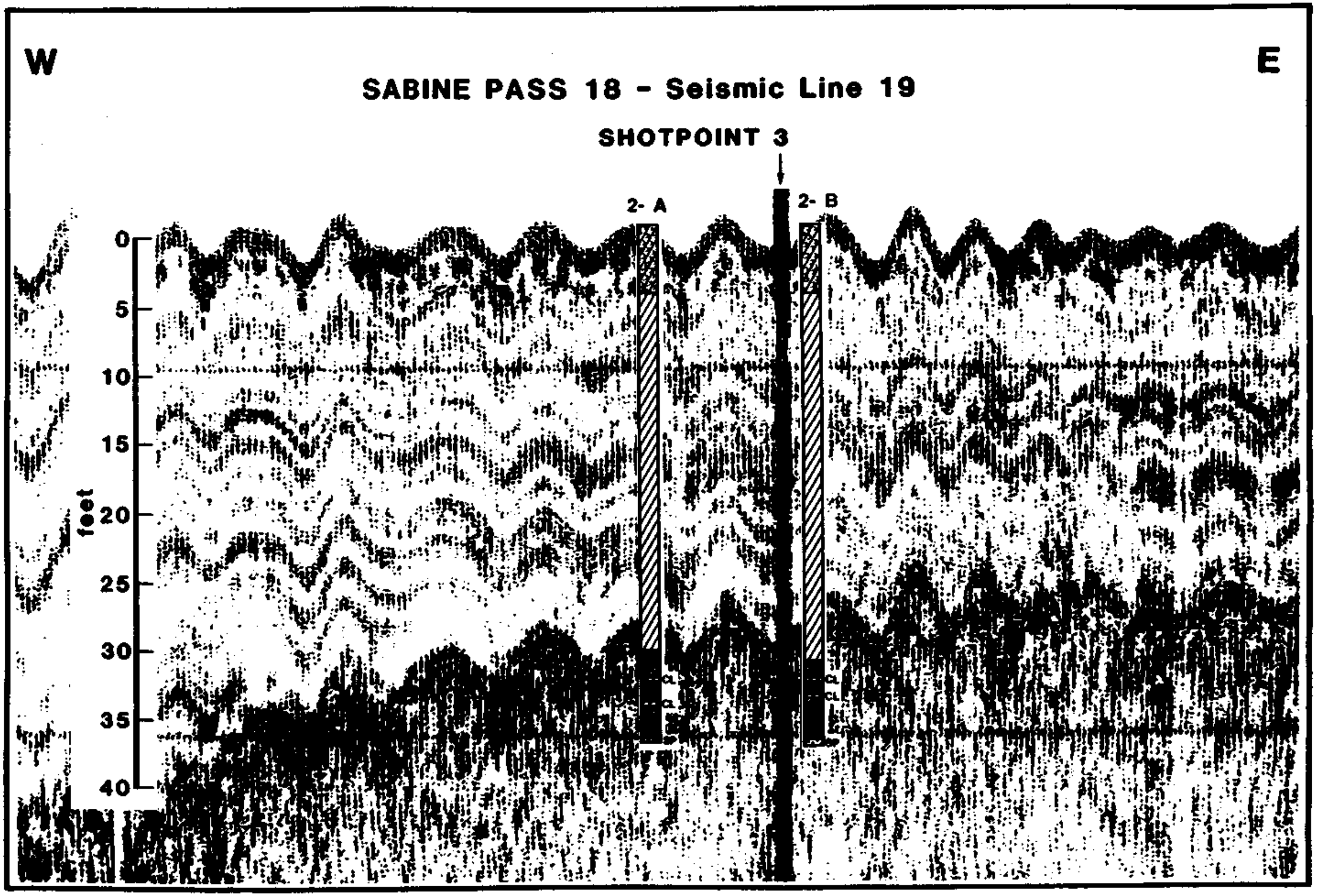


Figure 5–47. Example of a portion of Seismic Line 19 showing organics resting above a Deweyville point bar. Both Core 2-A and 2-B struck sand interpreted as point-bar deposits at about 37 feet below the sea floor.

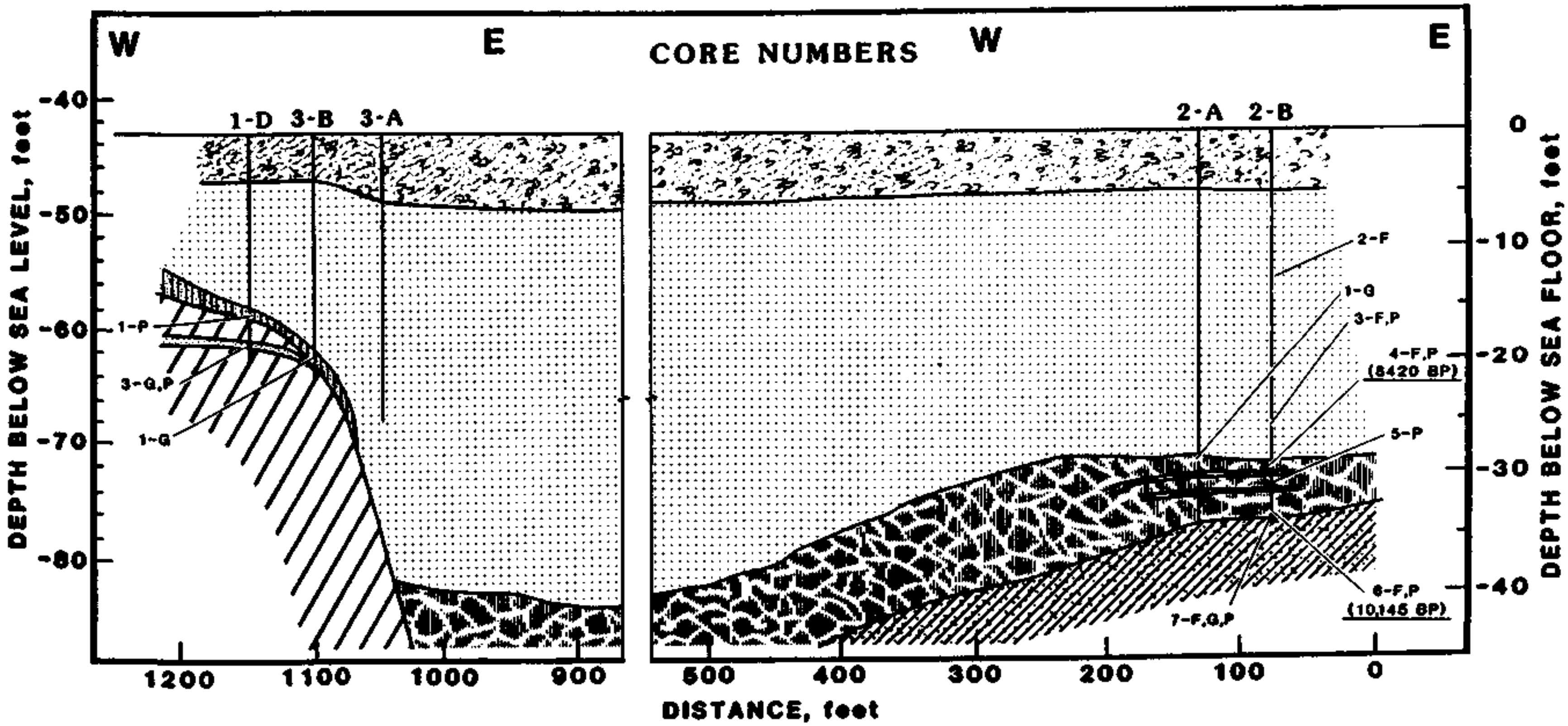


Figure 5-48. Geological interpretation of Sabine Pass 18 area. Interpretative section extends from the Prairie/Beaumont Terrace on the left, across the Deweyville channel, to the Deweyville point bar on the right.

edge, across the Deweyville channel, and up onto the Deweyville point bar. The earliest deposit encountered is the Prairie/Beaumont Terrace which was hit in the lower portions of Cores 1-D and 3-B. Other cores along Line 1 also penetrated the Prairie/Beaumont. In this instance the Prairie/Beaumont consisted of highly oxidized, thickly bedded, grayish brown (2.5Y 5/2) clay.

Perhaps the most interesting aspect of the Prairie/Beaumont deposit was the discovery within it of a thin stratum of highly oxidized sand containing whole and fragmented marine shells and tremendous quantities of foraminifera. This zone exhibited distorted bedding, animal burrows, and along with the shell and foraminifera, was composed primarily of light olive brown (2.5Y 5/4) sands and clays (Figure 5-49). Both grain-size and point-count analyses were performed on Sample 3 from Core 1-D (Figure 5-50 and Tables 5-11 and 5-12). The grain-size data (Sample SP18-1-D#3) indicate that slightly over 50% of the sample consisted of particles of sand size or greater, the majority of these being marine shell fragments. Examples of the identifiable species included Atlantic moon snails (Polinices duplicatus), pointed nut clams (Nuculana acuta), and cut-ribbed ark shells (Anadara lienosa floridana).

A portion of Sample 3 from Core 1-D was examined for pollen. It proved to be barren, suggesting a degradation and subaerial exposure (see Appendix B). While no sample from this zone was submitted for detailed foraminifera analysis, a portion from Core 1-H was examined superficially. The species Elphidium exavatum and Ammonia parkinsoniana made up about 95% of the assemblage (Barun K. Sen Gupta, personal communication 1985). The great density of foraminifera in the sample is unusual and probably reflects a high-energy beach deposit (Sen Gupta, personal communication 1985). Overall, these data support an interpretation of this sand and shell unit as a Pleistocene beach or chenier deposit associated with the Prairie/Beaumont Terrace. The fact that a compact, oxidized, gray clay layer immediately overlies the sand and shell seems to argue that the beach deposit is not related to the most recent episode of marine transgression. If this were true, we would anticipate the initial transgressive zone or bay/estuarine deposits immediately above the sand and shell. Whether this deposit is Sangamon or Farmdalian in age cannot now be determined. It represents a time, however, when this segment of the Prairie/Beaumont was subaerially exposed along the edge of what was probably the open Gulf.

According to our interpretation of geological events within the study area, the next feature to have developed in Sabine Pass 18 is the Deweyville floodplain, including the identified Deweyville channels and point-bar deposits. The point-bar deposits prevented core penetration and, as shown in Figure 5-51, were encountered only in the very bottoms of Cores 2-A and 2-B (see Figures 5-47 and 5-48). These deposits consisted of a homogeneous sand which was subjected to grain-size, point-count, foraminifera, and pollen analyses (Core 2-B, Sample No. 7). The grain-size analysis (see Figure 5-50) indicated that over 70% of the matrix consisted of particles of or greater than, sand size. The point-count data indicate a probable fluvial origin for the deposit, as only clastic particles and vegetal matter were found. The latter is almost certainly related to roots and other portions of the overlying swamp or marsh deposit. Both the pollen and foraminifera samples from the deposit were barren. This deep sand deposit, here interpreted as a Deweyville age fluvial feature, is apparently equivalent to the "basal sands" identified throughout the valley by Nelson and Bray (1970).

Overlying the Deweyville point bar, and apparently filling the adjacent Deweyville channel, was a thick bed of organics (Figure 5-51) containing at least two thin clay seams (see Figure 5-48). This organic deposit produced the pronounced reflector

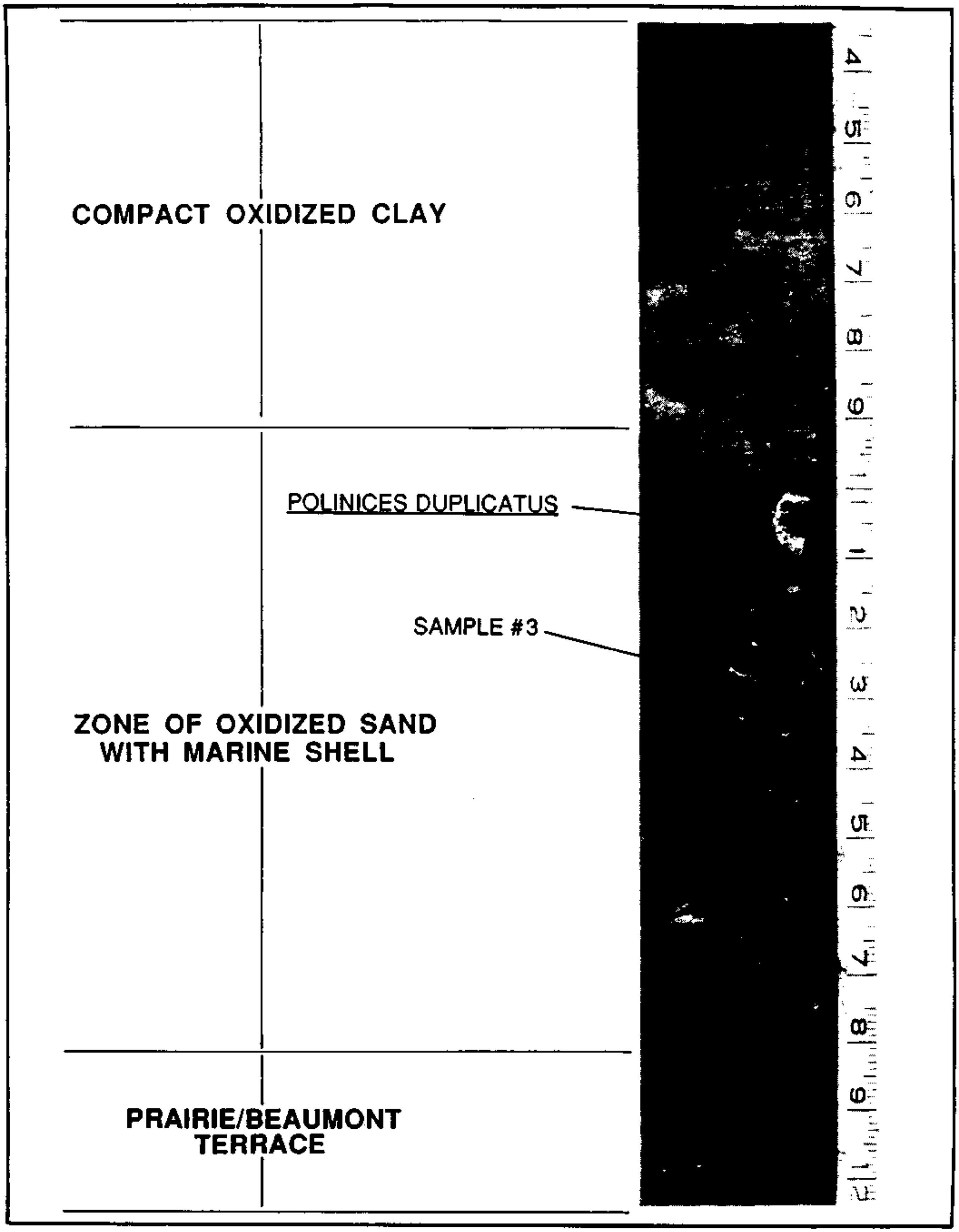


Figure 5-49. Stratum of marine shell and oxidized sand resting atop the Prairie/Beaumont Terrace in Sabine Pass 18 (from Core 1-D).

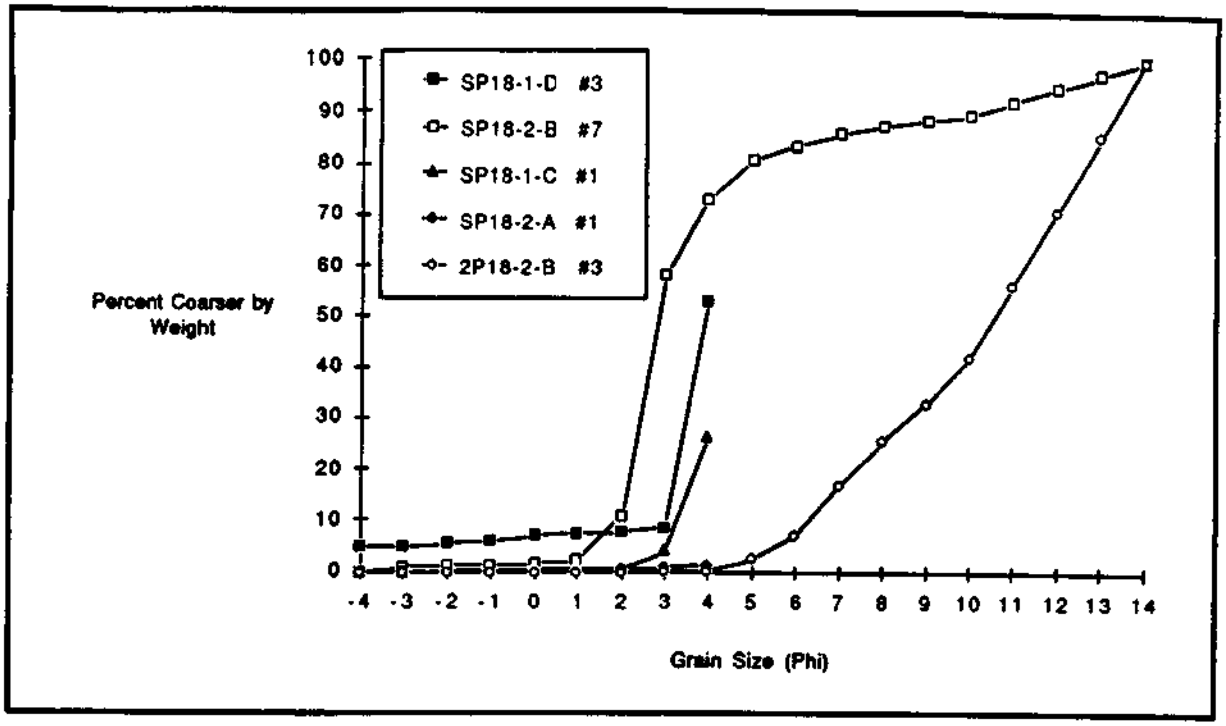


Figure 5-50. Grain-size distribution curves of selected samples from the Sabine Pass 18 area.

originally contoured as the Deweyville surface. Sample No. 6 from Core 2-B near the base of the organic stratum was analyzed for both pollen and foraminifera. It was barren of foraminifera, but contained a high proportion of grass pollen along with pollen from alder and tupelo (see Appendices A and B). Both sets of data suggest freshwater deposition, with the pollen indicative of a swamp adjacent to a nearby marsh. If this is correct, then the marsh may have existed within the filled Deweyville channel while the swamp was perched on the slightly higher point bar. A portion of the peat matrix from Sample No. 6 also was submitted for radiocarbon dating, providing an age of 10,145 ± 285 B.P. (UGa-5402). This date is approximately 1,000 years earlier than dates from similar swamp deposits encountered in Sabine Pass Blocks 3, 6, and 9. It seems reasonable, however, considering that Block 18 is located further down the Sabine Valley and would have undergone change to swamp and marsh earlier than the other blocks in the Sabine Pass area. In addition, the date from the Sabine Pass 18 area is from several feet lower than the dates on swamp deposits in the other three blocks.

Higher within the organic deposit, samples from a location between the two clay seams and from portions near the deposit's top (Core 2-B, Sample Nos. 4 and 5, and Core 2-A, Sample No. 1) were examined in detail by the various analyses. Sample No. 5, from between the clay seams (see Figure 5-48), was examined for pollen, however, the grains were obscured by oxidized organic remains, and they could not be counted. The upper portion of the same core (Sample No. 4) produced a pollen signature typical of a marsh, although an abundance of pine pollen may suggest proximity to an upland. In this instance, the upland may be the Prairie/Beaumont Terrace west of the major Deweyville channel. The foraminifera analysis substantiates the pollen data from Sample No. 4. The assemblage is dominated by *Saccammina sphaerica*, a species found in marshes of very low salinity (see Appendix A). A portion of the organics from Sample No. 4 was submitted for radiocarbon

Table 5-11. Point Counts for Sabine Pass 18 Area: -1 Phi Fraction Expressed in Particles per Kilogram.

	SAMPLES						
COMPONENT	SP18-1-B#1	SP18-1-C#1	SP18-1-D#3	SP18-1-E#1	SP18-2-A#1	SP18-2-B#7	SP18-3-B#1
Marine shell	310		126	10			123
Oyster shell		28		30			
Mussel shell							
Barnacle/brackish species	7		6	10			9
Rangia sp. shell				90			
Unidentified shell	860	56	417				47
Iron nodule/pyrite				10			
Clastic/clastic concretion				10		51	
Carbonate concretion							19
Vegetal material						559	
Charred vegetal material							
Seed							
Bone				10			
Charred bone							
Crustacean exoskeleton							
Stone							
Landsnails							
Other			6				

dating, and yielded a date of 8420 ± 105 B.P. (UGa-5401). Based on this date, and the one from Sample No. 6 in the same core, it is suggested that the area changed from a swamp environment at 10,135 B.P. to a freshwater marsh and was apparently just becoming a brackish marsh by 8420 B.P. The stratigraphy in the cores implies a slow, but steady, sea-level rise over the approximately 1700 years between the two dates.

Lastly, in regard to the point-bar organics, Sample No. 1 from Core 2-A, located at the very top of the organic unit, was subjected to grain-size and point-count analyses (see Figure 5-50 and Tables 5-11 and 5-12). The grain-size data indicate the sample is approximately 98% silts and clays. This appears to be too great a quantity of fine material for an organic unit, and implies that the overlying clays have contributed significantly to the sample. This is substantiated by the point-count data which indicate a moderate amount of vegetal material, occurring only in the 0 phi size range.

The next major stratigraphic unit encountered is the initial transgressive zone, as defined previously. Unlike the blocks reviewed earlier, however, the transgressive

Table 5-12. Point Counts for Sabine Pass 18 Area: 0 Phi Fraction Expressed in Particles per Kilogram.

COMPONENT	SP18-1-B#1	SP18-1-C#1	SP18-1-D#3	SP18-1-E#1	SP18-2-A#1	SP18-2-B#7	SP18-3-B#1
	SAMPLES						
Marine shell	91		84				
Oyster shell							
Mussel shell							
Barnacle/brackish species			36	20			152
Rangia sp. shell							
Unidentified shell	3104	132	2832	150	29		502
Iron nodule/pyrite		188		840			95
Clastic/clastic concretion	56			20	138	51	
Carbonate concretion							
Vegetal material	112	38	12		41	1551	
Charred vegetal material					138		
Seed		9					
Bone							
Charred bone							
Crustacean exoskeleton			12				
Stone				10			
Landsnails							
Other	48		146	10			

zone in Block 18 was not an all-encompassing unit. Rather, it was confined only to the top of the Prairie/Beaumont Terrace. Why this should be is not clearly known. Perhaps the organic substrate, prevalent across the area below the Prairie/Beaumont Terrace, played some part in preventing the development of the transgressive zone.

Several samples were taken from the transgressive zone atop the Prairie/Beaumont surface. Pollen from Cores 1-A, Sample No. 1, and 1-D, Sample No. 1, indicated that the transgressive zone is a highly disturbed unit. The initial sample was heavily weathered and mechanically damaged, indicating significant turbulence, while the latter sample indicated either swamp, marsh, or estuarine deposition (see Appendix B). One seed from Sample No. 1 in Core 1-C was the only one recovered in the entire block, and was identified as Scirpus olneyi (see Table 5-1), suggesting that a reworked marsh was responsible for at least some of the material found in the transgressive zone.

One section of the transgressive zone (Core 1-C, Sample No. 1) was subjected to grain-size analysis. The data reveal a moderate percentage (ca. 25%) of greater-than-silt-

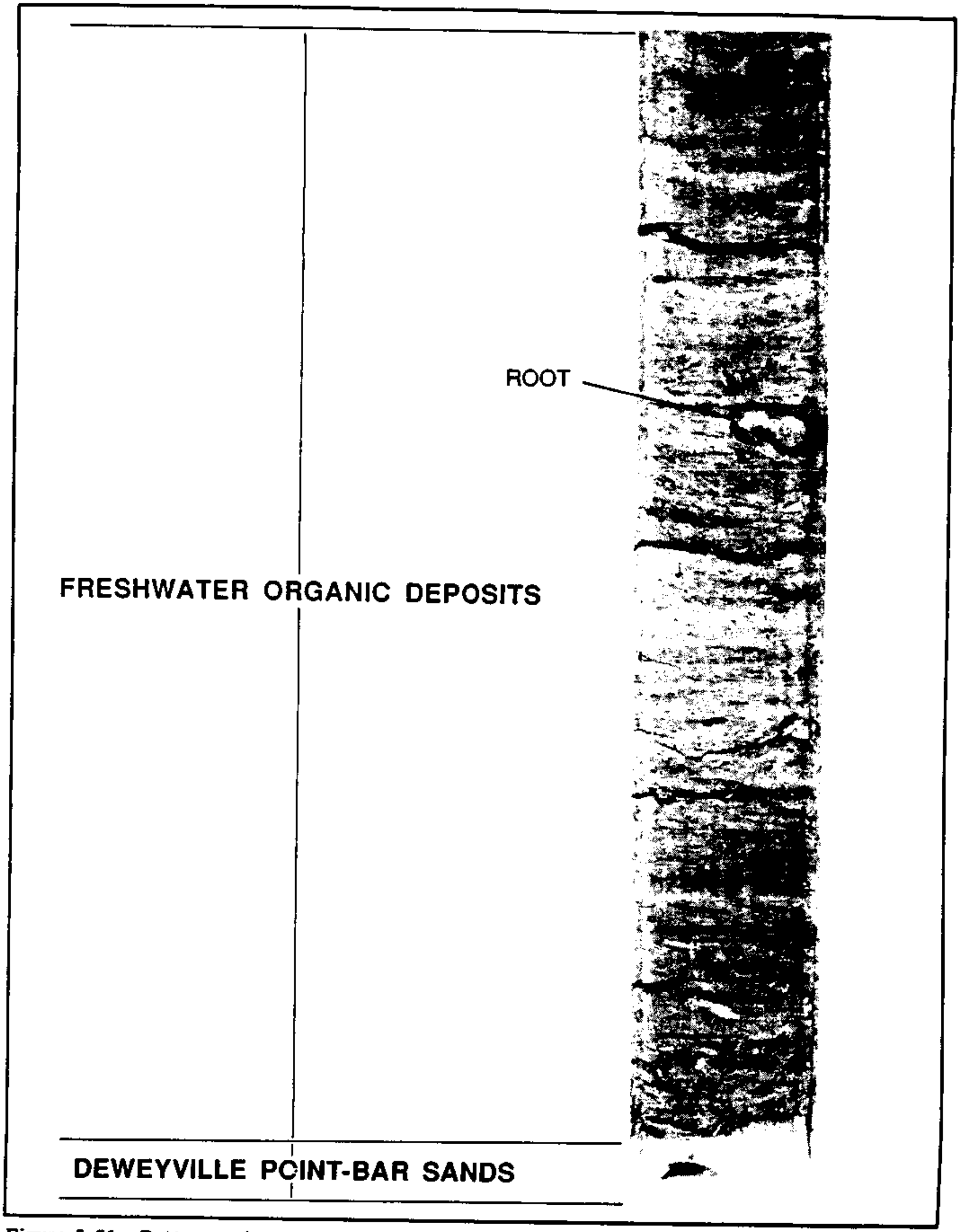


Figure 5-51. Bottom of Core 2-A, Sabine Pass 18 area, showing interpreted Deweyville point-bar sands and overlying freshwater organic deposits.

size particles (see Figure 5-50). Point-count analyses were performed on four samples from this zone (Core 1-B, No. 1; Core 1-C, No. 1; Core 1-E, No. 1; and Core 3-B, No. 1) (see Tables 5-11 and 5-12). All produced significant amounts of shell, mostly marine species such as cut-ribbed ark (Anadara lienosa floridiana), blood ark (Anadara ovalis), pointed nut clam (Nuculana acuta), moon snail (Naticidae), and lucine (Lucinidae), although some brackish-water species, such as Rangia, were identified. This implies that a somewhat more saline environment produced the transgressive zone in Block 18 as opposed to the same zone in Blocks 3, 6, and 9, or more likely that marine shell residue from the slightly deeper beach deposit is being incorporated into the initial transgressive zone.

Finally, capping both the transgressive zone atop the Prairie/Beaumont and the organic deposit within the Sabine Valley, was the typical bay/estuarine fill noted in the previous blocks. A grain-size sample from this unit (SP18-2-B#3 in Figure 5-50), indicates a primarily clay size composition. Foraminifera (Core 2-B, Nos. 2 and 3) and pollen (Core 2-B, No. 3) samples were taken from this unit. The foraminifera suggest a nearly marine environment within the estuary, while the pollen indicate proximity to marsh and upland pine habitats (see Appendices A and B). This suggests that as the Sabine Valley filled with estuarine deposits, and in all likelihood was an open body of moderately saline water, the nearby and upriver Prairie/Beaumont Terrace still supported stands of pine.

Archaeological Site Potential

Two locations within the Sabine Pass 18 area were considered possible areas for archaeological remains. These areas were the sandy point-bar deposit identified beneath the organic swamp and marsh channel fill, and the top of the Prairie/Beaumont Terrace feature with the capping initial transgressive zone. The point-bar surface offered an early (pre-10,000 B.P.), apparently intact, high probability landform for examination. The edge of the Prairie/Beaumont Terrace, overlooking the floodplain, represented a classic escarpment edge setting—a setting conducive to human settlement. It was assumed that the initial transgressive zone and its contact with the pretransgressive Prairie/Beaumont surface would be the most reasonable location to examine for archaeological deposits. In addition, samples were taken from the underlying beach or chenier deposit, both to characterize its content as a natural deposit and to assess it relative to possible archaeological inclusions.

Point-Count Analysis

The results of the point counts are presented in Tables 5-11 and 5-12. With one exception, the samples from the top of the Prairie/Beaumont surface (Samples from Core Lines 1 and 3) contain identifiable marine shell. This shell is presumably derived from the previously described beach deposit. One sample, SP18-1-E#1, contains Rangia, oyster, and marine shell. The occurrence of these types in the same sample suggests considerable mixing of the deposits. As noted earlier, it appears that marine shell from just beneath the Prairie/Beaumont surface has become incorporated in the clay and initial transgressive zone just above it. It had been thought that the top of the Prairie/Beaumont here may have been impacted by Gulf wave-front or wave-base erosion. However, it appears that relatively thick and intact bay/estuarine sediments overlie this area, meaning marine transgression was well above the Pleistocene surface. As can be seen in Figure 5-48, the Prairie/Beaumont rises rapidly toward the west, reaching the seafloor about 600 feet west of the area of the cores. To the west of the cored area then, the Prairie/Beaumont has been directly impacted and seriously disturbed by marine transgression.

One fragment of possible fish bone was recovered in the -1 phi fraction of Sample Number 1 from Core 1-E. A possible piece of stone was identified in the same sample in the 0 phi fraction. This stone is elongated (2.5 mm long) and blocky, and is reddish to reddish black in color. Visual examination indicates that it may be a shattered fragment of an "iron nodule", of which many were recovered in this sample. The point-count data provide no indications that archaeological remains are represented in these samples.

Discriminant Analysis

Discriminant analysis was conducted on each point-count fraction using quantitative and qualitative data. In none of the analyses were any of the offshore samples reclassified with the site samples nor did any of the offshore samples spatially fall within the overlap area between the two groups. There are no indications from the point-count data that archaeological remains were encountered in the Sabine Pass 18 area. No geochemical samples from the Sabine Pass 18 area were analyzed.

High Island 49

Seismic survey within High Island 49 focused on the terrace edge overlooking the Sabine River Valley and the margins of a filled stream channel which appeared to enter the valley from the north. Figure 5-52 presents a plan view of the area. Contours are of the Pleistocene terrace surface and the base of the filled stream channel. Initially this terrace was thought to be of Prairie/Beaumont age; however, examination of additional seismic data collected adjacent to Block 49 suggests that this surface is a Deweyville feature. The stream channel is also believed to be of Deweyville age, owing partly to its large size and partly to the fact that the surface of the deposits within it is at approximately the same elevation as the adjacent terrace. The eastern one third of the channel consists of massive point-bar deposits, indicating that the stream was shifting to the west prior to its abandonment. Preserved within the upper portion of the Deweyville channel is a much smaller stream which apparently drained the relict channel in terminal Pleistocene or early Holocene times.

Figure 5-53 is a section of a north-south seismic line (Line Number 31) which illustrates several of the features discussed. At its southern end is the Sabine River valley, obscured by biogenic gas. Immediately north of that, between shot points 6.5 and 9, is the Deweyville terrace. This deposit is characterized by the same initial hard reflector and underlying void noted in Sabine Pass 9. If the Deweyville terrace in High Island 49 is an Older Deweyville surface, as suggested by its elevation, then the floodplain surface south of it beneath the biogenic gas is probably of Younger Deweyville age. North of the Older Deweyville Terrace in Figure 5-53, between shot points 5 and 6.5, are a series of foreset beds representing point bar deposits within the Deweyville channel. The underfit stream within the upper portion of the Deweyville channel is roughly centered on shot point 4. North of that lie horizontally bedded clays and organic lenses which reflect gradual filling of the relict Deweyville channel.

Three localities within the High Island 49 survey area were selected for vibracoring: the Older Deweyville Terrace edge adjacent to the Holocene Sabine River, the margin of the Deweyville channel, and the margin of the underfit stream channel. A total of 18 cores arranged in three lines were taken from these localities. Line 1, consisting of 10 cores, was placed along the margin of the Deweyville channel, a situation believed to have a high potential for site occurrence (See Figure 5-52). An effort was made to position the cores just within the relict channel in order to avoid the potential impact of marine transgression on the terrace surface. Unfortunately, none of the cores

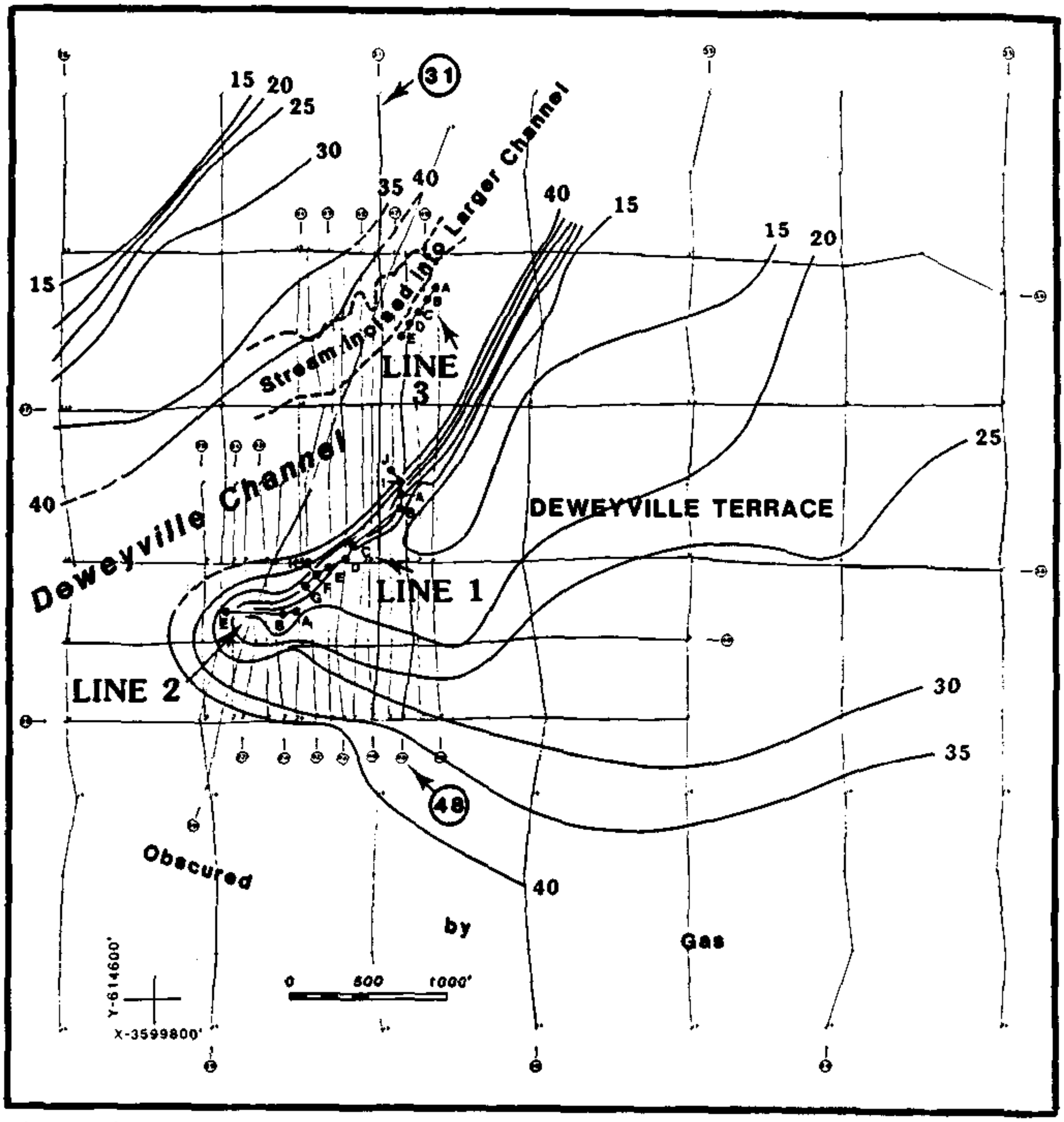


Figure 5-52. Contour of pretransgressive surfaces in the High Island 49 area. Note locations of Seismic Lines 31 and 48 and Vibracore Lines 1, 2, and 3.

succeeded in penetrating beneath the point-bar deposits within the channel. A geological interpretation of the southern portion of Line 1 based on the combined seismic and vibracore data is presented in Figure 5-54 (Since definition of Older and Younger Deweyville surfaces is tentative, only Deweyville deposits are identified in the figure). The basal feature encountered in the cores, the Deweyville point bar, is characterized by thinly bedded light brownish gray clay and highly oxidized reddish yellow sand lenses. Parallel laminations predominate, but wavy and lenticular laminations are also present (Figure 5-55). These structures are common in the zone of horizontal bedding typically found in the upper and middle portions of point bars (Bernard et al. 1970:6-8).

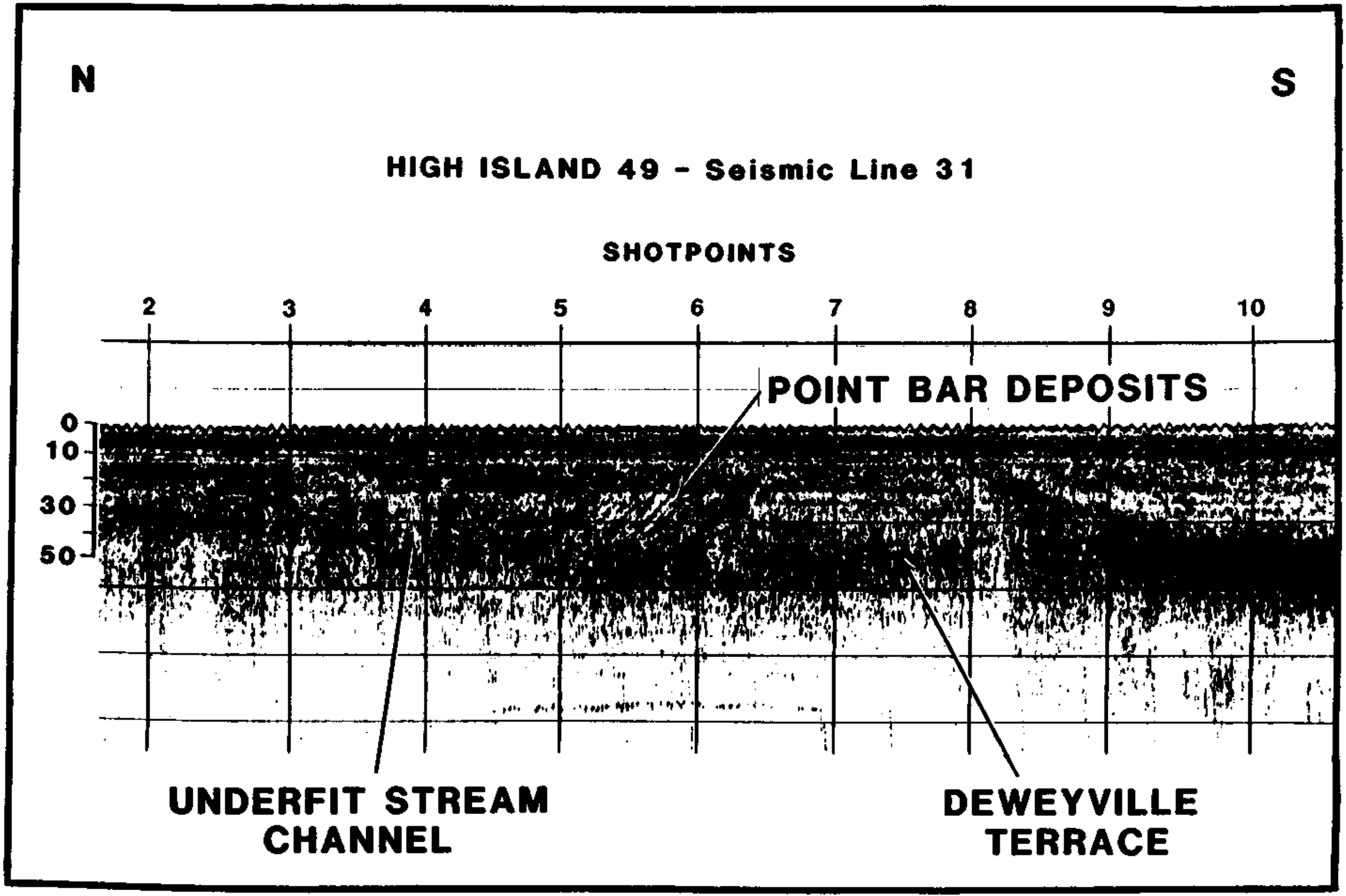


Figure 5–53. Section of Seismic Line 31 which crosses the major features identified in the High Island 49 area.

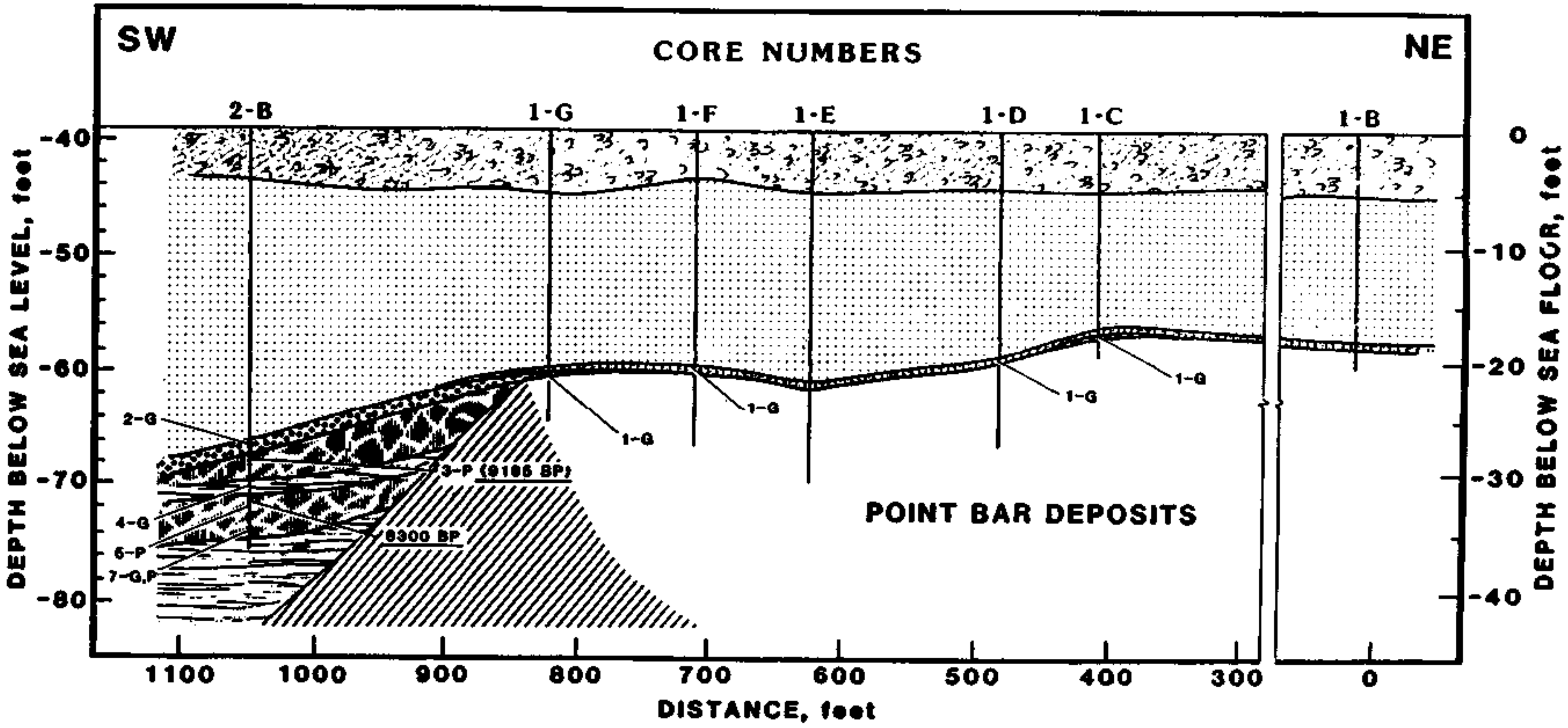


Figure 5-54. Geological interpretation along Core Lines 1 and 2, High Island 49 area.

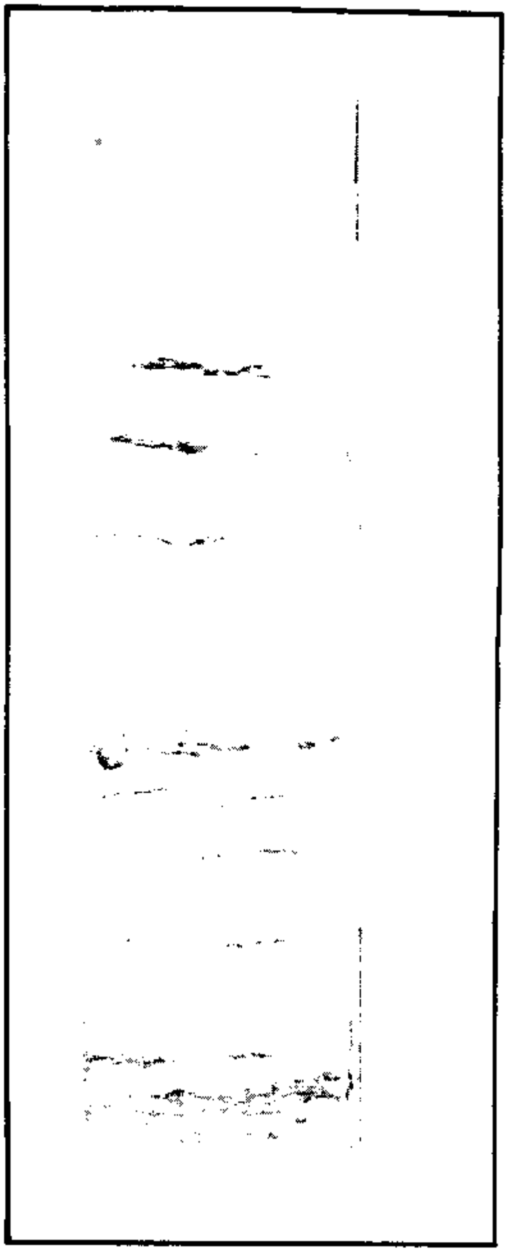


Figure 5-55. Oxidized and laminated sands and clay interpreted as point-bar deposits (Core 1-A, High Island 49).

Immediately overlying the point-bar deposits is a thin zone of bay/estuarine transgressive deposits (Figure 5-56). As in other portions of the study area, this initial transgressive zone consists of mottled clays and sand-filled burrows. Shells of Rangia cuneata are occasionally present, but they are not continuous throughout the stratum. A grain-size sample from one of the cores (HI49-1-C#1) indicates that just over 50% of the zone is composed of silt and clay, and that the coarse fraction consists predominantly of very fine sand (Figure 5-57).

Also present within this stratum are shell fragments of oyster (Crassostrea virginica) and barnacle (Balanus sp.), oxidized clastic concretions, and small quantities of charred vegetal material (Samples HI49-1-C#1, HI49-1-D#1, HI49-1-F#1 and HI49-1-G#1, Tables 5-13 and 5-14).

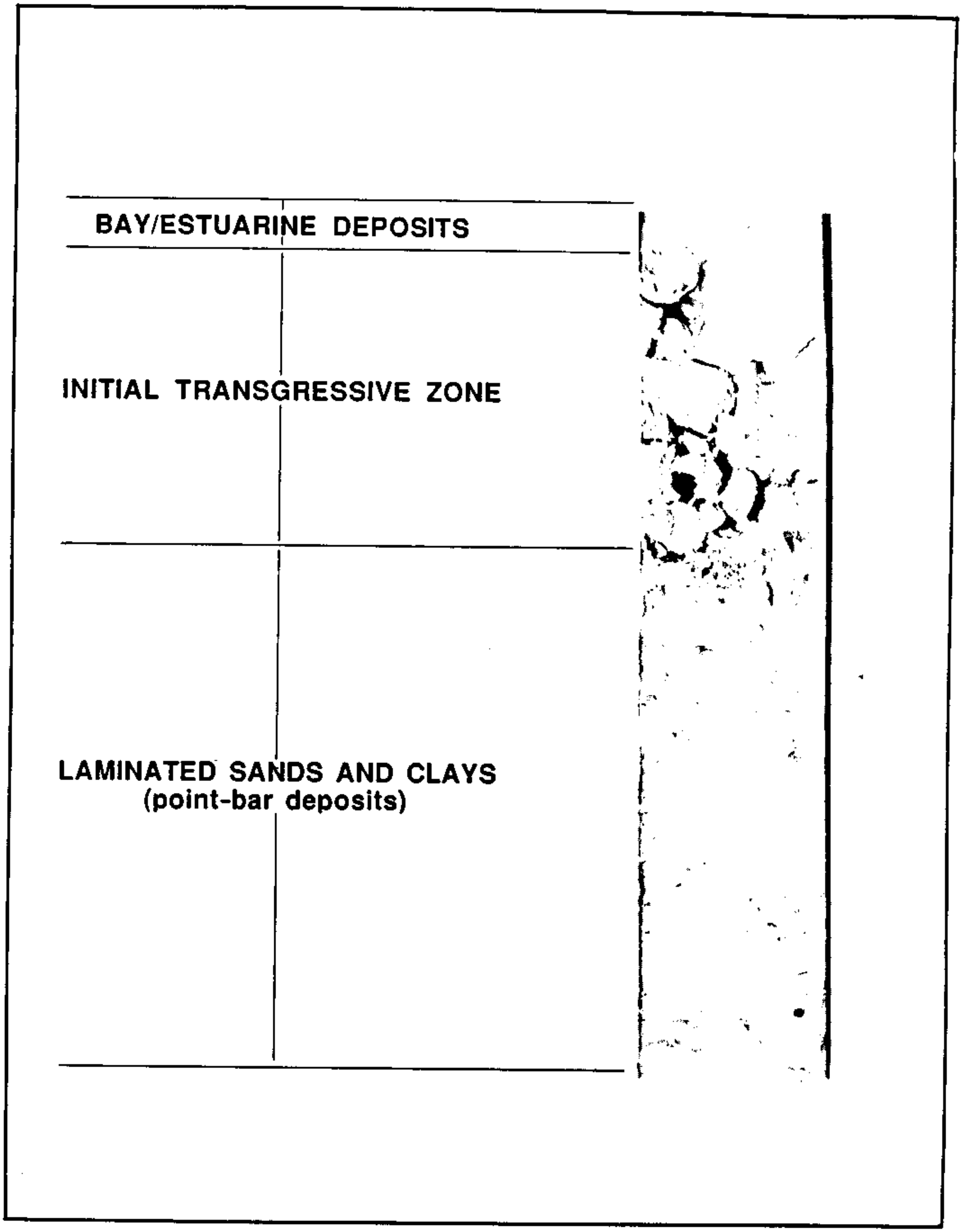


Figure 5-56. Bay/estuarine transgressive deposits in Core 1-A, High Island 49.

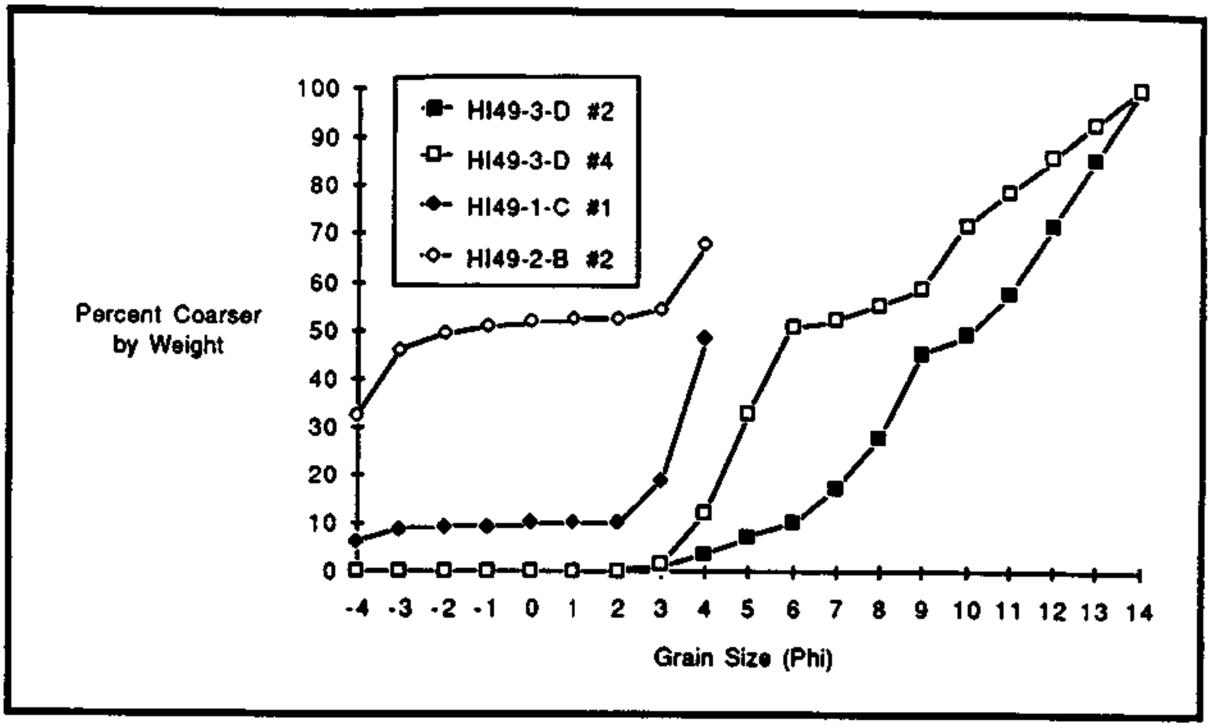


Figure 5-57. Grain-size distribution curves of samples from the High Island 49 area.

Above the initial transgressive zone is a homogenous deposit of soft, dark grayish brown clay. Thin parallel color laminations and sand laminations occur infrequently, but otherwise the deposit exhibits little variability (Figure 5-56). It is interpreted as representing the massive bay or estuarine fill noted throughout the study area. The uppermost sediments in the section consist of very soft to fluid, dark grayish brown clay and silty clay which have been extensively burrowed. These deposits are typical of nearshore Gulf environments in this area.

A second line of three cores was placed along what was interpreted from the seismic record as the Older Deweyville Terrace edge (See Line 2, Figure 5-52). Examination of the cores indicates that all of them missed this feature and penetrated younger fluvial and organic deposits within the relict Sabine River Valley. The location of one of these cores (Core 2-B) is shown in Figure 5-54. It now appears that the reflector interpreted as the terrace edge was actually a portion of the the initial transgressive zone containing a concentration of Rangia cuneata, which slopes gradually into the relict valley. The terrace edge, as can be seen in Figure 5-54, is instead 100 to 200 ft to the northeast and has a much steeper slope.

Although the second line of cores missed their intended target, they provide important data on the deposits filling the Sabine River Valley in this locality. The basal stratum encountered in these cores is a gray silty clay containing numerous small charcoal flecks (see Figure 5-54). It appears to be thickly bedded, but the maximum depth of this zone is unknown as none of the cores penetrated it completely. This stratum is interpreted as a fluvial deposit, possibly in a backswamp environment. Its age is uncertain, but its elevation with respect to the Older Deweyville Terrace and radiocarbon dates on overlying strata suggest that it is the Younger Deweyville Terrace surface.

Immediately above this stratum is a mottled gray and brown organic clay with more of the small flecks of charcoal and a few sand seams. Point-count analysis of the -1 phi and 0 phi fractions of a sample from this zone identified large quantities of clastic concretions, smaller frequencies of vegetal matter and unidentified shell fragments, and a charred fish scale (Sample HI49-2-B#7, Tables 5-13 and 5-14). A pollen sample from this unit proved to be barren, suggesting that the deposits were subjected to recurrent wet-dry cycles which can break down pollen grains (Appendix B). The stratum is thought to represent a swamp which received occasional overflows from the river and dried out during periods of low rainfall.

Table 5-13. Point Counts for High Island 49 Area: -1 Phi Fraction Expressed in Particles per Kilogram.

	SAMPLES								
COMPONENT	HI49-1-C#1	HI49-1-D#1	HI49-1-F#1	HI49-1-G#1	HI49-2-B#2	HI49-2-B#4	HI49-2-B#7	HI49-3-C#1	HI49-3-E#1
Marine shell					4				
Oyster shell	25		81	49					
Mussel shell									
Barnacle/brackish species			63	6	4			13	
Rangia sp. shell	69		9	48	225			1103	
Unidentified shell	38		36		428				
Iron nodule/pyrite			8	12					
Clastic/clastic concretion	6						112	4	
Carbonate concretion			9		92			42	
Vegetal material									
Charred vegetal material									
Seed									
Bone									
Charred bone									
Crustacean exoskeleton									
Stone									
Landsnails									
Other									

Capping this organic clay layer is a relatively thin (0.7 ft) zone of interbedded gray clays and fine sand lenses which appears to reflect a minor flood episode. This zone was too thin to be represented graphically in Figure 5-54. This is overlain by a second organic clay stratum containing numerous fine seams of vegetal material. A pollen sample from this stratum contained a diversity of bottomland and upland arboreal species and a relatively low percentage of grasses suggesting a continuation of the freshwater swamp environment seen farther down the core. A radiocarbon date of 8300 ± 185 B.P. (UGa-5420) was obtained from this layer. The date is out of sequence with a date from an overlying stratum and falls below the reconstructed sea level curves of both Nelson and Bray (1970) and the present project, suggesting that it is in error.

Table 5-14. Point Counts for High Island 49 Area: 0 Phi Fraction Expressed in Particles per Kilogram.

	SAMPLES								
COMPONENT	HI49-1-C#1	HI49-1-D#1	HI49-1-F#1	HI49-1-G#1	HI49-2-B#2	HI49-2-B#4	HI49-2-B#7	HI49-3-C#1	HI49-3-E#1
Marine shell									
Oyster shell									
Mussel shell									
Barnacle/brackish species		8	172		25			4	
Rangia sp. shell									
Unidentified shell	307	57	63		607	56	56	1279	16
Iron nodule/pyrite	75	16	136	6	4				
Clastic/clastic concretion					8	140	450	38	
Carbonate concretion					358			4	
Vegetal material	13					112	47		156
Charred vegetal material	6	16	9		12	19	28		248
Seed					4	9			37
Bone								4	
Charred bone					4		9		
Crustacean exoskeleton									
Stone									
Landsnails									
Other		8							

Above the second organic clay stratum is another zone of interbedded gray clays and sand lenses (see Figure 5-54). This zone is somewhat thicker than the first and contains a much higher percentage of sand. Also present within the coarse fraction are relatively high frequencies of clastic concretions and vegetal material and smaller quantities of unidentified shell fragments and seeds (Sample HI49-2-B#4, Table 5-14). One of the seeds was identifiable as three-cornered grass (Scirpus olneyi). The stratum apparently represents another flood episode, of somewhat greater magnitude than the first. The presence of three-cornered grass suggests that freshwater marshes were relatively close to the area by this time.

The flood deposit grades imperceptibly into a third organic clay stratum, the last and thickest encountered along this line of cores (see Figure 5-54). Vegetal material is again abundant, and in some instances horizontal bedding is apparent. The pollen profile for this stratum is very similar to that of the previous organic clay stratum, arguing for a persistence of the freshwater swamp (Appendix B). A radiocarbon date of 9165 + 130 B.P. (UGa-5419) was obtained from this deposit. This date is out of sequence with that from the underlying organic clay stratum, but, as noted above, the error appears to lie with that deeper sample.

Immediately overlying the uppermost organic clay layer is a thin zone of bay/estuarine transgressive deposits. The sample recovered in Core 2-B contains a high frequency of Rangia cuneata shells and exhibits little evidence of burrowing, but is otherwise similar to the initial transgressive deposits encountered elsewhere in the study area. A grain-size analysis of the coarse fraction of this deposit (Figure 5-57) indicates a majority of particles of sand size and larger, reflecting the numerous Rangia shell fragments in the sample. This zone's elevation in Core 2-B suggests that this zone dips markedly from the Older Deweyville Terrace into the adjacent swamp due partly to compaction and subsidence within the latter. The uppermost strata encountered on Line 2 were similar to those described from Line 1.

A third line of five cores was placed within and along the margin of the underfit stream channel located within the larger Deweyville channel (see Figure 5-52). A portion of a north-south seismic line which crosses the small meandering channel is shown in Figure 5-58. The channel is encountered once between shot point 1 and Core 3-A from about 15 ft below the seafloor to 28 ft below the seafloor. It is crossed a second time in the vicinity of Cores 3-D and 3-E.

A geological interpretation of this line of cores based on the combined seismic and vibracore data is presented in Figure 5-59. Some of the cores from Line 1 are added to this figure to provide an interpreted section across the large Deweyville channel (see Figure 5-52 for core locations). The depositional sequence in Cores 3-A, 3-B, and 3-C is similar to that described for Line 1. The basal feature encountered is the Deweyville point bar. This is overlain by a thin zone of initial transgressive deposits containing small quantities of Rangia shells. Above that are massive bay/estuarine clays and soft gulf bottom deposits.

The two remaining cores, 3-D and 3-E, were placed within the underfit stream channel (Figures 5-58 and 5-59). Core 3-D penetrated through the small stream's fill to the underlying Deweyville point bar, while 3-E stopped within the channel fill. The basal deposits encountered within the underfit stream channel are thinly bedded lenses of gray clay and sand (see Figure 5-59). The very bottom of Core 3-E contained a relatively high frequency of sand, suggesting that it was approaching the bed load of the small stream. Above the sand and clay lenses is a layer of gray silty clay (HI49-3-D#4, Figure 5-57) which is interpreted as a natural levee deposit. This is overlain by a thick organic clay stratum containing abundant fine seams of vegetal material. The grain-size curve for this deposit indicates primarily clays (Sample HI49-3-D#2, Figure 5-57). Two pollen samples were collected from this deposit (Appendix B). One from Sample No. 1, Core 3-E proved almost barren, but the other (Sample No. 2, Core 3-D) contained a diversity of grass, bottomland arboreal and nonarboreal pollen, indicating the presence of either a marsh or a swamp environment. The lithological and geomorphological data seem to support the latter, suggesting that a small swamp had formed within the now-relict underfit stream channel and that freshwater marshes were nearby. Two radiocarbon dates are available from this deposit: 8620 ± 115 B.P. (UGa-5421) and 8935 ± 95 B.P. (UGa-5422).

With one exception the remainder of Cores 3-D and 3-E are similar to those described above from other portions of High Island 49. The exception is a thin (0.2 ft) zone of dense, highly fragmented marine shell encountered near the base of the gulf bottom deposits in Core 3-D (Figure 5-60). Such zones are indicative of high energy episodes, possibly related to major storms (Morton and McGowen 1980:147,Fig.99).

Archaeological Site Potential

The highest probability areas in the High Island 49 area were the edge of the large Deweyville channel and the banks of the small underfit stream identified within the

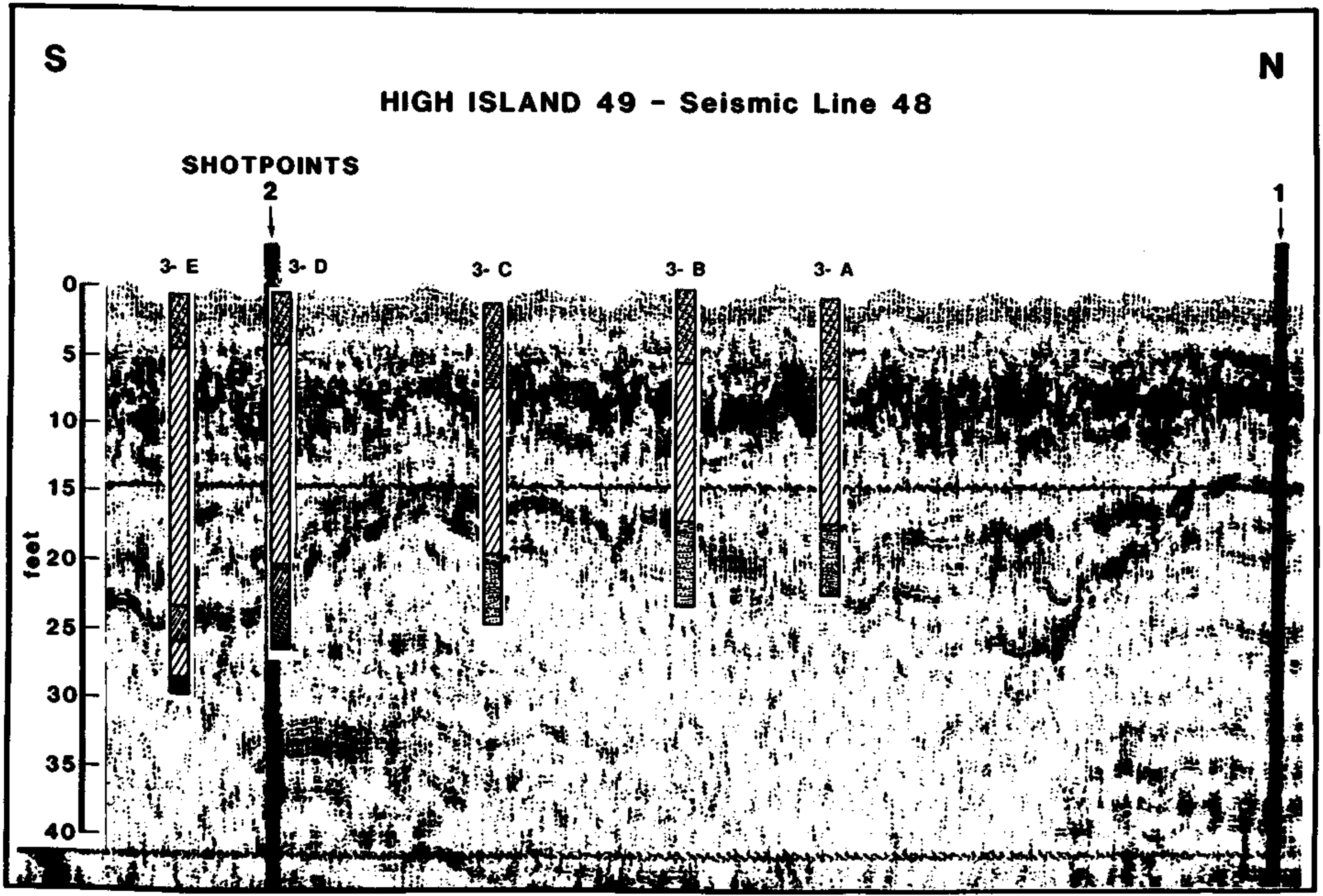


Figure 5–58. Section of Seismic Line 48 which crosses underfit stream identified within the Deweyville channel in the High Island 49 area. The organic filled channel of the stream can be seen starting at a depth of about 17 feet below the sea floor between Core 3–A and Shot Point 1 in the right of the figure. Cores 3–D and 3–E penetrate the stream channel where it is again crossed by the seismic line.

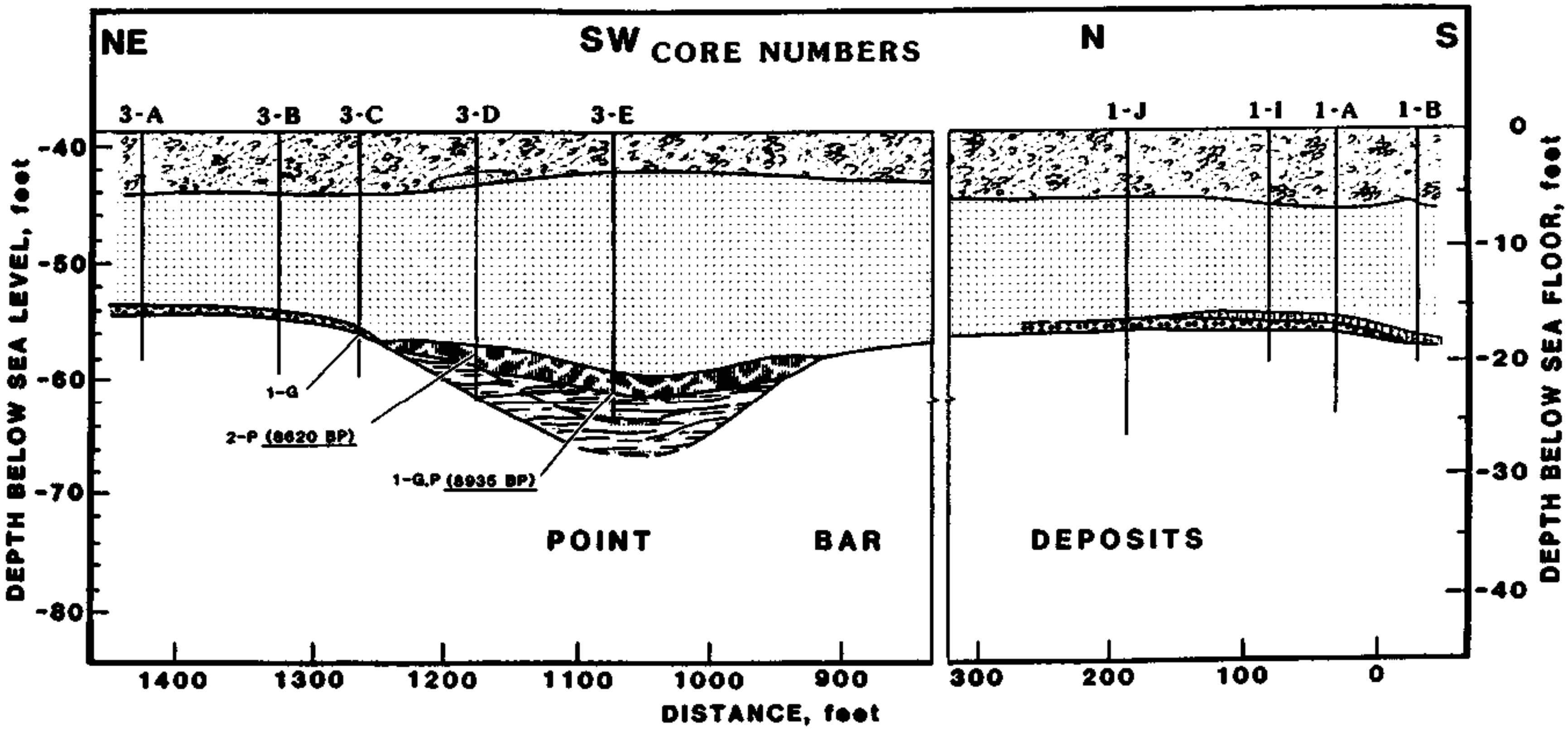


Figure 5–59. Geological interpretation of a section crossing the filled Deweyville channel identified in the High Island 49 area.

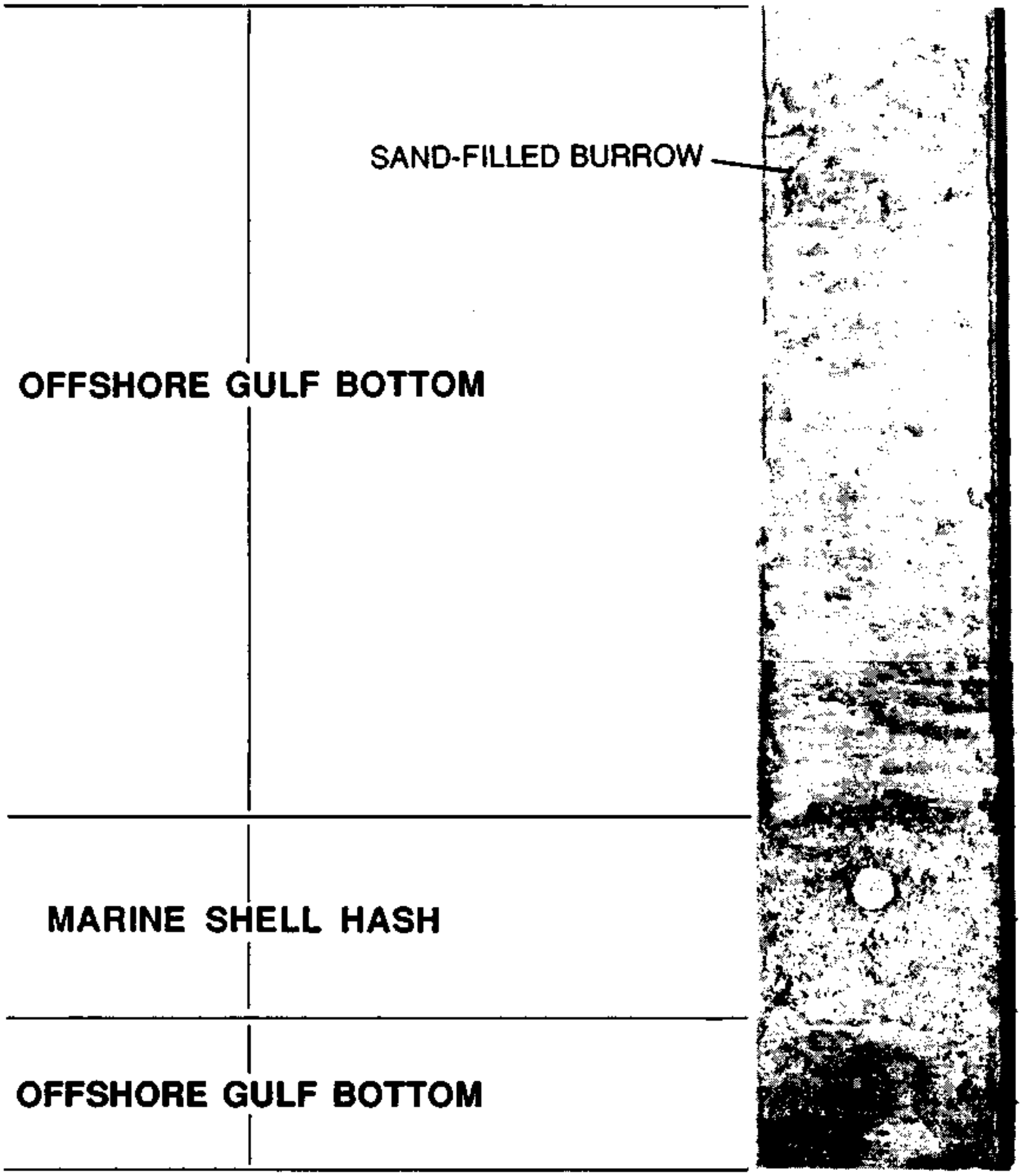


Figure 5-60. Marine shell zone encountered in Core 3-D, High Island 49.

channel. Core Line 1 was placed to hit the edge of the former feature, however, as noted, all of these cores apparently ended in channel fill. Core Line 2 was pla t closer to the junction of the large channel and the Sabine River valley and penetrate into underlying organic and fluvial deposits. Core Line 3 also contact features associated with the underfit stream. Samples primarily from presumed hig probability locales were collected for analysis.

Point-Count Analysis

The point-count data are presented in Tables 5-13 and 5-14. One sample, HI49-2-B#2, contained carbonate concretions in both size fractions. This sample is derived from the *Rangia*-laden initial transgressive deposit extending out into the Sabine Valley (Figure 5-54). The carbonate concretions presumably are lag derived from eroded marsh or swamp deposits or, possibly, from the adjacent Deweyville point-bar deposits. This same sample also produced a single piece of what appears to be charred bone in the 0 phi fraction.

One other sample in the same core (Sample No. 7, Core 2-B) produced a single fish scale in the 0 phi fraction. This is likely to be a natural inclusion.

Discriminant Analysis

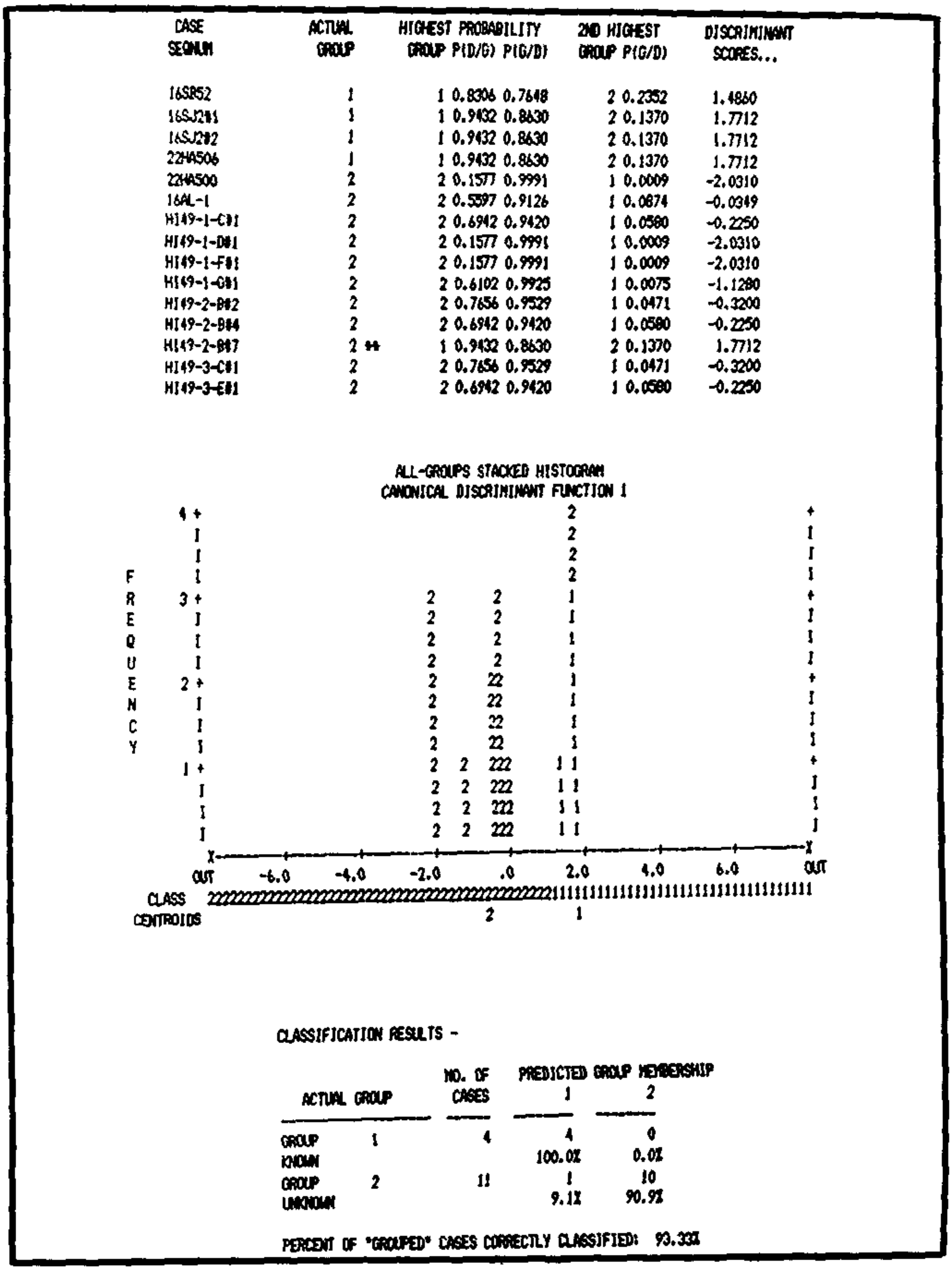
The point-count data from the high probability contexts sampled in High Island 49 were subjected to discriminant analyses in order to assess their potential for the presence of archaeological deposits. These analyses indicated that, with one exception, all of the samples were grouped with the onshore off-site samples. The exception is the 0 phi component from Sample 2-B#7, which, based on presence/absence criteria, was classified as a site (Figure 5-61). Two substances, charred vegetal material and bone (a charred fish scale), were responsible for this classification. Their occurrence in what has been interpreted as a backswamp deposit may be due to natural burning, as from a lightning-induced fire, or it may be related to human activity. If the burning is cultural in origin, then it seems probable that the materials have been displaced from their primary context by flooding or slope wash and redeposited in the backswamp. The archaeological site from which the burned remains might have originated could have been located either on the adjacent Older Deweyville Terrace edge (which has apparently been eroded somewhat by transgression) or elsewhere within the Younger Deweyville floodplain. The single fish scale is not, by itself, seen as a definitive indicator of cultural activity and there are no other indications to suggest that archaeological deposits were encountered in the High Island 49 area. No geochemical samples from the High Island 49 locale were examined.

High Island 163 and Galveston 151

Two areas, one in lease block High Island 163 and one in lease block Galveston 151, were slated for vibracoring; however, delays resulting from poor weather conditions prevented placing cores in these areas. A seismic survey was conducted in each of these areas and the interpretations derived from this are presented below.

High Island 163

Figure 5-62 provides a contour map of the surveyed area in High Island 163, with contour intervals in feet below the mud line, as previously noted. The seismic data clearly verified the presence of the large, meandering channel noted during the earlier block survey. What had originally been identified as a possible crevasse channel



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   CASE            ACTUAL      HIGHEST PROBABILITY     2ND HIGHEST      DISCRIMINANT
   SEQNUM          GROUP       GROUP P(D/G) P(G/D)     GROUP P(G/D)       SCORES...

   16SB52            1           1 0.8306 0.7648         2 0.2352          1.4860
   16SJ2#1           1           1 0.9432 0.8630         2 0.1370          1.7712
   16SJ2#2           1           1 0.9432 0.8630         2 0.1370          1.7712
   22HA506           1           1 0.9432 0.8630         2 0.1370          1.7712
   22HA500           2           2 0.1577 0.9991         1 0.0009         -2.0310
   16AL-1            2           2 0.5597 0.9126         1 0.0874         -0.0349
   HI49-1-C#1        2           2 0.6942 0.9420         1 0.0580         -0.2250
   HI49-1-D#1        2           2 0.1577 0.9991         1 0.0009         -2.0310
   HI49-1-F#1        2           2 0.1577 0.9991         1 0.0009         -2.0310
   HI49-1-G#1        2           2 0.6102 0.9925         1 0.0075         -1.1280
   HI49-2-B#2        2           2 0.7656 0.9529         1 0.0471         -0.3200
   HI49-2-B#4        2           2 0.6942 0.9420         1 0.0580         -0.2250
   HI49-2-B#7        2 **        1 0.9432 0.8630         2 0.1370          1.7712
   HI49-3-C#1        2           2 0.7656 0.9529         1 0.0471         -0.3200
   HI49-3-E#1        2           2 0.6942 0.9420         1 0.0580         -0.2250


                                ALL-GROUPS STACKED HISTOGRAM
                              CANONICAL DISCRIMINANT FUNCTION 1
      4 +                                               2                               +
        I                                               2                               I
        I                                               2                               I
F       I                                               2                               I
R     3 +                             2       2         1                               +
E       I                             2       2         1                               I
Q       I                             2       2         1                               I
U       I                             2       2         1                               I
E     2 +                             2      22         1                               +
N       I                             2      22         1                               I
C       I                             2      22         1                               I
Y       I                             2      22         1                               I
      1 +                             2   2  222      1 1                               +
        I                             2   2  222      1 1                               I
        I                             2   2  222      1 1                               I
        I                             2   2  222      1 1                               I
        X---------+---------+---------+---------+---------+---------+---------+---------X
       OUT      -6.0      -4.0      -2.0       .0       2.0       4.0       6.0        OUT
CLASS    2222222222222222222222222222222222222222222221111111111111111111111111111111111
CENTROIDS                                    2           1


                CLASSIFICATION RESULTS -

                                        NO. OF     PREDICTED GROUP MEMBERSHIP
                  ACTUAL GROUP           CASES          1           2
                ---------------------   ------    --------    --------
                GROUP      1               4            4           0
                KNOWN                                100.0%        0.0%
                GROUP      2              11            1          10
                UNKNOWN                                9.1%       90.9%

                PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED:  93.33%
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Figure 5-61. Results of discriminant analysis on qualitative data, 0 phi fraction, High Island 49 area.

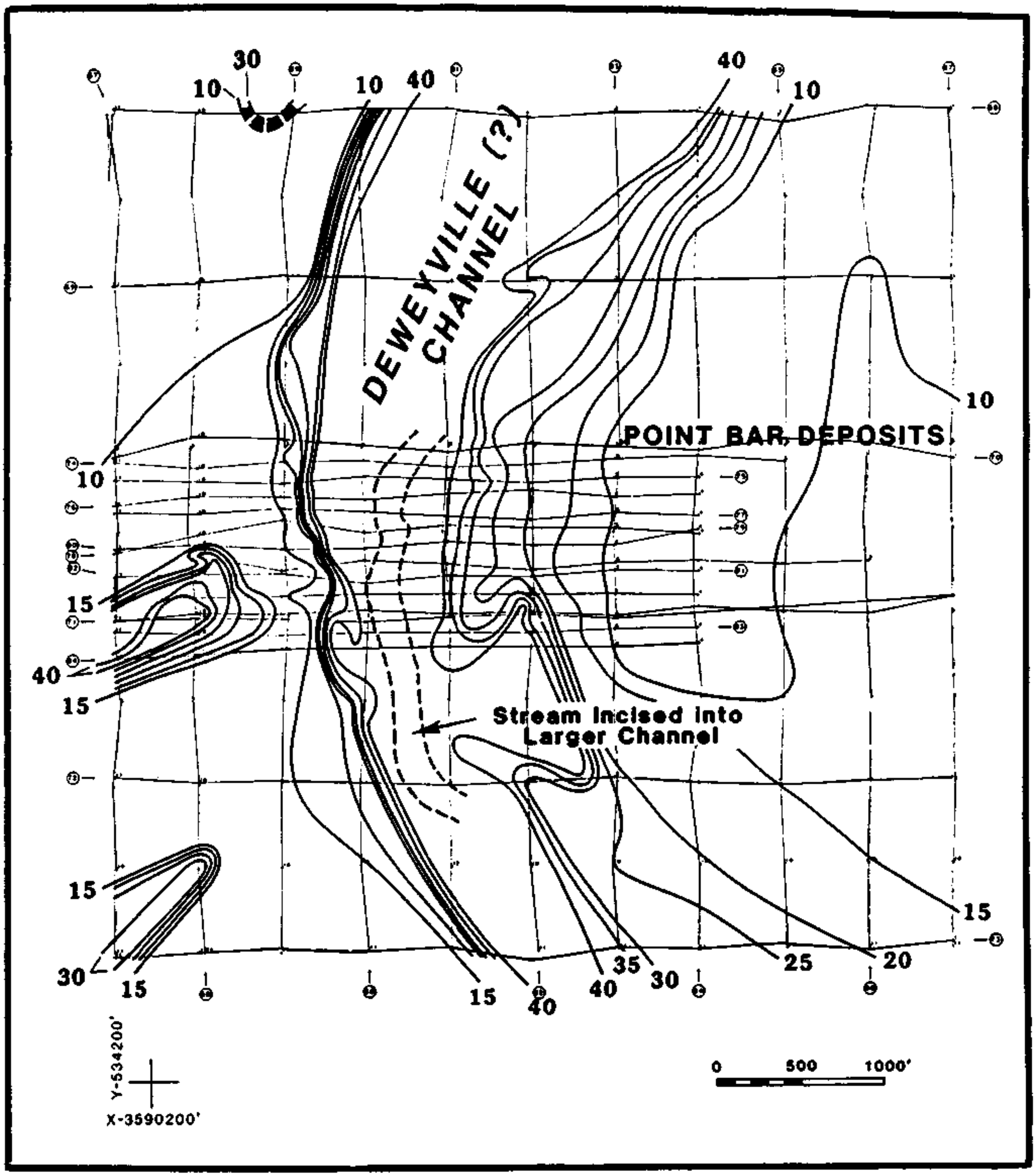

Figure 5-62. Subbottom contour map of the surveyed portion of High Island 163. Contour intervals in feet below sea floor. Note the small, underfit stream within the larger channel.

emanating from the western side of the larger channel was found, instead, to be a probable earlier channel that had been truncated and partially filled by the larger, later channel. Discontinuous portions of several smaller channels also were noted west of the larger channel. To the east of the large channel was identified a broad, sloping surface interpreted as a large point bar. The original interpretation that the large channel is a Deweyville feature still is considered probable. In fact, all of the surfaces noted in Figure 5-62 are considered probable elements of a more widespread Deweyville terrace occupying this section of the Sabine Valley.

Of interest in the present survey, was the identification of the remains of a smaller channel incised into the larger channel. This is interpreted as an underfit stream reoccupying the older Deweyville course, a situation like that seen in High Island 49. The width of the smaller channel approximates that of the modern-regime Sabine River, but it is uncertain (perhaps unlikely) whether this portion of the valley was even exposed during the Holocene. More likely, the small channel represents an underfit stream of Deweyville age.

Galveston 151

Figure 5-63 provides the interpretation of seismic data from Galveston 151. Basically, the data verified the presence of the Prairie/Beaumont Terrace and the filled channel situated to its west, but they provided somewhat different information on the other features located.

What had been identified originally as a large stream channel north of the Prairie/Beaumont Terrace is now considered a possible Deweyville surface. The distinction between the two terraces is not very clear, however. The separation is based entirely upon the reflector signatures for each, and not elevation differences. The Prairie/Beaumont is marked by well-defined, closely spaced reflectors, while the possible Deweyville is identified by a prominent upper reflector below which the signal is greatly attenuated. The surface of each terrace is at about the same elevation, thus raising questions about the accuracy of the interpretation. In fact, the Deweyville surface appears to overlie the northern edge of the Prairie/Beaumont. The dashed contour lines on Figure 5-63 mark the dip of the Prairie/Beaumont beneath the possible Deweyville. This may indicate that the upper portions of both surfaces have been sheared off during transgression. Without core data, however, it is impossible to be more definitive.

Lastly, two areas of sand or shell, which partially correspond to those originally identified in the lease-block survey, were noted atop the Prairie/Beaumont Terrace. The seismic signal produced by these features consisted of a mass of point source diffractions; however, the signal was neither clear nor distinctive.

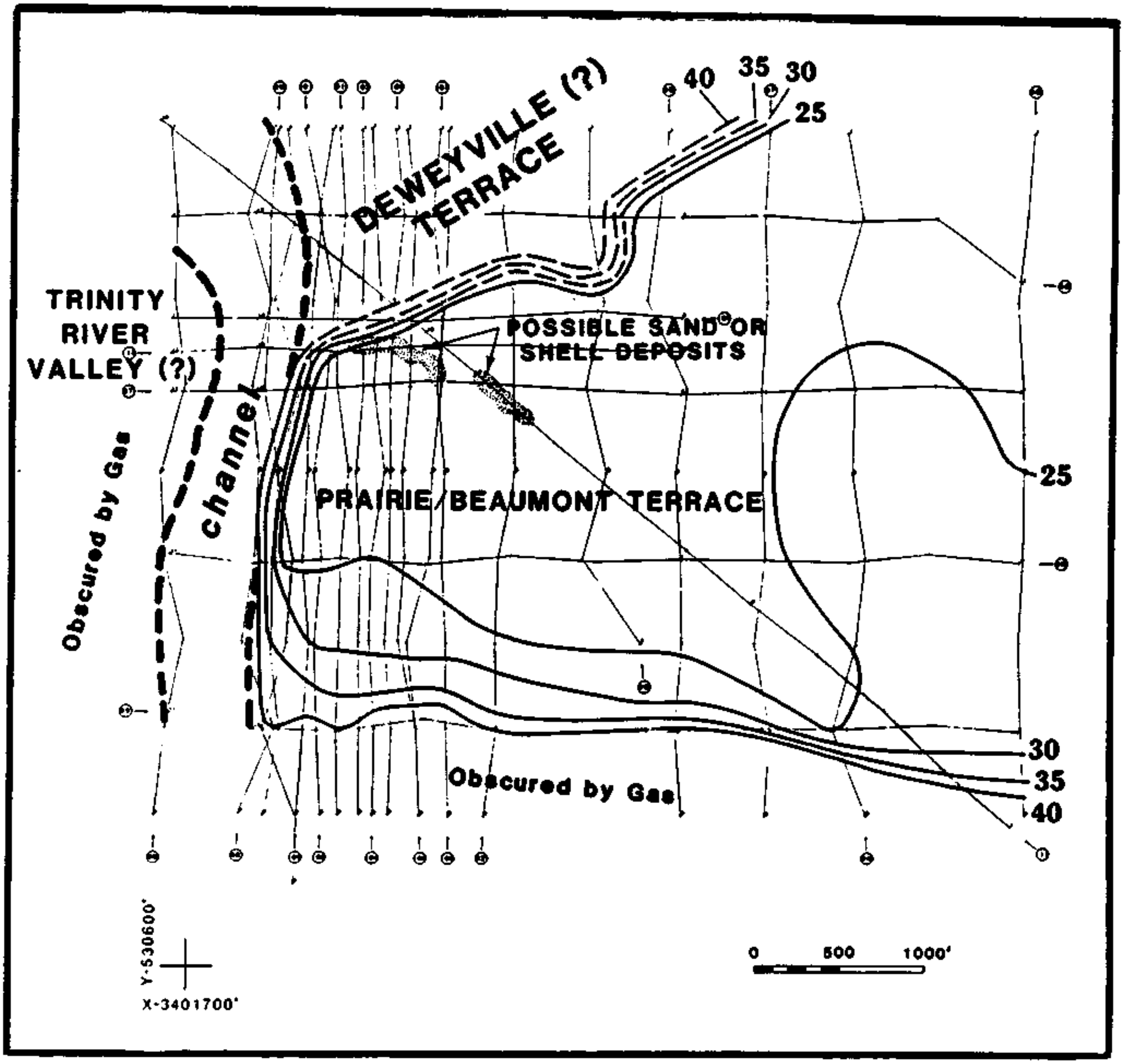

Figure 5–63. Subbottom contour map of the surveyed portion of Galveston 151. Contour intervals in feet below sea floor.

CHAPTER VI: CONCLUSIONS

The primary objective of this study has been to test a predictive model of site occurrence and preservation developed in an earlier study by CEI (1977). That model argued that, given certain conditions, archaeological sites on the OCS will have withstood Holocene transgressions and remain preserved and buried on the continental shelf. Further, it presumed that the locations and distributions of archaeological sites on the OCS could be best replicated by extension of site/landform relationships observed in coastal or riverine settings. Specifically, this project has attempted to examine one element of that model, the potential for site preservation within a filled and submerged stream valley, in this instance the valley of the offshore Sabine River. In addition to reconstructing the Holocene sequence of the study area and modeling site location and preservation potential, a concerted effort was made to actually locate archaeological remains buried on the OCS. The study has demonstrated conclusively that, as indicated in the CEI model, preserved, pretransgressive deposits of an age and type likely to contain archaeological remains do exist in the offshore Sabine Valley. In one of the areas selected for examination, lease block Sabine Pass 6, the predominance of evidence collected suggests strongly that archaeological deposits were encountered. Prior to the collection of core samples, this particular location was projected to have the highest likelihood of containing archaeological deposits of all areas examined.

This study was involved in the examination of an area of over 2000 mi^2, having an entirely unknown archaeological record. Projection of the presence and distribution of preserved archaeological sites in the area relied on a reconstruction of the geologic setting, primarily from scattered remote sensing data, on an assessment of the impacts of transgression on landforms and archaeological sites, and on developing a site locational model relying both on incomplete onshore analogs and assumptions about prehistoric adaptive patterns. In addition, the physical samples collected for analyses were very small, which, when viewed in light of equivalent archaeological land survey, represent an infinitesimal sample of the area being considered. When the obstacles facing this effort to locate buried sites on the OCS are considered, the fact that reasonable evidence of archaeological deposits was encountered, argues for a high degree of success. It seems apparent that an approach which integrates the best available evidence concerning prehistoric settlement patterns, geologic history and landform preservation potential, has the ability to locate buried archaeological deposits on the OCS.

While this study produced a quantity of new information on the geologic history and archaeological potential of one particular area of the OCS, it also raised a number of questions. Many of these have been resolved with the data collected. Others, however, remain unanswered and will require further consideration and evaluation. Overall the results of the present study are seen as supportive of the model of site occurrence and preservation presented by CEI (1977) as that model relates to a specific type of setting, the drowned river valley. In the following sections the various applications and findings of the study are reviewed. The first portion of the chapter presents evaluations of the study, per se, in terms of the utility of the overall approach and specific techniques used. The second section discusses and evaluates some of the models used to design and direct the project in light of the study's findings.

Evaluation of Results

Field Applications

Subbottom seismic survey and vibracoring were the two techniques used to collect primary data in the study area. In addition, information derived from seismic survey served as the primary data base for interpretations of offshore cultural resources surveys as they are currently implemented. It is important, therefore, that the utility of seismic survey data be considered as a tool not only for directing studies of the type undertaken here but also in terms of its use and application in the MMS's offshore cultural resources program.

There is little doubt that subbottom seismic survey is a useful technique in conducting geological investigations on the OCS. In the last 20 years it has become a basic and integral part of this type of research and the literature is full of examples of its use. Because archaeological research in shelf areas is primarily based upon geographical or landform models, seismic survey has become a necessary tool in most investigations of archaeological resources of these areas. An obvious recognition of the necessity and utility of seismic survey is MMS's requirement that seismic data be used as the fundamental tool for assessing the archaeological potential of lease blocks.

Specifically in regard to the present study, the 3.5 khz high-resolution "pinger", the primary instrument used, proved extremely productive in delineating the major, shallow, subsurface features in the study area. The pinger data collected were especially useful, and, of course, critical, in identifying high probability geological features that could be targeted for coring. Particularly significant was the ability of the seismic data to distinguish the various terrace levels (i.e., the Prairie/Beaumont, Older Deweyville, and, at times, possibly the Younger Deweyville) present within the study area. The size, depth, and configuration of most of the channels associated with the different terraces usually could be determined, as well. The depth to which pinger data could be interpreted varied but was generally on the order of 40 to 80 ft below the sea floor. This essentially permitted interpretation and targeting of landform features bordering the Sabine River valley, as well as higher features within the valley.

The "boomer", used as a supplement in this study, provided only a minimal amount of information relevant to the primary objectives of the project. Generally, it achieved greater penetration than the pinger, but resolution was commonly so poor that strata definition and interpretation were difficult. Part of this problem was because the boomer was surface towed and the generally bad weather experienced during the study resulted in poor records.

Seismic data derived from either the pinger or the boomer were not, however, useful in delineating features within the Holocene floodplain because the organics in this area have produced biogenic gas which absorbed and attenuated the seismic signal. This was a critical shortcoming of the present study since it is assumed that both site occurrence and preservation potential will be high in the modern floodplain. As noted earlier, variability in the density and elevations of the gas front in the floodplain was observed, probably reflecting underlying landform differences. However, no patterns in this variability were noted which would lead to the identification of the underlying features. It must be concluded, that while large stream valleys represent optimum locations for site occurrence and preservation, the current potential for examining the deeper portions of such valleys is relatively low.

It is obvious from this and other studies that ground-truth testing is critical in order to arrive at reliable interpretations of seismic records. While the seismic records allow for the identification and placement of a facies within the stratigraphic column, the interpretation of that facies relative to specific lithology and environment of deposition generally requires a physical sample. The need for physical verification has been emphasized by others (e.g., Roemer and Bryant 1977), but it is not a requirement relative to MMS cultural resources surveys. As a result, interpretation of geological strata resulting from these surveys is often impossible to make or, when made, is incorrect. We do not advocate the taking of cores relative to archaeological seismic surveys; however, we feel that core data from near the surveyed area should be used when they are available. In some areas, a significant amount of pertinent bore-hole information is available, the most useful generally being that derived from platform foundation cores. Even though the logging of these cores is often conducted at a level too broad for detailed stratigraphic analysis, the logs normally contain sufficient information to identify those pretransgressive surfaces which are of interest to archaeology. In addition, they often provide information on the depth, thickness and content of buried facies, such as shell lenses or organic strata, which have implications for both geological and archaeological interpretations. MMS should consider including the examination of available and pertinent industry core logs as a requirement in lease block evaluations. The need of these core-log data in developing accurate interpretations of lease-block geology is emphasized in the following sections.

The other major field technique utilized in this study was the collection of vibracores. The vibracore operated as anticipated and achieved the core recovery desired. The study has demonstrated the need for great precision in positioning when conducting what is essentially "prospecting" for archaeological sites. To achieve this accuracy in positioning and the stable platform required for vibracoring, the jack-up barge proved satisfactory and it is probably a necessity. The major problem with the jack-up barge is that it is extremely weather sensitive and can be safely operated only in relatively calm seas.

In most of the vibracores collected in this study, a significant amount of core loss occurred. By correlating the vibracores closely with the seismic records and with core penetration records, it was determined that the section being lost was the upper marine and estuarine muds which were soft and, in some cases, almost fluid. Similar loss of core material is likely to occur in future vibracores taken in the study area or in similar settings and the loss must be recognized and considered in stratigraphic interpretations.

Laboratory Applications

The final assessment of a collected sample proved to be the most difficult aspect of the study. This was not unexpected, however, considering the large number of unknowns involved in the process of trying to determining the archaeological or nonarchaeological nature of a small sample of sediment from a buried deposit on the OCS. There is presently a minimal amount of basic background data available against which to compare the results of several of the analyses conducted. Additionally, even while there is some amount of comparative data for terrestrial sites, little is known about buried offshore natural deposits or the impacts which inundation and burial may have on archaeological sediments. In spite of these shortcomings, the various analyses in combination provided a suite of techniques critical to this type of study. They have enabled rather precise assessments of the environments of deposition of individual strata, providing the basis for a comprehensive interpretation of change in environmental settings within the Sabine River valley over the past 10,000 years. The approach to analysis and final evaluation of a sample followed the procedures established in Gagliano et al. (1982). That study provided a methodology and a set of parameters for using small core-size samples in the identification of archaeological deposits. Because it dealt specifically with prehistoric sites and settings in the Gulf of Mexico coastal zone, that work provided a set of comparative data for this study.

The various analyses revealed the presence of constituents which are strongly suggestive of archaeological deposits in the Sabine Pass 6 area. Two features identified there, the Rangia cuneata shell deposit and the bone concentration, both in and below the transgressive zone, exhibit a number of characteristics in content, configuration, and location which are consistent with those of known archaeological deposits. The point-count analysis indicated the shell deposit was composed almost entirely of Rangia, while the other area contained large numbers of bone fragments from several animal species. Additionally, much of the bone had been burned and the pollen content of the Rangia deposit suggested subaerial deposition. Comparison of these two features with the data provided in Gagliano et al. (1982) and with both known coastal archaeological sites and buried natural deposits indicates more similarities to archaeological deposits than to natural ones. Attempting to numerically define these deposits in terms of a level of probability is presently impossible, however. The data available cannot support such an evaluation.

The point-count analysis, using fine-screen samples, was the most useful of the analytical procedures used in the evaluation of a sample. In the present study, this technique did not produce an identifiable artifact; however, this was considered unlikely in view of the very small sample sizes examined, and the fact that the cultural periods of interest are commonly characterized by very low artifact frequencies. It is believed, however, that the impacts of inundation and burial will have less effect on the constituents identified in point-count analysis than on other parameters. Therefore, point-count data from known, terrestrial archaeological deposits are useful in establishing the background against which to assess offshore samples.

As noted in the discussion of the geochemical analyses, while the results were not definitive, trends in the chemical content of samples seem to be related to independently derived assumptions about the potential archaeological nature of samples. It is particularly revealing that the two chemical constituents shown to have the most promise in this study, total phosphate and zinc, are also ones which are generally deemed useful indicators of cultural activity on terrestrial sites (Woods 1982).

It became obvious during the study that there were limitations in the earlier work by Gagliano et al. (1982), primarily as it related to the scope of examination. That study had included only a narrow range of natural landform settings, which obviously needs expansion to encompass the variability extant in buried deposits on the OCS. This limitation is not, however, seen as entirely restrictive to the application of the analytical approach presented, nor in its use as an interpretive tool. As with any newly established procedure, this approach requires refinement. Specifically, the point-count and geochemical analyses require further evaluation in order to enhance their utility in distinguishing archaeological deposits on the OCS. Doing so requires the collection of (1) more information on the composition and variability in terrestrial site sediments, (2) more detailed knowledge of the impacts of marine inundation and burial on the particle and chemical content of archaeological sites, and (3) more information on the characteristics of buried natural sediments in coastal and offshore settings.

Remote Sensing Interpretations

One requirement of this study was the review of the available lease block survey data from the study area. This information provided a primary data base for the implementation of the project. While this survey information, both in terms of raw seismic data and interpretative reports, represents an extremely valuable resource, our review of this material indicated several problems and limitations. Recognition of these difficulties was crucial to our study and is also critical to MMS's implementation of its cultural resources requirements.

The major failing seen in the seismic survey reports is inaccuracy in geological interpretations. While some geophysical survey companies provide excellent interpretations of the seismic data, they are in the minority. The most common failing is a lack of interpretation of the data in light of regional geology. It is not uncommon to find widely varying, and often inaccurate, interpretations of the same feature or features which occur in adjacent lease blocks surveyed by separate companies.

Although it is not the aim of this study to single out poor interpretations, it is felt that one example should be provided, at least to touch on some of the problems noted. Because Sabine Pass 9 was one of the blocks examined during the present study, and because it provided evidence of a series of distinctive, well-preserved and easily identified Deweyville channels and point-bar deposits, it is instructive to compare one of the original lease block survey interpretations with that offered here (Figure 6-1). The earlier interpretation (Decca Survey Systems, Inc. 1978e:Fig. 3) did not identify the well-developed Deweyville floodplain, largely because the sinuous meanders of the various Deweyville channels were either not recognized or not accurately followed. Portions of the channels certainly were seen and identified, but the geological context necessary for an accurate interpretation of these features was lacking.

This failure to place the interpretation within the appropriate geologic context is exemplified in the discussion accompanying the original survey (Decca Survey Systems, Inc. 1978e:5-6). The Deweyville terrace was identified as "Horizon A" and described as "an old erosional surface subaerially exposed during a period of lower sea stand" (Decca Survey Systems, Inc., 1978e:5). The edge of the Deweyville terrace, where it drops off onto either the Younger Deweyville or Holocene floodplain was recognized by "Lineament X" in the northwest corner of the block and by "Lineament Y" in the south-central portion (see Figure 6-1). In neither case, however, are these considered terrace-edge escarpments. Rather, only an "abrupt change from well defined reflectors (non-gassy) to 'hazy,' adumbrate or missing interfaces (gassy)" is noted (Decca Survey Systems, Inc. 1978e:5). From a geophysical point of view, such terminology may be accurate. The point is, however, that geological explanations for such features are not provided. Yet these explanations are critical since this and other similar reports are to be used as the basis for identifying potential high-probability locales for archaeological sites.

This interpretation error is compounded when identified high-probability locales are considered "archaeologically sensitive areas," as was the case in the Block 9 interpretation. There, areas consisting of corridors 500 ft wide were drawn by MMS personnel along the margins of only the recognized channels, and the oil company was asked to avoid work in these zones. Obviously, if the geological interpretation is inaccurate, then the avoidance zones will be inaccurate as well. Thus, a drilling platform actually may be placed in an extremely high probability area, rather than one less sensitive.

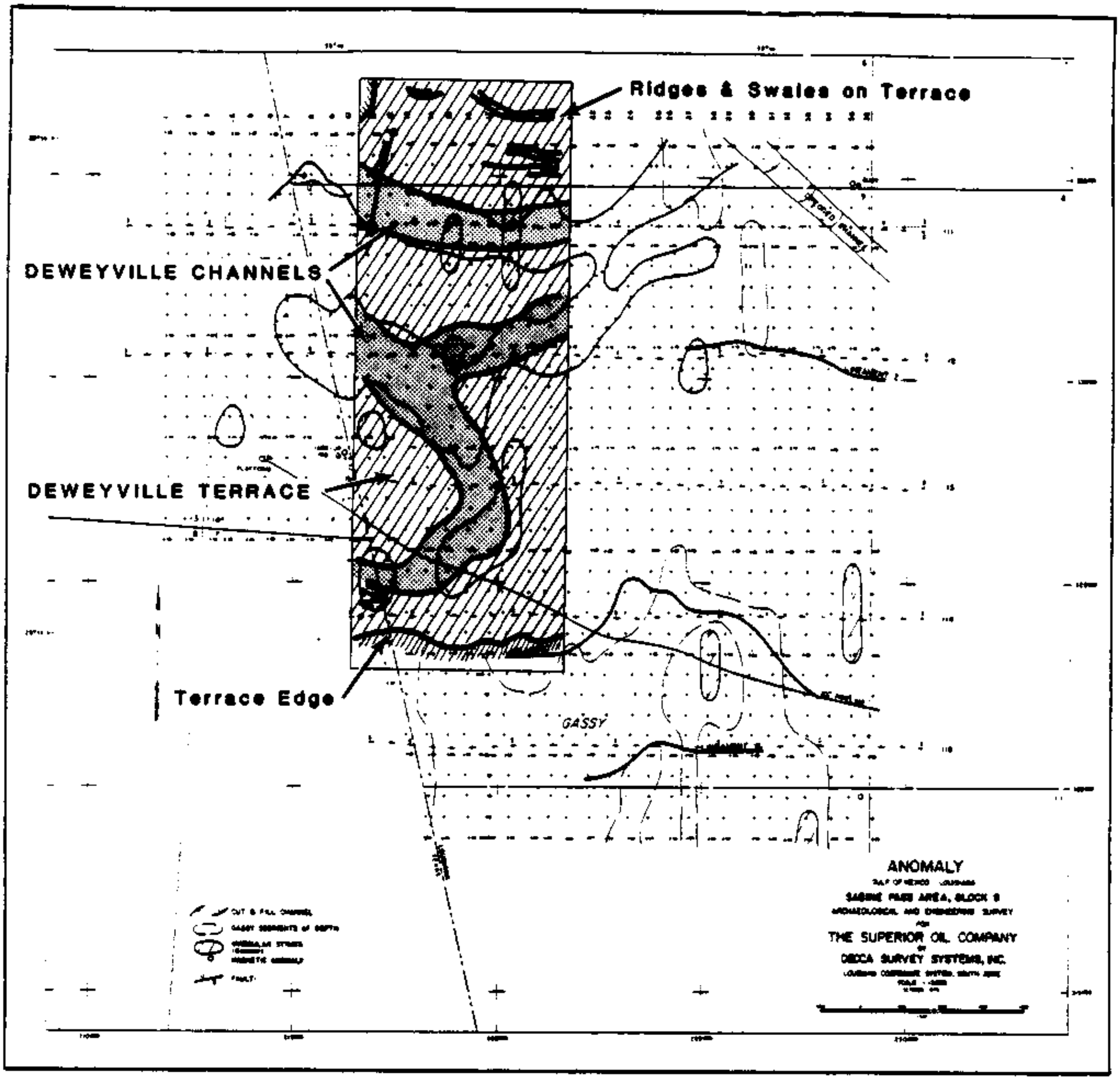

Figure 6-1. **Features identified in the Sabine Pass 9 study area during the present study overlain on the original lease-block interpretation by Decca Survey Systems, Inc. (1978e:Fig. 3).**

Another problem noted by the review of past research is that many of the previous geological interpretations associated with lease block surveys failed to consider the terraced nature of river valleys. In the Sabine Valley, for instance, there are potentially two Deweyville terraces, in addition to the Holocene floodplain and the bordering Prairie/Beaumont Terrace. The stratigraphic principle that older surfaces are found at deeper levels, does not pertain. In this case, the surface of the older Prairie/Beaumont is higher in elevation than the later Deweyville surfaces, and these, in turn, are higher than the more-recent Holocene floodplain.

A similar error is in the common identification of one channel incised within a larger channel and interpreting this circumstance as indicative of changes in sea level. While this may at times be the cause, it is also true that aggrading floodplains and underfit streams within relict channels can produce similar features, yet neither is necessarily related to sea level change.

As Ruppe (n.d.) noted in his earlier assessment of the cultural resources survey program of MMS, a consistent and serious problem is inaccuracy in geological interpretations, resulting primarily from lack of consideration of the regional geologic setting. Geologic interpretation is the underpinning of the entire MMS program of evaluation for prehistoric archaeological remains and from it are derived decisions concerning the need for avoidance. If the program is to be meaningful, quality control of the geologic interpretations of lease block surveys is essential.

Problems of a somewhat lesser nature also were encountered in seismic survey reports. One, already alluded to earlier, is the tendency for previous interpretations to identify a "gas front" or "gas heave" based on attenuated seismic signals. In fact, it appears that attenuated signals often are caused by actual organic layers. While features below these layers may be obscured, the layers themselves appear to be real surfaces that can be mapped.

Another problem, recognized during the present study, is for shell deposits to produce seismic signals similar to the hard reflectors noted for terrace surfaces. In Sabine Pass 6 and High Island 49 relatively broad areas of shell were contoured as part of the nearby Deweyville terrace. It was not until the vibracores were examined that the true situation was understood. This points to a need, also noted by Ruppe (n.d.), for a catalog of characteristic seismic signatures. The data collected and presented in this study provide a considerable amount of information useful for developing such a catalog, but more are needed.

Reassessment of Models

This section will offer a reevaluation, in light of present findings, of the paleoenvironmental, human settlement pattern and site preservation potential models developed at the outset of the study.

Paleoenvironmental Model

Among the most significant contributions of the present research, lie the quantity of data obtained on late Quaternary environments within the study area. The earlier work of Nelson and Bray (1970) permitted a general characterization of the environmental types represented and their sequence of change through time, but the present study has refined their model on certain points and necessitated a reinterpretation of their chronology of events. The major differences concern the extent and terminal age of the Deweyville terraces, which Nelson and Bray failed to identify, and the rate of Holocene sea-level rise within this area.

Extent of Deweyville Terraces

One aspect of the paleoenvironmental model suggested that the features identified within the Sabine Valley on land probably were duplicated within the valley offshore (see Chapter II). To a large degree this point has been substantiated by the seismic and core data retrieved from each of the areas surveyed. Generally, a series of at least three surfaces could be identified: Prairie/Beaumont Terrace, Deweyville terrace, and a more recent floodplain, usually obscured by gas. In two instances (Block 18 and Block 49) a Deweyville terrace was identified at a lower elevation than similar surfaces in nearby blocks, suggesting the possibility of separating Younger Deweyville from Older Deweyville formations.

As noted earlier, several long seismic lines were run across and down the Sabine Valley in an effort to gather geological data that would help tie together the areas surveyed during the present project with those examined previously by oil companies. The result of this data synthesis is presented in Figure 6-2. As can be seen, if the current interpretation is correct, there are extensive Deweyville-age features, including large segments of preserved floodplain, within the Sabine Valley. As noted above, there also are indications, albeit tentative, of two terraces related to the Deweyville. In addition to Sabine Pass 18, potential Younger Deweyville surfaces were recognized to the southeast of Block 18, principally within High Island Blocks 38 and 39, near the mouth of the former Calcasieu River valley, and in High Island 89, where a well-preserved, Deweyville-size meander was detected both by the original lease-block survey and one of our long seismic lines.

In the former case, several large, meandering channels were identified by the lease-block surveys at an elevation slightly below that of the more pronounced Deweyville surface located immediately to the south. One of the long seismic lines run for the present study crossed both of these surfaces and showed a difference in elevation of approximately 12 ft between them. In the latter case, although no reflectors indicative of a Deweyville surface could be identified, the morphology of the large channel clearly suggests a Deweyville feature. This channel is located in the identical position at which Nelson and Bray (1970:Figs. 5, 7, Pl. IV) recognized a Prairie/Beaumont inlier within the valley. Perhaps they actually recorded a Deweyville terrace segment, the same one responsible for the large channel presently under discussion. Why this terrace was not recognized in our seismic lines, three of which crossed its presumed location, is not known.

As added support for the identification of Deweyville terraces within the Sabine Valley, Figure 6-3 is provided. This is a copy of the seismic data recorded during the run of Long Line 10, the location of which is highlighted on Figure 6-2. Every fifth shot point is numbered along the top of the record segments. Basically, the line ran in a northeasterly direction from Sabine Pass 18, across Sabine Pass Blocks 17, 14, and 9, to Sabine Pass 8. At both ends of the line the closely spaced, horizontal reflectors indicative of the Prairie/Beaumont Terrace can be seen. At the southwestern end these occur principally between shot points 1 and 3, while at the northeastern end they can be found between shot points 58 and 66. The shallow depression in the sea floor between shot points 64 and 66 is the dredged Sabine Pass ship channel. The Deweyville terrace noted within Sabine Pass 9 can be seen as a somewhat lower surface between shot points 24 and 58. The prominent, multiple reflectors typical of the Prairie/Beaumont are lacking, and several large filled channels can be seen. One of these occurs between shot points 52 and 56 while a more obvious one can be seen between shot points 42 and 44. Both of these channels are illustrated in the plan view shown earlier in Figure 5-38. The surface of the Deweyville terrace is most obvious as a single, dark reflector between shot points 24 and 40. In this area the surface is somewhat undulating and exhibits several small channels incised into it.

A distinct break at about shot point 24 separates the obvious Deweyville terrace to the northeast from the lower, more undulating and somewhat obscured surface to the southwest. The darkness and somewhat hazy nature of this reflector is indicative of organics and biogenic gas. This lower surface may actually be the Younger Deweyville

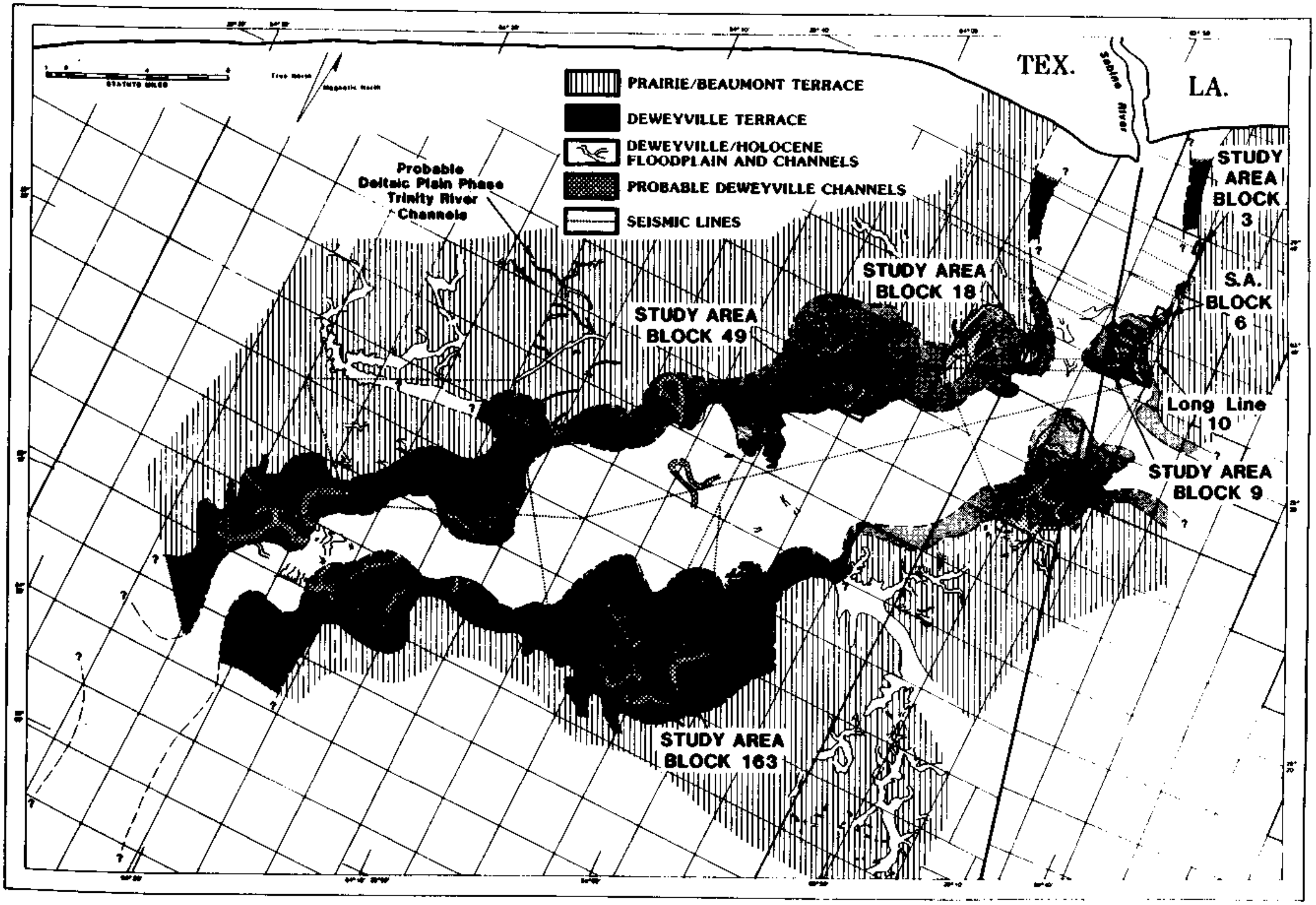

Figure 6-2. Reconstructed Sabine River valley, based on data collected by lease-block surveys, foundation borings, and CEI. Nelson and Bray's (1970:Fig. 5) interpretation of the area serves as the base map. Note the locations of the long seismic lines, particularly Long Line 10.

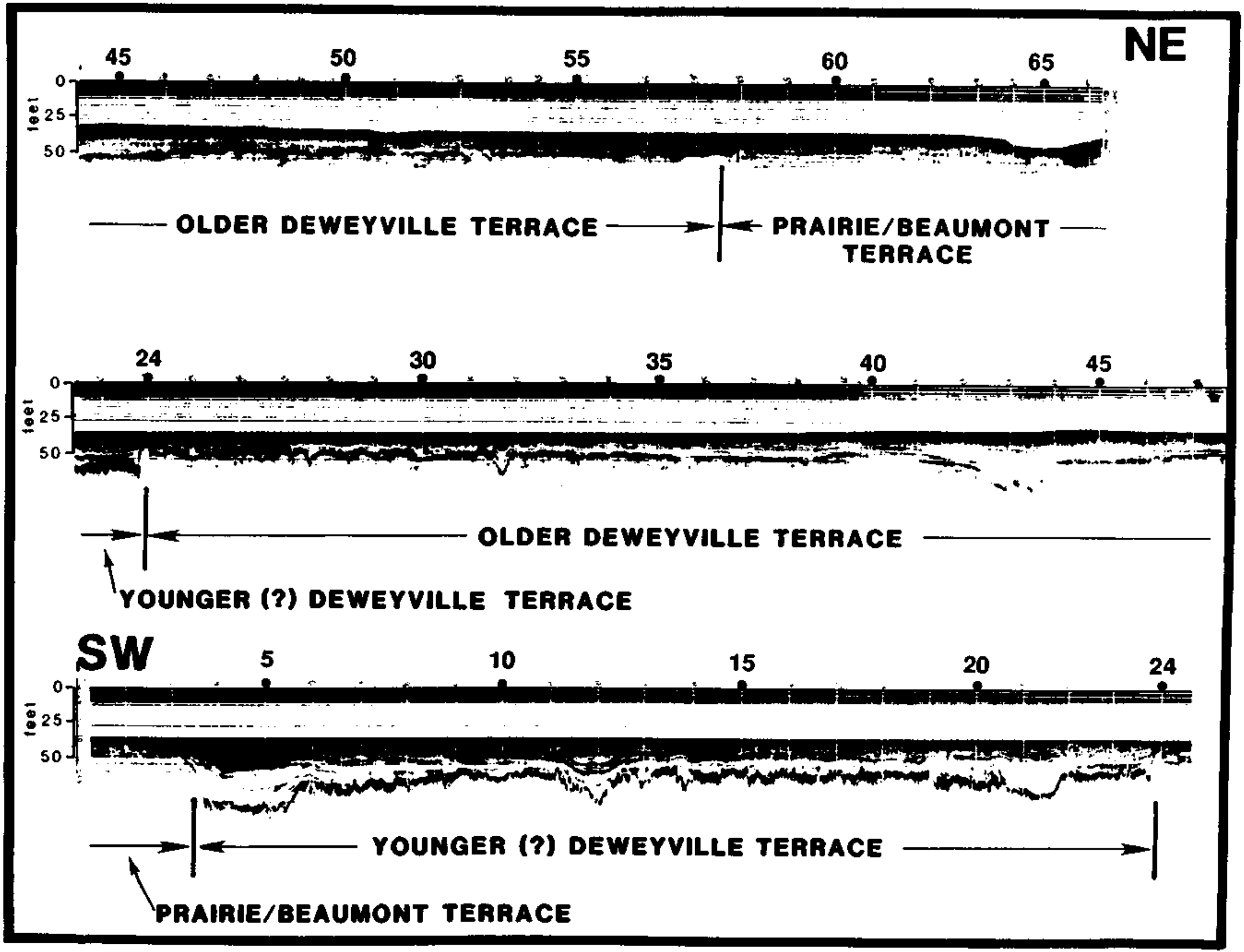

Figure 6-3. Seismic Long Line 10, showing three distinct surfaces across the Sabine Valley between Sabine Pass Blocks 18 and 8.

Terrace, as alluded to previously, or may represent post-Deweyville, Holocene organic deposits. The large, clearly defined channel at the base of the Prairie/Beaumont Terrace, between shot points 3 and 6, has been identified as a Deweyville feature in the discussion of Block 18 in Chapter V. Similarly, the surface to the east of this channel (northeast in Long Line 10) has been interpreted as a Deweyville point bar. Cores into the point bar revealed a 5-to-6-ft-thick blanket of organics overlying the surface, and these are undoubtedly the cause of the pronounced reflector shown on Figure 6-3. This reflector extends northeastward from the Deweyville channel, across the entire lower surface, to the edge of the obvious Deweyville terrace at shot point 24.

At least two other channels are seen on the seismic line, centered on shot points 12 and 21. It is uncertain whether these too are Deweyville features, or simply tidal channels which may have existed within the marsh overlying the Younger Deweyville surface. The large channel at the base of the Prairie/Beaumont Terrace, coupled with the vibracore data from Block 18, suggest that much, if not all, of the lower surface revealed in Figure 6-3 may be underlain by Younger Deweyville Terrace. By inference, this would assign the higher Deweyville terrace identified between shot points 24 and 58, and within the Block 9 survey area, to the Older Deweyville.

An important question raised by our interpretation of Long Line 10 is, where is the modern, post-Deweyville floodplain? The shift in fluvial regime which is represented by the change from the giant Deweyville channels to the smaller post-Deweyville channels should be recognizable at some point down the valley. However, because the area within which both Younger Deweyville and modern channels exist is obscured by organics and biogenic gas, we have been unable to identify the extension of modern-regime channels down valley. Our date of 10,145+ 285 B.P., on freshwater organic fill overlying a Deweyville point bar in Sabine Pass 18, suggests that Deweyville is earlier than that, but how much earlier is not now known. Nevertheless, accepting that as a possible latest date for Deweyville, and relating it to Nelson and Bray's (1970) sea level curve, places sea level of that time at about -117 ft. In terms of location within the valley this means that modern-regime-size channels would extend down the valley to a point approximately adjacent to the Block 163 study area shown in Figure 6-2. While this conclusion seems reasonable, it has been impossible to verify with the available data.

Age of the Deweyville Terraces

The controversy concerning the age of the Deweyville terraces has been discussed in Chapter II. The two most widely accepted positions are those of Saucier (1981), who would place the Deweyville terraces in the 25,000 to 20,000 B.P. time range, and Aten (1983), who argues for a position between 13,000 and 10,000 B.P. Recently however, Alford and Holmes (1985) have suggested a Middle Holocene date (ca. 7500-4000 B.P.) for the terraces.

The present project collected no new information concerning the early stages of Deweyville terrace formation, but a series of six radiocarbon dates was obtained which bears directly on the terminal date of their deposition. The radiocarbon samples are from freshwater swamp deposits overlying Deweyville features in Sabine Pass Blocks 6, 9, and 18, and High Island Block 49. Three of the samples came from deposits resting on interpreted Older Deweyville surfaces. They range in age from 13,120 ± 150 B.P. to 8840 + 140 B.P. The three remaining samples overlie probable Younger Deweyville surfaces, and are dated between 10,145 ± 285 B.P. and 8300 ± 185 B.P. As discussed earlier, the 13,120 ± 150 B.P. date is in question and should not be considered here. When viewed as a whole, the dates argue against a Holocene placement for the terraces. The presence of the 10,143 ± 285 B.P. date, and the absence of significantly earlier dates, provides some support for Aten's position, although this must be considered tentative.

Radiocarbon Dates and Holocene History

A series of radiocarbon dates was obtained from a variety of facies identified in the study area. A primary objective was to use these dates to establish the age of any archaeological materials found. In addition, the dates serve in the refinement of a sea level curve for the area. In the construction of sea level curves, dates from brackish to saline marsh deposits are probably most useful in establishing the true position of sea level. In many areas, however, compaction or subsidence of these deposits can seriously effect the vertical position of the sample. The effects of compaction are difficult to calculate; as a result, they are commonly ignored in the development of sea level curves. Within the study area, however, we have been able to demonstrate rather significant compaction of pretransgressive organic deposits in some locales which would seriously affect sea level interpretation. In the Sabine Pass 3 area, for instance, two dates, one of 7415 ± 100 B.P. and the other of 7035 ±105 B.P., were obtained from two points along what is apparently the same organic lens. One of the dates, however, is derived from a portion of the deposit which overlies the Sabine River valley. The valley contains organic fill which has compacted. As a result, this portion of the stratum, and the position of the radiocarbon date, is 9 ft lower than that segment of the stratum which lies above the stable Prairie/Beaumont surface.

It is quite apparent that in certain settings, such as an organic-filled stream valley, the effects of subsidence have to be considered when evaluating radiocarbon dates. This is not always easy to do. Experience from the Sabine River valley indicates that individual, widely spaced cores are unlikely to provide much information on localized compaction and that a line of cores that crosses the dip of the compacted surface(s) is often necessary.

Five dates were obtained from brackish or freshwater marsh environments. The obviously nonsubsided or uncompacted samples are used to construct the curve shown in Figure 6-4. If there is evidence for compaction, it is noted.

Most of the dates obtained were on wood or peat from identified freshwater swamp environments. This identification has been based on pollen, foraminifera and seed evidence, as well as on lithology and position of the deposit. It is assumed that these swamp dates, unless they have subsided, fall at or above sea level. How much above, however, is impossible to determine. The freshwater swamp dates do not, therefore, provide information on the precise level of the sea, but they do give elevations below which sea level must have been.

Several sea level rise curves have been developed for the Gulf of Mexico. The one most comparable to the present study is that offered by Nelson and Bray (1970) for the Sabine/High Island area. Their curve, as derived on wood and peats, is presented with our data in Figure 6-4. The significant difference in the curves is Nelson and Bray's postulated drop or stillstand in sea level between 8660 B.P. and 7800 B.P. which we do not interpret from our set of dates. A careful assessment of the Nelson and Bray data has suggested some questions about their projected drop in sea level.

The regression in the Nelson and Bray curve is based on three dated samples, numbered 69, 70, and 76 in their Appendix A (Nelson and Bray 1970). Two of the dates, No. 69

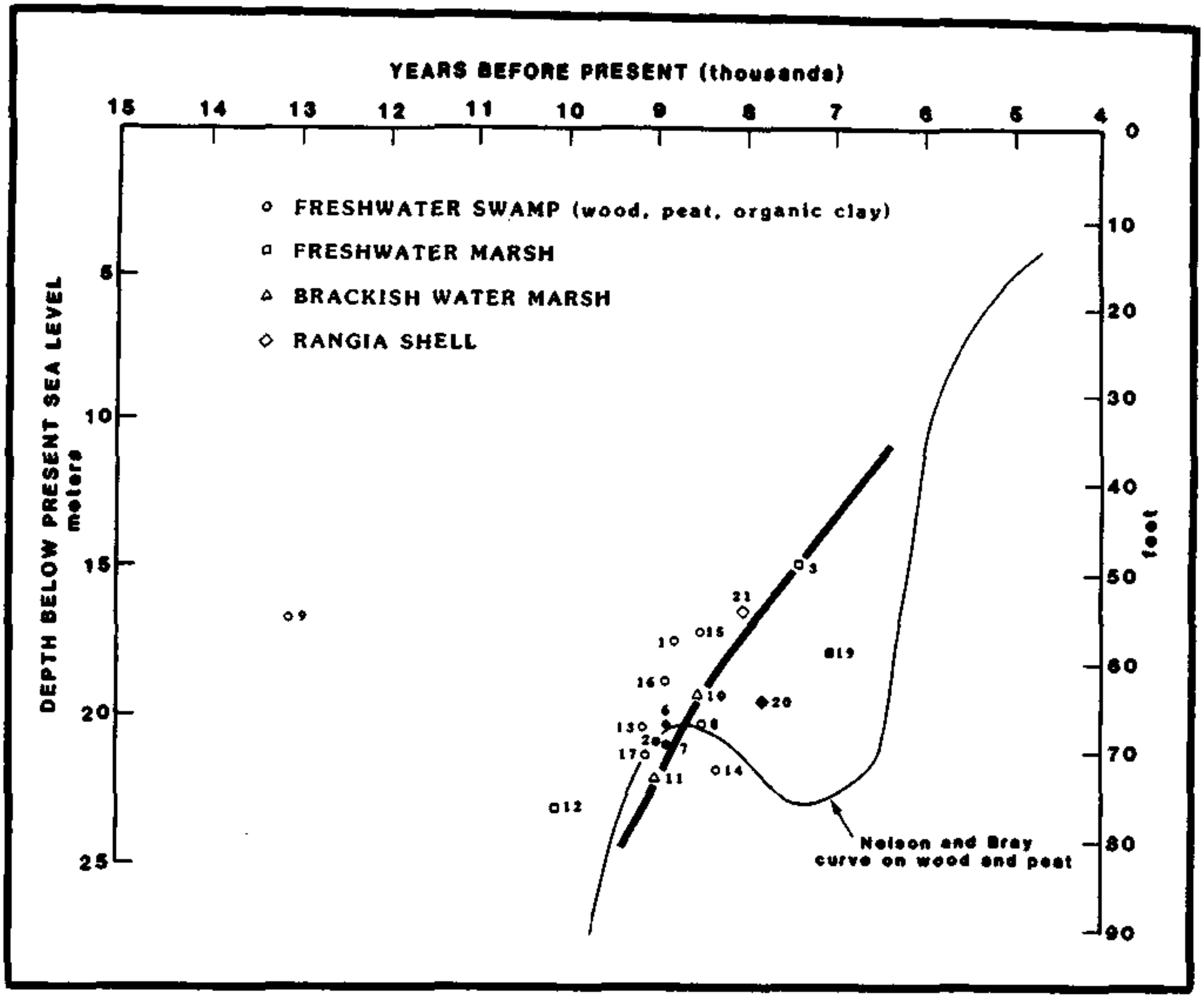

Figure 6-4. Relative sea level rise curve for the offshore Sabine River valley. The curve developed for the same area by Nelson and Bray (1970) is shown for comparison. Sample numbers correspond with numbers given in Table 1, Appendix C. Solid symbols indicate evidence of compaction.

and 70, are from, apparently, the same peat deposit within the same core, Core Hole 4. Sample No. 69, at an elevation of -72 to -72.5 ft, provided a date of 6635 + 200 B.P. and sample No. 70, at an elevation of -72.5 to -73 ft, provided a date of 7840 ± 250. These two samples are less than 1 ft apart yet provide dates that are 1200 years apart. There is apparently a problem with the dates, either one or both is incorrect or, more likely, compaction has seriously affected the elevations of these samples. Argument for the latter explanation is given by the fact that Core Hole 4 is near our Sabine Pass 3 area, where we feel confident that significant compaction of peat deposits has occurred.

The third date (7975 ± 200 B.P.) used by Nelson and Bray for their reversal is Sample No. 76, which was obtained from peat deposits at an elevation of -70 to -72 ft in a core taken in Galveston Bay. This core is located a considerable distance from the Sabine Valley and it would seem to be difficult to correlate the dates from the two areas. More importantly, this date is out of line with the sea level curve developed by

Rehkemper (1969) specifically for Galveston Bay and the Trinity River estuary. For the circa 7500-8000 B.P. period, Rehkemper (1969:40), taking subsidence into account, suggests that sea level was in the -40 to -50 ft range, which is in fairly close correspondence with our curve for the Sabine River area, but 25 ft or so above the curve developed by Nelson and Bray.

The dates considered in this study and considered usable indicate a relatively steady rise in sea level between 9000 B.P. and about 7400 B.P. There is a suggestion that the rate of rise slowed slightly after about 8600 B.P. but this is not definite. Over the 1600 or so years for which we have reasonable data, the rate of sea level rise averaged about 1.4 ft per century.

The sea level curve provides a framework for establishing a paleogeographic reconstruction of the study area. As Kraft (1971:2154), notes these types of efforts may have precision when applied locally, but are difficult to extend regionally. Our best data for assessing the Holocene sequence in the study area came from the upper end of the Sabine River valley, in the area of Sabine Pass Blocks 3, 6, and 9. The reconstructed sequence of events for this area between sometime prior to 10,000 B.P. and about 8000 B.P. is presented below.

Paleogeographical Reconstruction in the Vicinity of Sabine Pass Blocks 3, 6, and 9

With the data acquired for the area encompassing Sabine Pass Blocks 3, 6, and 9, it is possible to offer a detailed paleogeographical reconstruction of that region. Data recovered from Sabine Pass 18 also play an important part in the following discussion, but, since Block 18 was the only area examined along the western side of the valley, and little data were obtained north of there along the valley wall, the major concern of this section will be the area along the eastern side of the valley.

The following discussion will revolve primarily around three figures showing the reconstructed features within the area at three different times. These figures were compiled by utilizing all available data on channel locations, terrace formations, radiocarbon dates, and environmental change. This included data supplied by Nelson and Bray (1970), the original lease-block and pipeline surveys, the detailed seismic surveys conducted during the present study, the long seismic lines, and, of course, the cores. It must be recognized that each figure shows only an hypothesized estimate of the conditions and features present in the area, and only at a specific time within the temporal span covered by each figure. Many of the events which occurred in the area happened at such a rapid rate that it is not possible to show all of the changes. Nevertheless, the authors believe the general sequence of events is portrayed as accurately as possible given the limitations imposed by the data. The reconstruction of changing landscape provides a basis for refining our view of human use and habitation in this area.

Pre-10,000 B.P.

Figure 6-5 illustrates the area in question at a point sometime prior to 10,000 B.P. Based on the radiocarbon date of 10,145 B.P., obtained on organics overlying what is almost certainly the Younger Deweyville Terrace in Block 18, it may be surmised that both the Older and Younger Deweyville had formed prior to that date.

Figure 6-5 shows the Older Deweyville floodplain within the valley, with the exposed and higher Prairie/Beaumont Terrace forming the eastern valley wall. Various relict

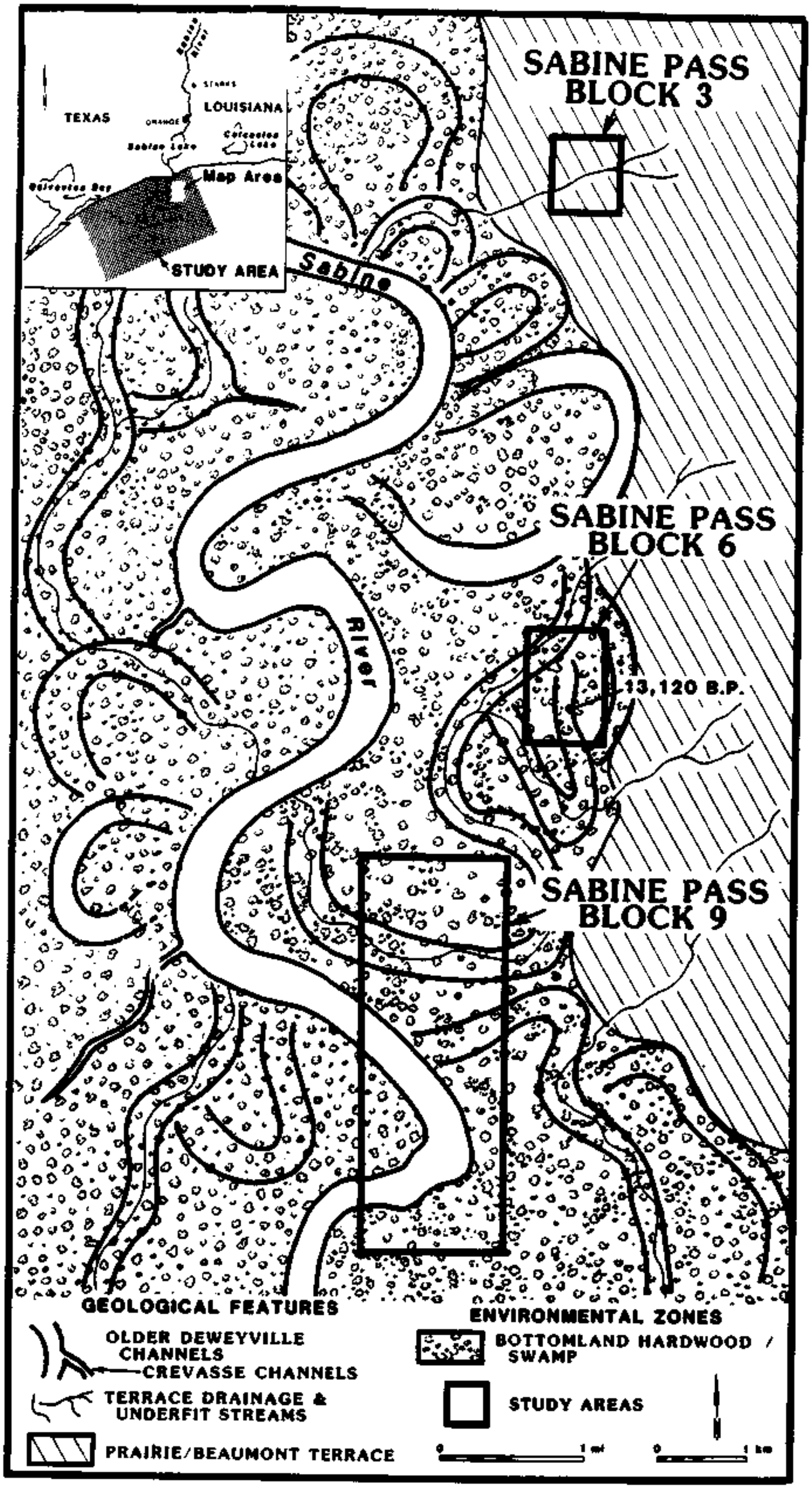

Figure 6-5. Paleogeographical reconstruction of the area around Sabine Pass Blocks 3, 6, and 9, at a time prior to 10,000 B.P. when the Older Deweyville system was active. Floodplain channel features outside of surveyed blocks are schematic.

Deweyville channels, along with an active Deweyville-Sabine River, are presented. In the northern portion of the figure, the Block 3 study area is illustrated entirely atop the Prairie/Beaumont, a situation somewhat different than that recognized by the seismic survey in that block. This situation is presented, however, to indicate that the margins of the Sabine Valley were not static, but continued to change through time, as both Older and Younger Deweyville and later Holocene channels eroded the Prairie/Beaumont Terrace edge. Seismic survey in this area also seemed to indicate several large, arcuate bights into the Prairie/Beaumont Terrace, presumably cut by Deweyville streams. Definite Deweyville features of similar size and configuration are seen along the modern Sabine River today.

The terminal date of the Older Deweyville is not known, nor is the initial date of the Younger Deweyville. However, as noted above, radiocarbon dates on organics overlying the Younger Deweyville in Sabine Pass 18 and High Island 49 suggest a terminal date prior to 10,000 B.P. Because little additional information was obtained on the Younger Deweyville within the area presently under review, primarily, it seems, because it later was covered by Holocene riverine and/or estuarine organic deposits, the following discussion will skip to a post-Younger Deweyville time frame. It should be stressed, however, that Younger Deweyville surfaces are present within the Sabine Valley, and may, in fact, be responsible for much of the deposits noted at elevations below the Older Deweyville. This is particularly noticeable in Block 18 and along Seismic Long Line 10, discussions of which were presented previously.

Ca. 10,000 to 8,800 B.P.

The reconstructed paleogeography for this time period is shown in Figure 6-6. At that time all features associated with both the Older and Younger Deweyville terraces had become relict. As discussed, the Younger Deweyville apparently had been covered by later deposits related to Holocene events. In Figure 6-6, these deposits are shown as marsh at the southern end and riverine swamp and bottomland hardwoods in the remainder of the area.

What is most interesting is the extremely close series of radiocarbon dates obtained on freshwater swamp deposits within the area. These come both from fill within relict Deweyville channels and the Holocene valley proper. The dates cluster around 9000 to 8900 B.P., and suggest that most of the area had not yet begun to feel the effects of estuary expansion resulting from sea-level rise.

The presence of a riverine environment is substantiated further by a review of the revised sea level curve presented above, which indicates that at 9000 B.P. sea level was at approximately -75 ft. Thus, the Older Deweyville Terrace in Blocks 6 and 9, at depths of between about -55 and 60 ft below present sea level, was 15 to 20 ft above sea level at that time. The Prairie/Beaumont Terrace in Block 3, at -50 to 55 ft, also was well above inundation. Swamp deposits within the Holocene floodplain in Blocks 3 and 6 were at depths of -68 ft. Thus, the Holocene floodplain was approximately 7 ft above sea level. Given the tendency for organics within the Holocene valley to compress under the weight of overlying sediment, the -68 ft depth may represent a maximum depth for the deposit.

Further evidence suggesting that only the lower portion of the area was under the direct influence of sea-level rise comes from Block 18. There, marsh deposits were encountered at a depth of -72 ft, and dated to 8420 ± 105 B.P. Although these deposits again may be compressed, this argues that that portion of the valley was at or very near sea level by that date.

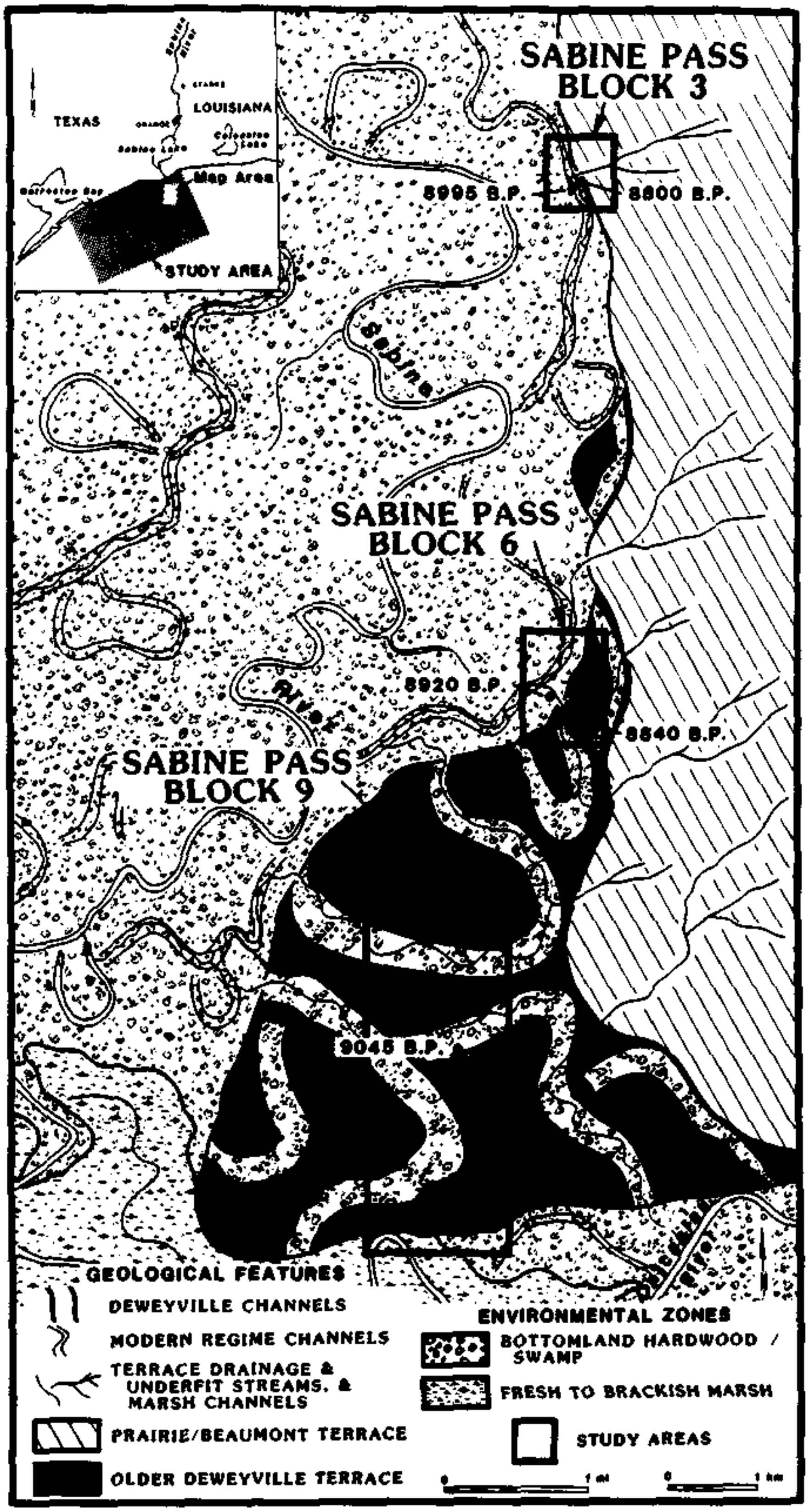

Figure 6-6. **Paleogeographical reconstruction of the area around Sabine Pass Blocks 3, 6, and 9, ca. 10,000 to 8800 B.P. Portions of the Older Deweyville floodplain exist as terrace remnants, while the modern-regime Sabine River occupies the valley proper. Floodplain channel features outside of**

8500 to 8000 B.P.

By about 8500 B.P. sea level had risen within the valley to a point where much of the Holocene floodplain was inundated (Figure 6-7). Only the northern portion of the area and higher surfaces such as the Older Deweyville Terrace were sufficiently elevated to support a marsh environment. Radiocarbon dates from organic deposits resting immediately atop the Older Deweyville Terrace in Block 6 suggest that the change to an estuarine setting occurred at about 8500 B.P. A date on the Rangia shell deposit from the same block indicates that the area still included a brackish-water estuary at about 8000 B.P. Dates from Block 3 of 7880 B.P., on Rangia shell within the transgressive zone, and 7415 B.P., on what was marsh or organic detritus within the bay/estuary, suggest that the marsh environments within the area were relatively short-lived, lasting only for about 800 to 1100 years.

The reconstruction shown in Figure 6-7 would place the potential archaeological sites in Block 6 adjacent to an open estuary at the junction of two small channels (the "tributary" channels noted in the Block 6 discussion in Chapter V).

Summary

While still containing many data gaps, the paleogeographical reconstruction outlined above, is a best-guess estimate of a small portion of the entire study area where the greatest quantity of data were collected. Aside from the fact that the reconstruction provides a clearer understanding of the environmental situation for each block at specific times, it also indicates the potential utility of studies such as these. With more refined seismic data and associated interpretations, coupled with selected core information, other regions within the Sabine/High Island study area may be examined and very specific paleogeographic interpretations can be developed.

Site Preservation Potential in the Study Area

In an earlier section (Chapter III) a conceptual model of site preservation within the study area was presented. That model drew upon several sources, including available geologic information on the buried Sabine River valley, an initial review of lease block survey and seismic data from the area, and similar models developed elsewhere, particularly that developed for the mid-Atlantic area (e.g., Belknap and Kraft 1981, 1985; Kraft et al. 1983). Upon evaluation of the additional seismic data collected, and the information derived from the vibracores, it appears that our initial model was reasonably correct. A graphical depiction of a finalized model of site occurrence, preservation potential and discovery potential is presented as Figure 6-8.

Figure 6-8 depicts a stylized section across the east-west trending portion of the Sabine River valley. High-probability site locales, as derived from the settlement models discussed earlier, are shown, as are pertinent landforms. The figure portrays the three "preservation zones" discussed earlier. Zone 1 consists of the pretransgressive fill of the valley and includes those features shown below the "Estuarine Transgressive Zone" in Figure 6-8. This zone is an area of low to high site probability, dependent upon landform, and of low to high preservation potential, dependent upon the impacts, primarily fluvial, on a site or landform. As suggested earlier, and demonstrated by collected seismic data, except for the Older Deweyville surfaces, most of this area is obscured by organics and gas, such that it is difficult, if not impossible, to delineate landforms in the area. As a result, the chances of discovering archaeological sites in the area remain very low until a suitable method can be developed for mapping the geomorphology of the gas-obscured region.

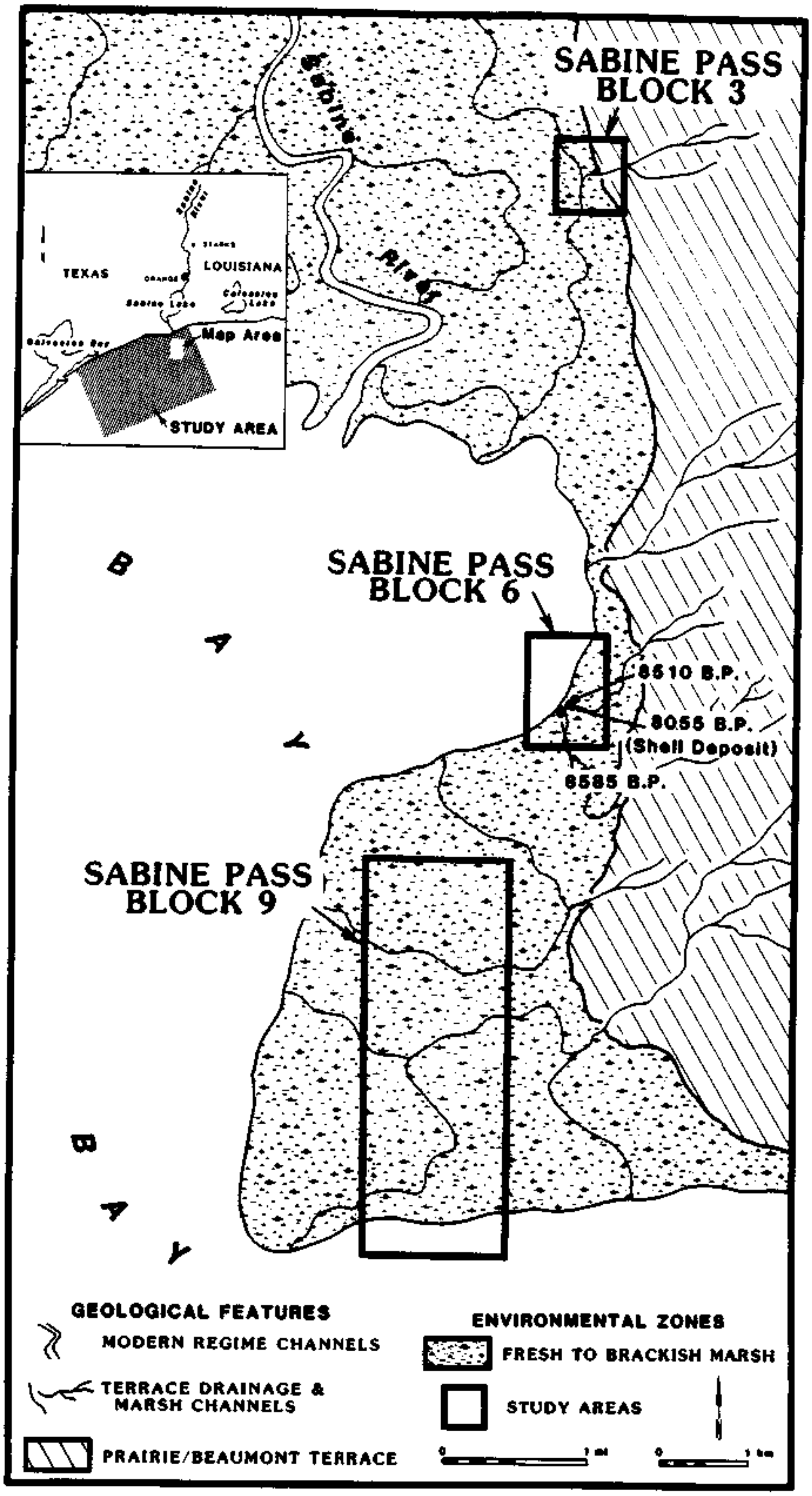

Figure 6-7. Paleogeographical reconstruction of the area around Sabine Pass Blocks 3, 6, and 9, ca. 8500 to 8000 B.P. Rising sea level has flooded much of the valley, leaving marsh atop higher elevations and at the northern end of the valley. Floodplain channel features outside of surveyed blocks are schematic.

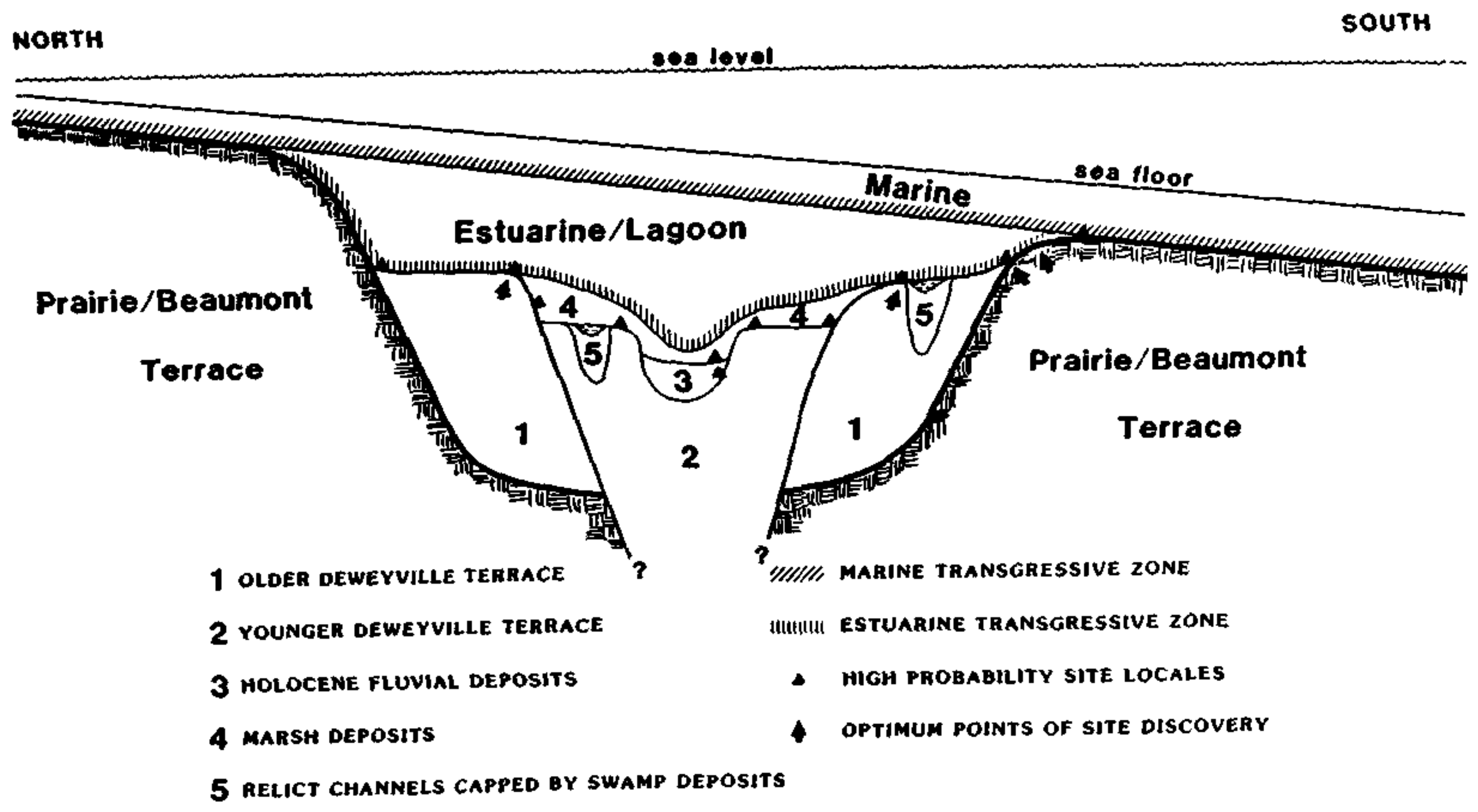

Figure 6-8. Graphic model of site occurrence and preservation potential depicted as a cross section of the offshore Sabine River valley.

In the mid-Atlantic area, Kraft et al. (1983) portray little, if any, preservation of pretransgressive fluvial landforms. In the Sabine River valley, however, we are confident that extensive and deep pretransgressive deposits exist, as well as, we assume, associated archaeological remains. As shown in Figure 6-8, Deweyville formations and post-Deweyville (Holocene) fluvial and marsh deposits, may have archaeological materials upon, as well as within, them.

The "Estuarine Transgressive Zone" essentially marks the boundary between pretransgressive and transgressive deposits. Referred to in the text as the initial transgressive zone, this facies represents the location of initial impact of sea level rise. As noted earlier, this is considered a generally, low-energy, transgressive front resulting from estuarine bay, lagoon and lake expansion.

This zone was essentially horizontal as it moved up the valley; however, due to later compaction of underlying organics it now sags into the valley as shown in Figure 6-8. In many areas this zone has impacted high probability landforms and associated archaeological deposits. In some instances, these deposits would have been destroyed; in others, minimally disturbed; and in some cases, because of local topography, transgression likely passed just above a site, leaving it undisturbed and preserved.

As our preconceived model suggested, it was in and just below the initial transgressive zone that the search for archaeological sites would be most productive. Data collected in the study do not significantly alter this conclusion. These data do suggest, however, that within the study area only those surfaces free of extensive organic cover will be amenable to detailed interpretation via seismic profiling. This, therefore, limits the optimum points of site discovery to within or just below the initial transgressive zone on the Older Deweyville Terrace and the slopes of the Prairie/Beaumont Terrace.

The Estuarine/Lagoon fill above the initial transgressive zone, as noted in our model, is an area having essentially no probability of site occurrence. Above the Estuarine/Lagoon deposits is the Marine Transgressive Zone (Figure 6-8). This represents the zone of impact by wave-front and wave-base erosion, a force which would, more than likely, destroy any prehistoric archaeological site impacted. Therefore, while sites no doubt existed on the higher portions of the Prairie/Beaumont Terrace, these areas have been impacted by marine transgression and probably destroyed. In the study area, only on the slopes of the Prairie/Beaumont Terrace, below the marine transgressive zone, is there a chance of site preservation.

The model shown in Figure 6-8 can reasonably be extended to other large and relatively deep, inundated stream valleys on the OCS. In these settings, the factor most critical to site preservation is topography, followed to a lesser extent by factors of subsidence and compaction. These are essentially the findings presented in the CEI model (Coastal Environments, Inc. 1977) and are similar to those recently prepared by Belknap and Kraft (1985) for the Middle Atlantic OCS.

Recommendations

This study has produced a quantity of information on the geologic history and current conditions of a relatively small area on the Gulf of Mexico Outer Continental Shelf. Techniques for gathering data needed to direct a search for archaeological sites and retrieve samples from potential site locations were employed and shown to be of utility. The study has demonstrated the existence of pretransgressive landforms preserved intact within the offshore Sabine River valley. The potential for archaeological sites occurring on or within some of these deposits is high and finding them is possible. This, however, requires a full understanding of the environmental history and archaeological potential of specific areas.

The consistent failure to place geologic interpretations within a regional geologic context is identified as a major shortcoming in the lease block evaluation program as it now stands. This, in turn, affects the MMS management of archaeological resources on the OCS since archaeological potential is tied directly to geologic interpretation.

In the evaluation of submitted lease-block surveys, greater attention needs to be placed by MMS personnel on insuring accurate geological interpretations. The present study has provided an interpretation of the geologic setting and history of the offshore Sabine River valley, which, it is believed, provides adequate information to direct geological interpretations and assess archaeological potential in other lease blocks in the area. Other, similar syntheses are required for other regions. There are now at the disposal of MMS a large set of data that can provide the same types of information collected and produced in this study, and which can be used to develop the required regional synthesis.

To do this, we would recommend that a program of careful evaluation and synthesis of already collected lease block surveys be undertaken. The survey reports, even with all of their problems and inaccuracies, in combination with the raw seismic data, represent a significant resource of information on the shallow, subsurface geology of the OCS. In addition, evaluation of pertinent industry-collect core logs should be used to refine the interpretations of seismic records. Any effort to reevaluate these data in light of a reasonable regional geologic framework would contribute to our understanding of OCS geology and, ultimately, aid MMS in its management and protection of archaeological resources on the OCS.

As noted earlier, the techniques employed in the analysis of samples need refinement. The major effort needs to be directed at expanding the data base presented in Gagliano et al. (1982) through examination of a larger number, and greater variety, of archaeological and landform settings. In particular, buried natural deposits of the type anticipated to occur preserved on the OCS need to be included in the available sample. This may eventually lead to the ability to accurately discriminate between natural and archaeological sediments solely on the basis of particle or geochemical content.

As it now stands, "avoidance" is the key to the MMS cultural resources program on the OCS. In relation to prehistoric sites, when an archaeologist identifies a high probability landform from seismic records, MMS normally recommends a zone of avoidance around that landform, removing the area from considerations for construction. As a result, no cores are taken or samples retrieved from these high-probability landforms and, consequently, no data from potential archaeological locales have been retrieved. (As Ruppe [n.d.:5-6] notes, there have been one or two exceptions to this and, at the request of marine survey archaeologists, cores were taken of high-probability landforms. In one instance a deer tooth was recovered.) Recognizing that there is a need for protecting archaeological remains, it is believed that on the OCS the situation is such that at present the retrieval of data is as important as protection. We would suggest that MMS incorporate within its management program alternatives to avoidance which would include the collection and analysis of core or dredge samples from high-probability landforms. This, in itself, will begin to accrue the data needed to expand and refine the parameters used to distinguish archaeological from natural deposits, as noted above, and the accumulation of these data would further our understanding of the archaeological resources on the continental shelves.

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APPENDIX A:

HOLOCENE BENTHIC FORAMINIFERA FROM THE FORMER SABINE RIVER VALLEY, OFFSHORE LOUISIANA AND TEXAS

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INTRODUCTION

The goal of the investigation was to assess, on the basis of assemblages of benthic foraminifera, the pre-Recent environmental shifts recorded in three cores obtained from the Sabine Pass area of offshore Louisiana and Texas.

The study was based on 22 samples, including four samples barren of foraminifera. All samples were provided by Mr. David Kelley of Coastal Environments, Inc.

BACKGROUND

Past studies of benthic foraminifera in modern brackish to shallow marine environments of the Gulf coast (Phleger 1954, 1956; Lehman 1957; Wantland 1969) have shown that three species are regionally dominant. These are the agglutinated species *Ammotium salsum* and the calcareous species *Ammonia parkinsoniana* and *Elphidium excavatum*. *A. salsum* is dominant in environments characterized by very low salinities. With increase in salinity, *A. parkinsoniana* and *E. excavatum* become dominant. Furthermore, the relative abundance of two ecophenotypes of *A. parkinsoniana* also reflect salinity shifts. These are *A. parkinsoniana* forma *typica* and *A. parkinsoniana* forma *tepida*. Field studies by Poag (1978) and by Mechler and Grady (1984) have shown that the two forms are characteristic of different salinity regimes, an abundance of *A. parkinsoniana* forma *typica* being generally associated with lower salinities. Thus, the dominance of *A. parkinsoniana* forma *typica* would indicate intermediate salinities, whereas the dominance of *A. parkinsoniana* forma *tepida* or of *Elphidium excavatum* would indicate close to normal marine salinities.

BENTHIC FORAMINIFERA

Methods

The samples were wet-sieved, and the fraction coarser than 0.063 mm was examined for foraminifera. Species percentages were determined on the basis of at least 100 specimens, except in two poor samples: SP9-4-C#5 and SP9-4-C#7.

Assemblage Composition

Nineteen species and ecophenotypes constitute the benthic foraminiferal assemblages recorded in our samples from the three cores (Table A-1). The sample species diversity ranges from 3 to 12 in the samples in which foraminifera are present. In 50% of these samples, however, the diversity is 5 to 7.

Environmental Interpretations of Assemblages

Core SP3-1-F

This core, taken at a water depth of about 26 ft, is located on the eastern bank of the former Sabine Valley. The base of the core contains wood and plant fragments, indicating a subaerial or a swampy environment. Above this, samples 13 and 12 (at 13.8 and 15.1 ft depths in the core, respectively) are dominated by *Ammotium salsum*. Marsh species are not present and the sand content is relatively high. This suggests a shallow water, low salinity estuarine environment. At a depth of 12.2 ft (sample 11), a dominance change is observed. *Elphidium excavatum* becomes dominant and *Ammonia parkinsoniana* (only forma *tepida*) is abundant. This suggests an increase in the salinity of the estuary, compared to that reflected in the previous samples. The

Table A-1. Species Percentages in Foraminiferal Assemblages, Sabine Pass Core Samples.

SPECIES	SAMPLES SP3-1-F #13	SP3-1-F #12	SP3-1-F #11	SP3-1-F #10	SP3-1-F # 9	SP3-1-F # 8	SP3-1-F # 7**	SP3-1-F # 6	SP3-1-F # 5	SP3-1-F # 3	SP9-4-C # 9**	SP9-4-C # 7*	SP9-4-C # 5*	SP9-4-C # 4	SP9-4-C # 3	SP9-4-C # 2	SP9-4-C # 1	SP18-2-B # 7**	SP18-2-B # 6**	SP18-2-B # 4	SP18-2-B # 3	SP18-2-B # 2
Ammonia parkinsoniana forma tepida	5.0	0.9	31.8	13.2	10.6	0.9			8.8	48.8		15.0	35.7	15.5	16.5	61.7	11.7				35.0	6.7
Ammonia parkinsoniana forma typica	3.0			0.9	1.9	28.3		25.2	34.2	10.2			7.1	0.9	9.7	7.5	41.4				2.6	38.5
Ammotium salsum	90.1	96.4	5.5		3.8	36.3		70.9	6.1	13.4		80.0	50.0		1.0		2.7			1.9	6.8	10.6
Bigenerina irregularis									0.9	0.8												
Bolivina striatula									0.9	3.1												
Buccella hannai				0.9																		
Buliminella elegantissima										0.8						0.9					0.9	
Buliminella morgani												5.0										
Elphidium sp. cf. E. delicatulum				5.3	48.1	23.9		3.9													0.9	
Elphidium discoidale forma discoidale						0.9			6.1	1.6				0.9		0.9						
Elphidium discoidale forma transluscens									1.8						1.0							
Elphidium galvestonense						8.8			0.9													
Elphidium excavatum forma lidoense		2.7	58.2	68.4	34.6				37.7	20.5			7.1	74.1	69.9	26.2	38.7			1.0	47.9	43.3
Elphidium sp. cf. E. matagordanum				11.4										0.9		1.9						
Elphidium sp. cf. E. mexicanum			2.7		1.0				0.9													1.0
Elphidium poeyanum						0.9			0.9								5.4				4.3	
Palmerinella palmerae	2.0		0.9						0.9					7.8								
Quinqueloculina seminulum			0.9							0.8					1.9	0.9					1.7	
Saccammina sphaerica																				97.1		
NUMBER OF SPECIMENS COUNTED	101	112	110	114	104	113		103	114	127		20	14	116	103	107	111			105	117	104

* Poor samples with less than 100 specimens

** Samples barren of foraminifera

low sand content and the high amount of pyrite indicate that the environment had become deeper and more restricted.

In sample 10 (at 11 ft depth), *Elphidium excavatum* increases its dominance over the other species; *Ammonia parkinsoniana* is still almost solely represented by the forma *tepida*. *Ammotium salsum* is not present. Pyritization remains high, suggesting little environmental change from sample 11. Sample 9 (10.4 ft depth) is dominated by *Elphidium* sp. cf. *E. delicatulum*, but *E. excavatum* is still significant. *A. parkinsoniana* is still dominated by the *tepida* variety. The environmental conditions do not appear to have changed much from sample 10. However, the little pyritization may suggest an increase in oxygen content. The change in oxygen content could be due to a shallowing of the environment to which the dominance of *Elphidium* sp. cf. *E. delicatulum* may be related.

In sample 8 (9.6 ft depth), *Ammotium salsum* dominates. *Ammonia parkinsoniana* and *Elphidium* sp. cf. *E. delicatulum* are both present in significant quantities. *A. parkinsoniana* forma *typica* is now the dominant ecophenotype. This suggests a decrease in the salinity of the estuary. Sample 7 (8.8 ft depth) is barren of foraminifera. This may represent a subaerial or a swampy environment. A regressive change is thus indicated by the sequence of samples from 10 to 7. The low salinity environment of sample 8 may be due to a lowering of the sea level and a dominance of fluvial discharge over marine conditions. With a continued fall of sea level, aerial exposure is achieved in sample 7.

Sample 6 (8.2 ft depth) has *Ammotium salsum* as the dominant species. *Ammonia parkinsoniana* is also present in significant quantities, and is dominated by the forma *typica*. This suggests a low salinity estuarine environment and is probably due to a renewed rise in sea level. Sample 5 (6.9 ft depth) is dominated by *A. parkinsoniana* (led by forma *typica*) and *E. excavatum*. A rise in salinity (compared to sample 6) is suggested, but the high percentage of *A. parkinsoniana* forma *typica* indicates that the environment was still somewhat brackish. In sample 3 (2.8 ft depth) *A. parkinsoniana* dominates, but *Ammotium salsum* and *Elphidium excavatum* are still significant. An increase in salinity is suggested by the shift to a greater abundance of forma *tepida* within *Ammonia parkinsoniana*. The high percentage of *Ammotium salsum*, however, indicates some brackish water influence.

Core SP9-4-C

The core location is on the eastern bank of the former Sabine Valley, just north of where the Calcasieu River joined the Sabine. The core was taken in a water depth of 38 ft. The basal part of the core (SP9-4-C#9) is highly organic, barren of foraminifera, and thus may represent aerial exposure. Above this, sample 7 (10.9 ft depth in core) is from a sandy unit with very few foraminifera. *Ammotium salsum* dominates the fauna, and this suggests a low salinity, shallow water, estuarine environment. Sample 5 (9.7 ft depth), also dominated by *A. salsum*, contains less sand than sample 7. This may suggest a slight increase in water depth but little change in salinity between sample 7 and sample 5 horizons. The remainder of the core, represented by samples 4 (7 ft depth), 3 (4.9 ft), 2 (3.3 ft), and 1 (2 ft), is dominated by *Elphidium excavatum* and *Ammonia parkinsoniana*. The minor species have living representatives in both brackish and shallow marine environments. *A. parkinsoniana* forma *tepida* is the dominant ecophenotype in the samples studied in this core, except in sample 1. Overall, the record from these samples suggest that, except for the very top of the core, sea level and salinities remained relatively high, with some fluctuations.

Core SP18-2-B

This core was taken from a water depth of about 40 ft, the site being on the west bank of the former Sabine Valley. The lower two samples in the core are barren of foraminifera. The lowermost sample (sample 7 at 17.2 ft depth) is from a sandy unit, and sample 6 (16.6 ft depth) is from a organic-rich layer. These samples probably represent subaerial or freshwater conditions. Sample 4 (12 ft depth) is also highly organic, but foraminifera are present. The assemblage is dominated by Saccammina sphaerica which is generally an uncommon species found in nearly freshwater marshes. Sample 3 (10.3 ft depth) is dominated by Ammonia parkinsoniana and Elphidium excavatum. The forma tepida of A. parkinsoniana is the most common ecophenotype; this represents nearly marine salinity within the estuary. Sample 2 (6.8 ft depth) is also dominated by E. excavatum and A. parkinsoniana. However, forma typica is most common, suggesting a slight decrease in salinity.

Regional Implications

The bases of all three cores are rich in organic matter and barren of foraminifera. These sediments may represent freshwater, swampy conditions along the valley walls during a low stand of the sea level. This was followed by a sea level rise, inundating the swamps on the eastern bank and forming the sandy, Ammotium salsum dominated units. The estuary was still shallow and very low in salinity. The relatively thick sand units suggest that the sea level rose slowly or remained at this level for some time. Along the western valley wall (core SP18-2-B), sandy units are absent above the organic swamp deposits. The top of the swamp bed, however, contains some foraminifera. The sample is dominated by Saccammina sphaerica which is generally found in nearly freshwater marshes. This may represent some inundation of the swamps by the higher water levels of the estuary. All three cores then show a rapid change to a mainly calcareous fauna representing nearly normal marine salinities. The dominance of the forma tepida of Ammonia parkinsoniana also suggests that the salinity within the estuary was nearly marine. The sea level rise was rapid, because the change from nearly freshwater to marine salinities occurred in one core (SP9-4-C) over a maximum of 8 in of section.

In the most extensively sampled core (SP3-1-F), there is clear evidence that a regression followed this transgression. The evidence consists of a reduction in the relative abundance of Ammonia parkinsoniana forma tepida, a dominance shift to Ammotium salsum, and the absence of foraminifera in an organic-rich sample similar to the one at the base of the core. The regression is followed by a second transgression, which is reflected in the reversal of the faunal trend, ending in the dominance of Ammonia parkinsoniana forma tepida near the top of the core.

The regressive and the second transgressive sequences, and the organic-rich barren interval in the middle of core SP3-1-F are not seen in the other two cores. The lack of the latter unit suggests that the sites of these two cores remained submerged during the regression. They are therefore deeper parts of the estuary. The lack of regressive sequences in SP9-4-C and SP18-2-B, however, may simply reflect inadequate sampling. Core SP9-4-C contains four ft of unsampled section at the approximate stratigraphic level of the regressive sequence in SP3-1-F. Core SP18-2-B contains only two samples taken from the marine/estuarine section of the core. It is therefore difficult to ascertain all of the significant environmental changes in these cores. The few samples taken from the upper portion of each core do not permit a confident determination of sea level changes after the second transgression. The fauna, however, are generally representative of a shallow marine environment. The sea level apparently had only minor fluctuations after this second transgression.

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APPENDIX B:

POLLEN ANALYSIS OF HOLOCENE SEDIMENTS FROM THE FORMER SABINE RIVER VALLEY

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INTRODUCTION

As part of a larger project concerning the development of prospecting methodologies for offshore archaeological sites, Coastal Environments, Inc., submitted a series of pollen samples from continental shelf deposits that have a high probability of containing archaeological materials.

This report concerns the first known application of offshore archaeological pollen analysis. The data presented provide baseline information on the pollen content of several types of buried offshore deposits. These data are used to assess local environmental settings and conditions of deposition. While these offshore pollen samples can be compared to known onshore analogs as an aid to interpretation, the lack of directly comparable offshore samples limits somewhat the precision of the interpretations presented.

POLLEN EXTRACTION AND ANALYSIS

Upon arrival at the Paleoenvironmental Laboratory, MIT, the samples were unpacked and entered into the laboratory sample inventory to await processing. At the initiation of processing the samples were split to preserve one-half for future analyses and one for treatment. The samples were placed in 250 ml beakers and were "wet down" with distilled water. The wet samples were then taken to the extraction laboratory where they were treated with hydrochloric acid, hydrofluoric acid, nitric acid, hydrochloric acid again, and finally sodium hydroxide. Such chemical treatment successively removes carbonates, silicates and organics from the sample, leaving a potentially pollen-rich residue. This residue is then concentrated and placed in a vial for storage.

Later, the vial is opened and a drop of the residue is transferred to a warmed microscope slide, which is then prepared for counting. Pollen counting is done on an AO 110 Microstar binocular microscope. Routine pollen counting is performed with the 40X objective in place, although obscure or unknown pollen grains are observed with the 100X objective. Pollen grains are tallied by taxon (name) and number in a laboratory notebook. An attempt was made to secure total grain counts in excess of 200 identified pollen grains, although for some samples this was an impossible goal. Several samples were barren (contained no pollen) and several were sparse (contained less than the 100 grains necessary for a percentage conversion). One sample contained pollen, but was so obscured by tiny flecks of charcoal that a meaningful count was impossible. The resulting tallies were then converted to percentages and arrayed as a table for ease of study and interpretation (Table B-1).

DESCRIPTION OF THE PALYNOLOGICAL DATA BASE

There were twenty distinct pollen types that were found in percentages greater than 1%, but only eight accounted for most of the significant between-sample variation. Several rare pollen types were encountered, but did not affect the interpretation at all, as is sometimes the case with exotic pollen types. The barren samples were either from sand deposits which allowed air and water movement through the sample matrix (thereby leaching and/or oxidizing the pollen), or from burned deposits (causing oxidation and obscuring of pollen by charcoal flecks).

Pollen preservation was generally good. Either the pollen was completely destroyed or it was fairly well preserved. The only sample showing significant fungal degradation

Table B-1. Pollen Data Presented as Percentages

CORE NUMBER	SAMPLE	SEDIMENT	*Pinus*	*Juniperus*	*Taxodium*	*Acer*	*Alnus*	*Betula*	*Carya*	*Fraxinus*	*Ilex*	*Juglans*	*Liquidambar*	*Nyssa*	*Ostrya/Carpinus*	*Quercus*	Ulmaceae	Cheno/Am	Compositae (high-spine)	Compositae (low-spine)	Cyperaceae	Gramineae	MISC. TYPES not in % sums	TOTAL GRAINS	REMARKS
SP3-1-F	2	clay/org.	15	3	5				2		3		3	2		15		3	2	3	14	30	Cl, Pl, Sa, Ty	345	Abundant pollen
	7	"	15	1	2	2		2			2	1		1		12	1	4	1	1	7	47	Pl, Pr, Sa	321	Charcoal chunks present
	9	clay	10	5	2		3						3		2	5		2		12	5	52	Cl, Sa, Ti, Ty	268	
	12	sand	+											+										27	
	13	sand										BARREN												0	
SP6-1-B	3	peat	5	3	4	1	1			4	3	1	2	4	3	23	4	13	3	4	5	20	Ca, Cl, Pl, Ro, Ty	260	Unique pollen flora
SP6-1-D	7	clay/shell	16	7	3		1									16	2	10	8	11	5	20	Ro, Sa, Ti	200	Unique sample
SP6-2-C	1	clay/org.	10	2	3			5				3				10		13	2	10	3	38			
	2	silt	13		7											5		8	7	4	5	51	Cl, Pl, Sa	261	
SP6-2-I	4	silt	24	6	5			1		1						17		8	3	6	7	23	Ca, Dr, Sa, Ti	200	
	5	clay	22	1	2			1	2	3	1		1			13	1	2	3	2	10	35	Pl, Ro, Ty	307	
	6	sand	+	+	+											+		+		+	+	+	Sa	34	
	8	sand/silt										BARREN												0	
	10	peat	16	3	1						1	1		3		10		8	8	7	12	30		281	
SP6-3-A	1	silt/org.	9		9											6	3	3	3	6	3	60		342	
	2	peat	14	4						6		2		2		20		12		4	14	32	Ro, Sa, Ty	306	
	4	clay	8		3			1	2	2		1		1		11	2	3	3	2	9	53		318	
SP9-2-B	1	clay/org.	23	5				2								10		6	5	3	2	45	Ca, Ct, Sa, Ty	231	Abundant pollen
SP9-4-C	6	silt	+		+															+	+	+		18	
	9	charcoal										BARREN												226	Charcoal chunks present
SP18-1-A	1	sand/clay	+		+											+						+		12	Mech. damage
SP18-1-D	1	clay	23	1	5	4										22		3	6	2	1	32	Ro, Ti, Ty	241	
	3	yellow sand										BARREN												304	
SP18-2-B	3	clay/org.	30		7											13	2	4		5	6	30	R0, Sa, Ti	200	High pine!
	4	clay/org.	34	2	3			3	4							11		2	3	2	2	33	Pl, Pr, Ti	227	High pine!
	5	charcoal										BARREN												?	Pollen obsc. by charcoal
	6	silt/org.	12		6		3	1						4		11	3	6	4	1	3	45	Pl, Ro, Ty	310	
	7	sand										BARREN												0	
HI49-2-B	3	clay	18	1	6	1	2		2	1		2			2	10	1	6	7	8	4	27	Ct, Pr	286	
	5	clay	8	4	8	2			1	4	2	1	3		4	8	2	5	5	3	6	32	Ro, Ti, Ty	244	
	7	silt										BARREN												0	
HI49-3-D	2	clay/char.	16	2	6				1						2	21	1	3	7	1	6	35	Pl, Ro, Sa, Ty	233	Abundant charcoal
HI49-3-E	1	clay/char.	+													+						+		13	Abundant charcoal

NOTE: Ca = Caprifoliaceae; Ct = Catalpa; Cl = Celtis; Pl = Platanus; Pr = Prunus; Ro = Robinia; Sa = Salix; Ti = Tilia; Ty=Typha was from core SP18-1-A, which contained only twelve badly preserved grains that could be identified within a much larger number of heavily weathered and/or fragmented grains. None of the samples showed any evidence of significant mechanical damage (breakage) to the pollen grains.

PALYNOLOGICAL RESULTS

Fourteen cores are represented in the series submitted to the Paleoenvironmental Laboratory, MIT, each of which (except for Cores SP9-4-C and HI49-3-D) contained countable pollen. In this section, we will discuss the pollen data and their paleoenvironmental implications core by core. In the following section a regional paleogeographic synthesis will be proposed from these data.

Core SP3-1-F

Two samples, numbers 12 and 13, were either barren or contained too few pollen grains for a statistically significant count. This dearth of pollen, plus the presence of a large fraction of sand in the samples, imply a rather high-energy depositional environment such as an estuary, levee, or delta that experiences alternating periods of inundation and dessication. Modern sediment samples taken from such environments almost always lack pollen due to rapid oxidation and mechanical weathering.

The other samples from above and below this zone contain abundant and well-preserved pollen, especially Sample 2, which also contained a large fraction of other organic remains. In general these pollen data imply fairly shallow but stable water levels, representing either a marsh or swamp environment. Sample 7 contained charcoal flecks much larger than most other samples in which charcoal was present, perhaps indicative of in situ burning, thus implying exposed land nearby.

Core SP6-1-B

Sample 3 from Core SP6-1-B contains a significantly different pollen flora than that of the rest of the series. First, its palynological diversity is much greater than the others, containing fifteen pollen taxa with percentages greater than 1%. Second, the percentage of grass pollen is the lowest in the series, implying a significant distance from prairie or marsh. The pollen flora most resembles bottomland hardwood forest such as is found on the Prairie Terrace in the present-day Gulf coastal area. However, it may also be accounted for in several other ways, including presence of a very wide levee, movement of water-borne pollen downriver, or even contamination. However, this sample was probably deposited on a dry land surface which was quickly covered with sediment (I envision a shallow depression in a bottomland hardwood environment), or in a small water-filled depression such as an oxbow lake adjacent to a wide levee or bottomland hardwood forest.

Core SP6-1-D

The sample (7) from this core was somewhat distinct from the rest of the series. First, it contained the most Rangia shell of any of the samples submitted, and had a distinct calcareous reaction under treatment with hydrochloric acid. Second, the sample percentage showed a tie for the lowest relative abundance of grass pollen (20%). Third, this sample contained an overall large percentage of disturbance plant pollen (forbs). Fourth, this sample contained the most juniper pollen of the series. These data suggest that the shell-rich edaphic environment encouraged the growth of a forb and perhaps juniper-rich microcommunity. In other parts of the southern United States, juniper is an indicator of calcareous soils.

Core SP6-2-C

The high grass percentages characterizing the bottom sample (2) indicate a fairly extensive marsh environment. Sample 1, with lower grass and a higher diversity of arboreal pollen types, may be from either a marsh/swamp ecotone or a swamp.

Core SP6-2-I

Sample 10, the bottommost sample submitted, has a very high organic content with well-preserved plant remains, implying a fairly shallow, but never-exposed depositional environment. Grass pollen is slightly lower than average in this sample, as is the swamp indicator *Taxodium*. The balance of evidence (low grass is much more significant than low *Taxodium*) favors a swamp interpretation.

The next two samples, 6 and 8, are from deposits that are barren (or almost so) of pollen. Sample 6 was in a matrix resembling levee or estuarine deposits. Sample 8 came from a clay-organic matrix. The uppermost samples, 4 and 5, are similar both in their matrix and pollen. The pollen data from Sample 5 implies a marsh (high grass pollen), but Sample 4 is more equivocal and may contain some nonlocal pollen and may either be a swamp or marsh.

Core SP6-3-A

The bottommost sample (4) contains the greatest amount of grass pollen of any in the series and therefore probably came from a marsh-type environment, although other data bases seem to imply a swamp origin for the sample (Pearson, personal communication 1985). Sample 2, on the other hand, may be from either swamp or marsh, while Sample 1, also with extremely high grass pollen, was probably surrounded by marsh environments.

Core SP9-2-B

The single pollen sample from this core (Sample 1) contained abundant pollen as well as other organic remains. The matrix and pollen imply either a marsh environment or an open body of water adjacent to marsh. The condition of the pollen and organics does not support the contention that this sample came from an alternately wet-dry levee or estuary type environment.

Core SP9-4-C

The lower of the two samples from this core (Sample 9) was barren and contained many large particles of charcoal implying exposure to the atmosphere, while the other sample (6) contained but eighteen heavily weathered pollen grains, also suggesting post-depositional, wet-dry conditions.

Core SP18-1-A

Pollen from the one sample (1) from this core was heavily weathered and mechanically damaged, implying an alternate wet-dry environment with significant turbulence, although the sand/silt matrix implies a somewhat less vigorous depositional environment.

Core SP18-1-D

The lower sample (3) was barren of both pollen and any other organics, implying a beach or levee-type deposit, also supported by the yellowish sandy matrix. The upper sample (1), from a clay matrix, contained abundant pollen implying swamp, marsh or even estuarine deposition (the latter probably unlikely). The pollen flora is undistinguished; it could represent any one of these environments.

Core SP18-2-B

Sample 7, the lowest in the pollen series, was barren of pollen. This fact, plus the sandy nature of the matrix tends to indicate a high-energy, often aerated depositional environment. Sample 6 came from a silty/peaty deposit. It contains abundant grass pollen implying proximity to marsh, although the presence of alder and tupelo pollen indicate a nearby swamp. The balance of the evidence favors more swamp than marsh, however. The next sample, Sample 5, contains pollen, but the grains are so obscured by oxidized organic remains that the sample was uncountable. The organic preservation and mineral particle size imply a low energy depositional environment such as a marsh or swamp. Samples 3 and 4 are very similar in both their matrix (a mix of clay and organics) and their pollen counts. The interesting thing about these two samples is the large percentage of pine pollen found in them, both containing above 30%. In all previous samples I have assumed that the presence of this pollen type may be accounted for by long-range air or water transport. These two samples may imply closer proximity to the drier upland environments that characterize pine's habitat. Perhaps other forms of data will help decide whether proximity or transport accounts for this larger representation of pine. Otherwise, the samples are indicative of marshy lowland environments with little aeration or turbulence.

Core HI49-2-B

The bottommost sample (7), from a silt matrix, was barren, thus implying post-depositional, wet-dry cycling. Levee or estuarine depositional environments are suggested. Samples 3 and 5 are very similar in their pollen floras. They both have a relatively large diversity of upland/swamp forest pollen types, implying swamp rather than marsh environments. The diversity of arboreal pollen may be seen as indicating a more well-developed forest than is evident in most other samples, with the exception of Sample 3 from Core SP6-1-B, although the percentage of grass pollen is nowhere as low.

Core HI49-3-D

Sample 2, the only sample submitted from this core, contained abundant pollen and charcoal flecks. The pollen flora is borderline between a marsh environment (containing grass pollen), and a swamp environment (containing a diversity of other nonarboreal pollen and tree pollen). The marsh reconstruction is the more plausible one.

Core HI49-3-E

Sample 1, extracted from a clay-organic matrix, was barren. It was the second barren sample recorded from such a depositional environment (see Sample 8 from Core SP6-2-I). Abundant charcoal particles were present, however. The anomalous nature of this sample prevents any environmental inferences.

OVERVIEW AND CONCLUSION

The environments inferred from the pollen and sedimentary data are almost without exception those which characterize the lowlying Gulf coastal plain today. Salt marsh and freshwater swamp are found in low-energy depositional environments within twenty-five miles of the present coast, while estuarine, beach and levee (or deltaic) environments characterize the dynamic coastal plain/Gulf interface. Comparison of the core samples with pollen data from Louisiana in the files of the Quaternary Paleoecology Laboratory at Louisiana State University indicates that, except for two samples (SP6-2-I Sample 10 and SP6-1-D Sample 7), all of the core data could have come from Recent floodplain and coastal marsh/swamp environments. Such environments were probably less used by Late Wisconsinan and Early Holocene hunters and gatherers than more upland environments. Levee and perhaps beach habitats have the highest probability of containing archaeological materials in such a macrohabitat type.

Sample 3 from Core SP6-1-B does not much resemble the other samples or marsh/swamp modern pollen samples. It more resembles samples taken from bottomland hardwood associations such as are found associated with floodplain environments on the Prairie or older terraces. It is unclear how much a very high or wide levee in a coastal environment would vegetationally resemble bottomland hardwood associations, but such a reconstruction is a distinct possibility.

Sample 7 of Core SP6-1-D is another anomalous sample. However, if the deposit was a shell midden of sufficient size, it would contain a local flora very distinct from adjacent habitats. I suspect that this was the case.

In conclusion, it seems that the reconstructed environments from the core data strongly resemble analogous contemporary environments just inland from the Gulf waters that have sealed these remains for many thousands of years.

APPENDIX C:

GEOCHEMICAL ANALYSIS CONDUCTED FOR PREHISTORIC SITE EVALUATION IN THE NORTHERN GULF OF MEXICO OCS

by
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INTRODUCTION

This appendix presents the results of the geochemical analysis of nine samples selected from buried locales on the OCS. The primary purpose of the geochemical evaluation was to serve as a final assessment of samples which other analyses indicated may be archaeological in origin. An associated purpose was to simply gather data on the chemical properties of buried, inundated deposits, about which relatively little is known.

Background

The use of chemical analyses of soils to help locate or discriminate archaeological deposits is relatively recent, but is rapidly developing. Analyses of phosphates, which have been shown to concentrate in soils (anthrosoils) at human habitation sites (Arrhenius 1931; Buehrer 1950; Cornwall 1958; Mattingly and Williams 1962; Eidt 1973; Woods 1975; and others), have received considerable attention. Woods (1975, 1977) has proposed a technique for phosphate analysis by solubility fractionation that allows distinction between modern and prehistoric phosphate concentrations.

Other chemical parameters which have been used with varying success to detect and locate archaeological sites include: organic carbon (Buehrer 1950); nitrogen (Eddy and Dregne 1964); pH (Parsons 1962); calcium (Buehrer 1950); potassium and magnesium (Buehrer 1950; Wise 1944; Kimber et al. 1966); iron (Limbrey 1975; Bowen 1966); copper and zinc (Bowen 1966; Sauchelli 1969). A brief review is contained in Jefferies and Butler (1982).

A study conducted by Carbon Systems, Inc. (in Gagliano et al. 1982) on five selected archaeological sites from the Gulf coastal region found zinc, magnesium, and total phosphate enriched on the sites. In that study, each sample was sieved through a 200-mesh sieve to achieve sample uniformity. The phosphate results indicated that total phosphate (strong acid extraction) was a useful indicator, but that the more easily extracted forms had been lost (leached) from the exposed sites. The study recommended that total orthophosphates (TP) and heavy metals be tested on submerged sites.

In determining which chemical parameters to measure in this study, two factors were taken into account. One of these related to our present understanding of the chemical composition of known archaeological sites as briefly outlined above. The other factor relates to the known and presumed impacts which burial and inundation would have on the chemical content of an archaeological site on the OCS. From a consideration of these two factors, the following assumptions were made:

1. Sites have prograded over time from upland to bottomland hardwood to swamp to marsh to submerged with the potential for leaching in each environment.

2. The more soluble and less tightly bound constituents in archaeological deposits have been substantially reduced by leaching.

3. While phosphates are undoubtedly concentrated at human habitation sites, the more soluble (available) forms have been leached by rainfall during the early history of the site and by fresh- and saltwater covering the sites as they prograded. The tightly bound forms (total phosphate, TP) may still be a pertinent indicator of human habitation.

4. A number of metals, including copper (Cu), magnesium (Mg), manganese (Mn), iron (Fe), calcium (Ca), potassium (K), and zinc (Zn) should be concentrated at human habitation sites because they are constituents of the food gathered by man or they occur as waste products.

5. Many of the metals could be held by clays (ion exchange capacity) in the oxidized form in which they usually exist when air is present, thus remaining on-site even though rainfall tends to leach out ions.

6. As the site prograded and became covered by fresh or saltwater, and a layer of silt covered the site, the bacterial decomposition of the organic matter present would have quickly depleted the available oxygen, and the site would have become anaerobic.

7. Under anaerobic conditions the metals present would have been converted from the oxide forms to the insoluble sulfide form by anaerobic bacterial action and should resist further leaching. Thus, the metals may serve as relatively permanent markers of human habitation.

Methods

The nine samples selected for analysis were derived from three lease blocks, Sabine Pass 3, 6 and 9. The majority of the samples (6) were taken from the Sabine Pass 6 area because of the probability that archaeological deposits were encountered there. The samples and the results of the chemical analyses are presented in Table C-1. The last column in Table C-1 presents a priority ranking of the samples on the basis of their potential for being cultural. A ranking of 9 is the highest probability of being cultural. This ranking was based on the other, nonchemical, evaluation of the samples.

The analytical chemistry procedures used in this project are described in Plumb (1981) and are listed below.

Inorganic Anaysis for Sediment Samples:

1. Carbon (TOC), total organic and inorganic;
2 Metals, method 1, total metals, direct flame atomic absorption;
3. Nitrogen (TKN), method 1, Kjeldahl digestion;
4. Phosphates (APO4), soluble;
5. Phosphates Total (TP), acid digestion.

RESULTS AND DISCUSSION

Comparing with Other Gulf Data

Table C-1 also compares the average analyses of our nine samples with data from the Texas Bureau of Economic Geology (White et al. 1983) for OCS sediments off Corpus Christi, Texas (White et al. 1983) and Galveston (White et al. 1985) and from the USGS (Holmes 1973) for the northwestern shelf (west of Mississippi River and north of latitude 28) and slope sediments of the Gulf of Mexico. Additionally, data presented by Gagliano et al. (1982) from coastal sites and natural landforms are provided.

The bay sediment data from the Corpus Christi and Galveston areas showed considerable variation from the shelf data averages shown in Table C-1, probably because of the significance of rivers, which impact the bays more directly. The USGS

Table C-1. Results of Analyses and Comparison with other Gulf Data.

	Chemical Parameter											
Sample	**Ca**	**Cu**	**Fe**	**Mg**	**Mn**	**K**	**Zn**	**PO4**	**TP**	**TKN**	**TOC**	**Priority**
SP3-1-A#1	678.00	22.70	11204.00	5858.00	2184.00	3995.00	88.40	4.73	532.00	2008.00	1891.00	3
SP3-1-D1#3	40.70	86.00	19294.00	1808.00	4435.00	2642.00	68.30	1.37	1344.00	340.50	13639.00	5
SP6-1-A#2	4.50	20.80	4286.50	1293.00	19.20	2580.50	15.90	0.17	832.00	1203.00	38465.00	4
SP6-1-A#3	40.70	89.20	3639.00	268.00	15.80	1022.00	42.20	3.13	412.00	303.00	1346.00	1
SP6-1-C#2	15814.00	49.70	47161.00	3463.00	604.00	4575.00	39.30	1.62	950.00	320.00	3018.00	9
SP6-2-C#2	1228.00	319.00	19240.00	2829.00	631.00	2850.00	31.20	7.48	1268.00	787.00	5508.50	7
SP6-3-B#1	23.75	31.00	19591.50	1820.00	544.50	2878.50	49.10	7.57	720.00	977.00	4074.00	6
SP6-4-C#4	27.25	15.60	10422.00	1140.00	123.50	2607.50	52.15	29.30	890.00	280.00	9509.00	8
SP9-4-B#1	19.50	40.85	14757.50	2379.00	134.50	6402.50	9.40	211.00	634.00	468.00	5037.00	2
Average	1986.27	74.98	16621.72	2317.56	965.72	3283.667	53.39	29.60	842.44	742.94	5318.78	
TBEG (a)	--	24.00	31900.00	—	560.00	—	60.00	—	—	—	—	
TBEG (b)	—	18.00	30000.00	—	783.00	—	53.00	—	—	—	—	
USGS (c)	15800.00	10.00	15100.00	7400.00	401.00	—	—	—	—	—	—	
Gagliano et al. (1982):												
Average site	--	10.00	4568.00	--	555.00	--	58.00	--	2835.00	5900.00	34760.00	
Average off-site	--	8.00	8856.00	--	990.00	--	25.00	--	698.00	5180.00	37540.00	

(a) Corpus Christi, Texas, OCS (White et al. 1983)
(b) Galveston-Houston, Texas, OCS (White et al. 1985)
(c)Northwestern Gulf of Mexico, OCS (Holmes 1973)

sediment data also showed considerable variation by region of the Gulf and types of bottom (carbonate, shale, sandstone, and clay). The Bureau of Economic Geology and USGS data are for surficial sediments, while this presents data from cores at various depths. The specific consequences of burial to chemical elements in deposits on the OCS are currently unknown. There is no doubt, however, that changes will occur. On a terrestrial archaeological site Woods (1982) has noted a general decrease in most chemical parameters with depth.

Correlation of the Chemical Data with the Archaeological Priority Ranking

Each of the nine samples analyzed was also ranked by three archaeologists using other information, and the chemical data were correlated with the priority ranking. The ranking was determined using expert judgement and a Delphi technique, with a rank of 9 representing the highest probability of being cultural and 1 the lowest.

As shown in Table C-2, each chemical parameter was then compared to the proposed ranking using a multiple regression statistical analysis (note that the samples are listed in the order in which they were analyzed). The correlations resulting from this analysis are shown in Table C-3. A perfect correlation is 1; a lack of any correlation is zero, and a negative number indicates an inverse correlation, i.e., a chemical parameter could decrease as the priority ranking increases. In addition to the chemical parameters shown in the table, each parameter was normalized (divided by) the concentrations of Fe, Ca, and TOC to determine if the correlations improved. An earlier study (Gagliano et al. 1982), found that Zn correlated better when normalized to Fe, so Zn/Fe was also tried. Because this was a marine environment suspected to be high in calcium, a normalization using Ca (division by Ca concentration) was also included. Finally, the Texas Bureau of Economic Geology (White et al. 1983) study found a correlation of TOC with metal concentration. To examine this possibility, the chemical data were normalized to TOC, but no significant correlations were found so the TOC normalized values were omitted from Tables C-2 and C-3 for brevity.

The method followed in the calculations was to run a multiple regression analysis, generate a correlation table, manually pick the highest correlation values (>|0.5|), and then perform a second order polynomial regression individually on each of those parameters using the priority ranking as the dependent variable. The results of the significant calculations are shown in Table C-4.

Table C-2. Chemical Parameters Correlated.

	1	2	3	4	5	6	7	8
1	PARAMETER	Ca	Cu	Fe	Mg	Mn	K	Zn
2	SAMPLE							
3	SP3-1-A#1	678	22.7	11204	5858	2184	3995	88.4
4	SP6-3-B#1	23.75	31	19591.5	1820	544.5	2878.5	49.1
5	SP9-4-B#1	19.5	40.85	14757.5	2379	134.5	6402.5	94
6	SP6-4-C#4	27.25	15.6	10422	1140	123.5	2607.5	52.15
7	SP3-1-D1#3	40.7	86	19294	1808	4435	2642	68.3
8	SP6-1-A#2	4.5	20.8	4286.5	1293	19.2	2580.5	15.9
9	SP6-1-A#3	40.7	89.2	3639	268	15.8	1022	42.2
10	SP6-1-C#2	15814	49.7	47161	3463	604	4575	39.3
11	SP6-2-C#2	1228	319	19240	2829	631	2850	31.2

Table C-2. Concluded.

	9	10	11	12	13	14	15	16
1	Avail. PO4	Total Phos. (TP)	TKN	TOC	TOC/TKN	Cu/Fe	Mg/Fe	Mn/Fe
2								
3	4.73	532	2008	1891	0.94173307	0.00202606	0.52284898	0.19493038
4	7.57	720	977	4074	4.16990788	0.00158232	0.09289743	0.02779267
5	211	634	468	5037	10.7628205	0.00276808	0.16120617	0.00911401
6	29.3	890	280	9509	33.9607143	0.00149683	0.109384	0.01184993
7	1.37	1344	340.5	13639	40.0558003	0.00445734	0.09370789	0.22986421
8	0.17	832	1203	3846.5	3.19742311	0.00485244	0.3016447	0.00447918
9	3.13	412	303	1346	4.44224422	0.02451223	0.07364661	0.00434185
10	1.62	950	320	3018	9.43125	0.00105384	0.07342932	0.01280719
11	7.475	1268	787	5508.5	6.99936468	0.01658004	0.14703742	0.03279626

	17	18	19	20	21	22	23	24
1	K/Fe	Zn/fe	Cu/Ca	Mg/Ca	Mn/Ca	K/Ca	Zn/Ca	Avail. Po4/Fe
2								
3	0.35656908	0.00789004	0.03348083	8.64011799	3.22123894	5.89233038	0.13038348	0.00042217
4	0.14692596	0.00250619	1.30526316	76.6315789	22.9263158	121.2	2.06736842	0.00038639
5	0.4338472	0.00636964	2.09487179	122	6.8974359	328.333333	4.82051282	0.01429781
6	0.2501919	0.00500384	0.57247706	41.8348624	4.53211009	95.6880734	1.91376147	0.00281136
7	0.13693376	0.00353996	2.11302211	44.4226044	108.968059	64.9140049	1.67813268	7.1007E-05
8	0.6020063	0.00370932	4.62222222	287.333333	4.26666667	573.444444	3.53333333	3.9659E-05
9	0.28084639	0.01159659	2.19164619	6.58476658	0.38820639	25.1105651	1.03685504	0.00086013
10	0.09700812	0.00083332	0.00314278	0.21898318	0.03819401	0.28930062	0.00248514	3.435E-05
11	0.1481289	0.00162162	0.25977199	2.30374593	0.51384365	2.32084691	0.02540717	0.00038851

	25	26	27	28	29	30	31	32
1	TP/Fe	Av. PO4/Ca	TP/Ca	TKN/Fe	TKN/Ca	TOC/Fe	TOC/Ca	N+AP+K
2								
3	0.04748304	0.0069764	0.78466077	0.17922171	2.96165192	0.16877901	2.78908555	6007.73
4	0.03675063	0.31873684	30.3157895	0.04986857	41.1368421	0.20794732	171.536842	3863.07
5	0.04296121	10.8205128	32.5128205	0.03171269	24	0.34131797	258.307692	7081.5
6	0.08539628	1.07522936	32.6605505	0.02686624	10.2752294	0.91239685	348.954128	2916.8
7	0.06965896	0.03366093	33.022113	0.01764797	8.36609337	0.7069037	335.110565	2983.87
8	0.19409775	0.03777778	184.888889	0.28064855	267.333333	0.89735215	854.777778	3783.67
9	0.11321792	0.07690418	10.1228501	0.08326463	7.44471744	0.36988184	33.0712531	1328.13
10	0.02014376	0.00010244	0.06007335	0.00678527	0.02023523	0.06399355	0.19084356	4896.62
11	0.06590437	0.00608713	1.03257329	0.04090437	0.64087948	0.28630457	4.48574919	3644.475

	33	34	35	36	37	38	39	40
1	N+TP+K	N+AP+K/Fe	N+TP+K/Fe	N+AP+K/Ca	N+TP+K/Ca	N+AP+K+C	N+TP+K+C	N+AP+K+C/Fe
2								
3	6535	0.53621296	2540.35657	8.8609587	2545.89233	7898.73	8426	0.704991967
4	4575.5	0.19718092	1697.14693	162.655579	1818.2	7937.07	8649.5	0.405128244
5	7504.5	0.4798577	1102.43385	363.153846	1430.33333	12118.5	12541.5	0.821175673
6	3777.5	0.27986951	1170.25019	107.038532	1265.68807	12425.8	13286.5	1.19226636
7	4326.5	0.15465274	1684.63693	73.3137592	1749.414	16622.87	17965.5	0.861556442
8	4615.5	0.88269451	2035.60201	840.815556	2608.44444	7630.17	8462	1.780046658
9	1737	0.36497115	715.280846	32.6321867	740.110565	2674.13	3083	0.734852982
10	5845	0.10382774	1270.09701	0.3096383	1270.2893	7914.62	8863	0.167821293
11	4905	0.18942178	2055.14813	2.96781352	2057.32085	9152.975	10413.5	0.475726351

	41	42	43	44	45
1	N+TP+K+C/Fe	N+AP+K+C/Ca	N+TP+K+C/Ca	Fe/Ca	Priority 9tot
2					
3	6535.168779	11.65004425	6537.789086	16.5250737	3
4	4575.7079473	334.1924211	4747.036842	824.905263	6
5	7504.841318	621.4615385	7762.807692	756.794872	2
6	3778.4123969	455.9926606	4126.454128	382.458716	8
7	4327.2069037	408.4243243	4661.610565	474.054054	5
8	4616.3973522	1695.593333	5470.277778	952.555556	4
9	1737.3698818	65.7034398	1770.071253	89.4103194	1
10	5845.0639936	0.500481852	5845.190844	2.98223093	9
11	4905.2863046	7.453562704	4909.485749	15.6677524	7

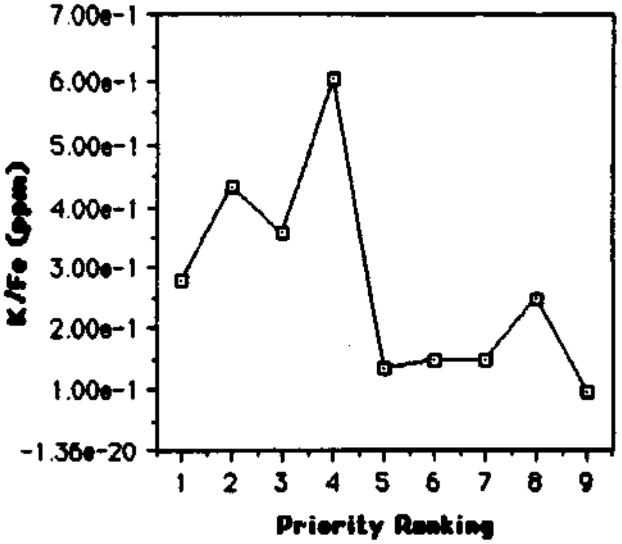

Figure C-3. K/Fe vs. priority ranking.

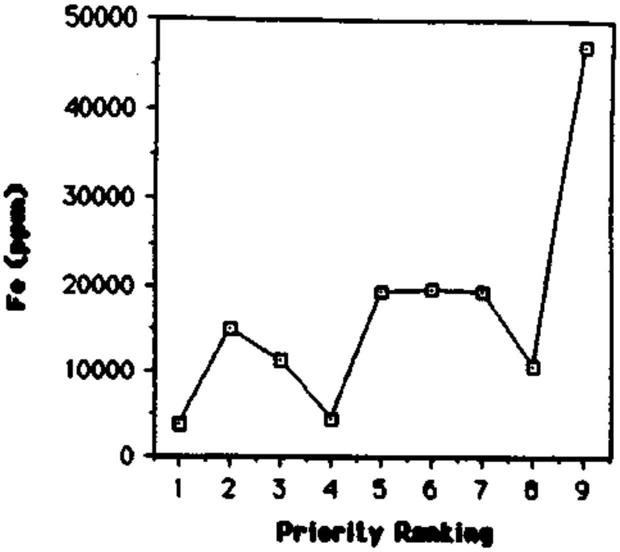

Figure C-4. Iron vs. priority ranking.

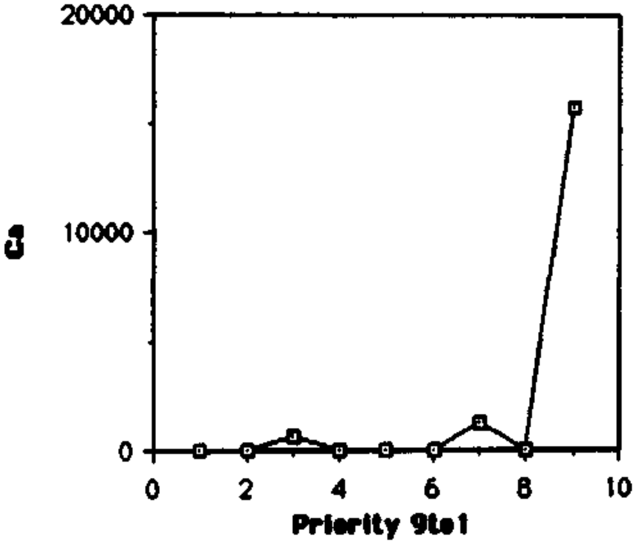

Figure C-5. Calcium vs. priority ranking.

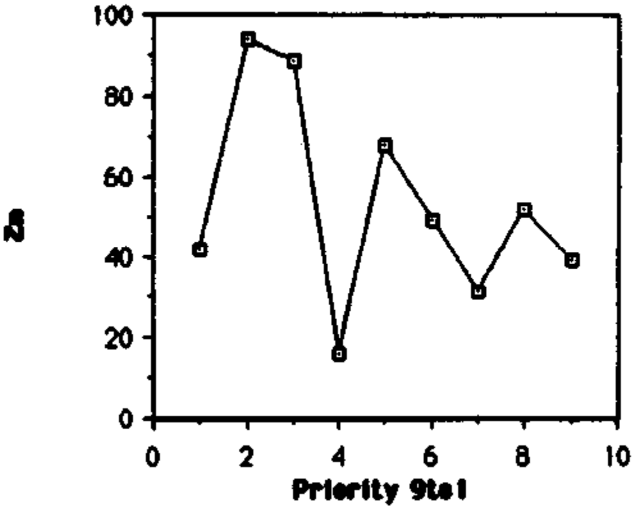

Figure C-6. Zinc vs. priority ranking.

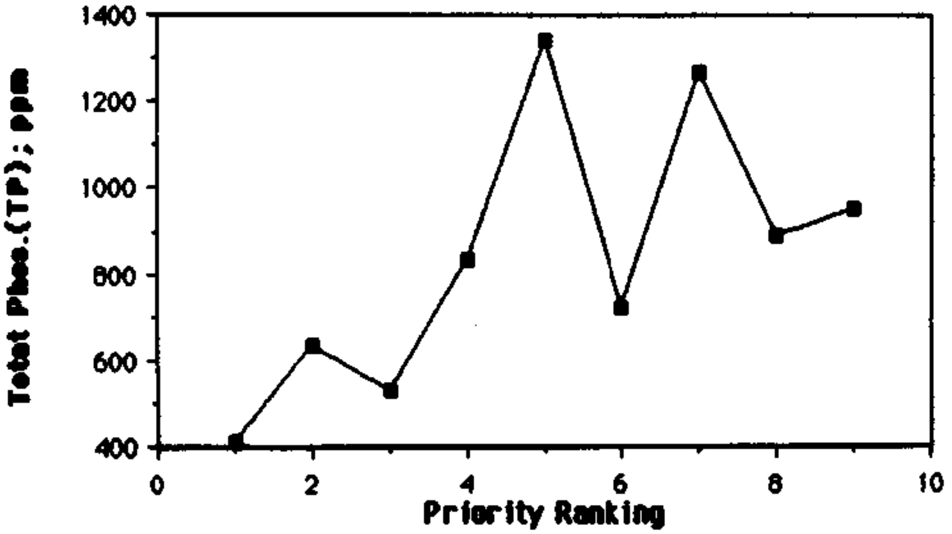

Figure C-7.
Total phosphates vs.
priority ranking.

Table C-5. Chemical Parameters Correlated by Priority Ranking Using Spearman Correlation.

Ranking Correlated With:	Correlation Statistic	Significance
TP	0.73	0.024
Zn/Fe	-0.82	0.007
TKN+APO4+K/Fe	-0.68	0.041
K/Fe	-0.68	0.041
Fe	0.60	0.086
Ca	0.40	0.284
Zn	-0.35	0.642

Table C-6. Other Significant Correlations.

Ranking Correlated With:	Coefficient of Correlation (r)	Probability F
Ca and Fe	0.99	0.000
Mg and Mn	0.93	0.003
TOC and Mn	0.80	0.048
Mg and TKN	0.77	0.067
Mg and K	0.74	0.092
TKN and Mn	0.71	0.117
Zn and K	0.62	0.228
Mg and Zn	0.51	0.399
TKN and Zn	0.51	0.405

CONCLUSION

Two of the chemical parameters, total phosphate (TP) and the ratio Zn/Fe, correlate well, within acceptable limits, with the priority ranking of samples that was established from other data. Since there is not an extensive history of chemical analysis of submerged natural deposits, and none from submerged archaeological sites, one purpose of this study was to point out those parameters which may have utility in distinguishing offshore archaeological deposits. Considering the limitations of a comparative data base, there seems to have been some success in associating some chemical parameters with presumed archaeological deposits. Significantly, the pertinent parameters identified here are some of the same ones indicated in the study of terrestrial archaeological sites.

The correlations carried out here are only as accurate as the variables. The validity of the chemical analysis is reasonably assured by a level of quality control substantially higher than normal (4 of the 9 samples were analyzed in duplicate for all parameters, in addition to usual Quality Control procedures). Since acceptable correlations were achieved with a low probability of random effects, then additional validity can be attached to the priority ranking as a result of the chemical analyses. This suggests that the highest probability sites, as indicated by the priority ranking are, very likely, archaeological in nature.

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APPENDIX D:

RADIOCARBON DATES

Table D-1. Radiocarbon Dates.

CEI Sample No.	Laboratory No.	Dating Medium	Environment	Depth below Sea Level (ft.)	Uncorrected Date (B.P.)
SP3-1-C#1 (3)*	UGa-5355	Organic clay	Freshwater marsh/detritus (?)	-48	7415±100
SP3-1-D1#1 (1)	UGa-5353	Wood (*Taxodium* sp.)	Freshwater swamp	-58	8800±95
SP3-1-F#1 (2)	UGa-5354	Peat	Freshwater swamp	-68	8995±95
SP3-1-F#7 (19)	UGa-5425	Organic clay	Freshwater marsh/detritus (?)	-57	7035±105
SP3-1-F#13 (20)	UGa-5426	*Rangia cuneata* shells	Initial transgressive zone	-64	7880±90
SP6-1-B#3 (8)	UGa-5372	Peat	Bottomland hardwood forest/detritus(?)	-58	8510±95
SP6-1-C#2 (21)	UGa-5450	*Rangia cuneata* shells	Shell deposit	-54	8055±90
SP6-2-E#4 (6)	UGa-5370	Peat	Freshwater swamp	-68	8840±140
SP6-2-I#7 (7)	UGa-5371	Peat	Freshwater swamp	-70	8920±95
SP6-3-A#3 (10)	UGa-5374	Organic clay	Fresh to brackish marsh	-63	8585±95
SP6-4-C#3 (9)	UGa-5373	Peat	Adjacent to fresh or brackish marsh	-54	13,120±150
SP9-4-C#10 (17)	UGa-5423	Peat	Freshwater swamp	-69	9045±95
SP18-2-B#4 (11)	UGa-5401	Organic clay	Slightly brackish marsh	-72	8420±105
SP18-2-B#6 (12)	UGa-5402	Peat	Freshwater marsh/swamp	-77	10,145±285
HI49-2-B#3 (13)	UGa-5419	Organic clay	Freshwater swamp	-68	9165±130
HI49-2-B#5 (14)	UGa-5420	Organic clay	Freshwater swamp	-72	8300±185
HI49-3-D#2 (15)	UGa-5421	Organic clay	Freshwater swamp	-58	8620±115
HI49-3-E#1 (16)	UGa-5422	Organic clay	Freshwater swamp	-61	8935±95

*Numbers in parentheses correspond to samples numbered in Figure 6-4.

APPENDIX E:

VIBRACORE RECOVERY DATA

Offshore Area	Block No.	Line No.	Boring Designation	Coordinates X	Coordinates Y	Maximum Penetration (ft)	Core Length Recovered (ft)	Date Sampled
Sabine Pass	3	1	A	1,227,815	361,504	21.5	14.0	11/07/84
Sabine Pass	3	1	B	1,227,705	361,530	22.2	13.0	11/07/84
Sabine Pass	3	1	C	1,227,636	361,457	**	12.0	11/10/84
Sabine Pass	3	1	D-1	1,227,534	361,442	26.0	16.0	11/10/84
Sabine Pass	3	1	D-2	1,227,534	361,442	17.0	10.5	11/10/84
Sabine Pass	3	1	E	1,227,468	361,426	25.5	14.3	11/10/84
Sabine Pass	3	1	F	1,227,371	361,389	37.5	18.5	11/10/84
Sabine Pass	3	2	A	1,227,748	361,425	33.0	15.0	11/10/84
Sabine Pass	3	2	B	1,227,763	361,320	19.8	11.5	11/10/84
Sabine Pass	3	2	C	1,227,792	361,224	31.0	11.0	11/10/84
Sabine Pass	3	2	D	1,227,816	361,129	25.0	13.0	11/10/84
Sabine Pass	6	1	A	1,226,133	342,676	22.0	14.0	11/11/84
Sabine Pass	6	1	B	1,226,062	342,597	21.0	14.0	11/11/84
Sabine Pass	6	1	C	1,225,995	342,516	16.5	9.0	11/11/84
Sabine Pass	6	1	D	1,225,944	342,444	27.5	19.0	11/11/84
Sabine Pass	6	1	E	1,225,876	342,369	24.5	15.0	11/11/84
Sabine Pass	6	2	A	1,226,030	342,241	20.0	13.5	11/11/84
Sabine Pass	6	2	B	1,225,943	342,201	21.0	12.5	11/11/84
Sabine Pass	6	2	C	1,225,898	342,218	21.0	14.0	11/11/84
Sabine Pass	6	2	D	1,225,807	342,277	26.0	17.0	11/11/84
Sabine Pass	6	2	E	1,225,721	342,312	31.0	18.0	11/11/84
Sabine Pass	6	2	F	1,225,625	342,362	23.0	15.0	11/11/84
Sabine Pass	6	2	G	1,225,529	342,392	24.0	16.0	11/11/84
Sabine Pass	6	2	H	1,225,443	342,425	27.0	15.3	11/11/84
Sabine Pass	6	2	I	1,225,348	342,466	32.0	18.5	11/11/84
Sabine Pass	6	3	A	1,225,615	342,412	27.0	16.0	11/11/84

Legend
* No recovery
** Depth recorder broke

PREHISTORIC SITE EVALUATION
VIBRACORE LOCATION AND CORE PENETRATION DATA
MINERAL MANAGEMENT SERVICE
CONTRACT No. 14-12-0001-30072

Offshore Area	Block No.	Line No.	Boring Designation	Coordinates X	Coordinates Y	Maximum Penetration (ft)	Core Length Recovered (ft)	Date Sampled
Sabine Pass	6	3	B	1,225,594	342,364	23.6	13.5	11/11/84
Sabine Pass	6	3	C	1,225,575	342,310	23.0	14.0	11/11/84
Sabine Pass	6	4	A	1,225,938	342,312	19.0	11.5	11/19/84
Sabine Pass	6	4	B	1,225,917	342,266	20.0	10.0	11/19/84
Sabine Pass	6	4	C	1,225,875	342,176	21.0	13.0	11/19/84
Sabine Pass	9	2	A	1,221,400	330,641	18.0	13.5	11/12/84
Sabine Pass	9	2	B	1,221,308	330,593	18.0	12.0	11/12/84
Sabine Pass	9	2	C	1,221,222	330,545	18.0	11.0	11/12/84
Sabine Pass	9	2	D	1,221,133	330,500	19.0	10.0	11/12/84
Sabine Pass	9	2	E	1,221,048	330,451	20.0	11.0	11/12/84
Sabine Pass	9	2	F	1,220,974	330,414	21.0	13.5	11/12/84
Sabine Pass	9	2	G	1,220,867	330,360	23.0	*	11/12/84
Sabine Pass	9	2	G-2	1,220,867	330,360	21.9	13.0	11/12/84
Sabine Pass	9	2	H	1,220,776	330,316	22.5	11.5	11/12/84
Sabine Pass	9	2	I	1,220,689	330,267	20.0	12.0	11/12/84
Sabine Pass	9	2	J	1,220,600	330,222	24.0	9.5	11/12/84
Sabine Pass	9	4	A	1,220,658	330,221	23.0	12.0	11/12/84
Sabine Pass	9	4	B	1,220,606	330,338	20.5	11.5	11/13/84
Sabine Pass	9	4	C	1,220,576	330,447	28.0	14.0	11/13/84
Sabine Pass	18	1	A	3,638,640	651,396	21.0	13.0	11/13/84
Sabine Pass	18	1	B	3,638,641	651,296	21.0	14.0	11/13/84
Sabine Pass	18	1	C	3,638,640	651,196	18.0	14.0	11/13/84
Sabine Pass	18	1	D	3,638,641	651,095	20.0	13.0	11/13/84
Sabine Pass	18	1	E	3,638,633	650,997	19.0	12.0	11/13/84
Sabine Pass	18	1	F	3,638,639	650,895	20.0	14.0	11/13/84
Sabine Pass	18	1	G	3,638,643	650,800	19.0	13.5	11/14/84
Sabine Pass	18	1	H	3,638,634	650,697	20.0	13.5	11/14/84

Legend
* No recovery
** Depth recorder broke

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Offshore Area	Block No.	Line No.	Boring Designation	Coordinates X	Coordinates Y	Maximum Penetration (ft)	Core Length Recovered (ft)	Date Sampled
Sabine Pass	18	1	I	3,638,637	650,596	17.0	10.0	11/14/84
Sabine Pass	18	2	A	3,638,840	651,095	33.5	18.0	11/14/84
Sabine Pass	18	2	B	3,638,734	651,098	32.0	17.5	11/14/84
Sabine Pass	18	3	A	3,640,599	649,815	25.0	13.0	11/14/84
Sabine Pass	18	3	B	3,640,695	649,815	22.0	14.5	11/14/84
High Island	49	1	A	3,601,365	617,855	25.5	17.0	11/16/84
High Island	49	1	I	3,601,356	617,912	21.0	10.0	11/17/84
High Island	49	1	J	3,601,295	617,991	27.0	15.5	11/17/84
High Island	49	1	B	3,601,340	617,771	21.0	9.5	11/17/84
High Island	49	1	C	3,601,034	617,517	20.0	9.0	11/17/84
High Island	49	1	D	3,600,955	617,454	28.0	14.0	11/18/84
High Island	49	1	E	3,600,879	617,389	31.0	15.5	11/18/84
High Island	49	1	F	3,600,803	617,325	28.0	12.5	11/18/84
High Island	49	1	G	3,600,716	617,257	26.0	11.5	11/17/84
High Island	49	1	H	3,600,739	617,402	26.0	10.0	11/17/84
High Island	49	2	A	3,600,626	617,077	40.0	13.5	11/18/84
High Island	49	2	B	3,600,526	617,076	36.8	15.0	11/18/84
High Island	49	2	E	3,600,231	617,088	35.0	12.5	11/18/84
High Island	49	3	A	3,601,583	619,181	21.0	10.5	11/19/84
High Island	49	3	B	3,601,527	619,095	21.0	11.0	11/19/84
High Island	49	3	C	3,601,471	619,008	22.0	11.0	11/19/84
High Island	49	3	D	3,601,418	618,926	24.0	8.0	11/19/84
High Island	49	3	E	3,601,362	618,836	27.0	9.0	11/19/84

Legend
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