UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Depositional history of Louisiana-Mississippi outer continental shelf

by

Jack L. Kindinger, Ronald J. Miller

Charles E. Stelting, and Arnold H. Bouma

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ABSTRACT

A geological study was undertaken in 1981 in the Louisiana-Mississippi outer continental shelf for the Bureau of Land Management. The study included a high-resolution seismic reflection survey, surficial sediment sampling and surface current drifter sampling. Approximately 7100 sq km of the Louisiana-Mississippi shelf and upper slope were surveyed.

The sea floor of the entire area is relatively smooth except for occasional areas of uplift produced by diapiric intrusion along the upper slope. Characteristics of the topography and subsurface shelf sediments are the result of depositional sequences due to delta outbuilding over transgressive sediments with intervening periods of erosion during low sea level stands. Little evidence of structural deformation such as faults, diapirs, and shallow gas is present on the shelf and only a few minor faults and scarps are found on the slope.

Minisparker seismic records in combination with air gun (40 and 5 cu in) and 3.5-kHz subbottom profile records reveal that seven major stages of shelf development have occurred since the middle Pleistocene. The shelf development has been controlled by the rise and fall of sea level. These stages are defined by four major unconformities, several depositions of transgressive sediments, sequences of river channeling and progradational delta deposits.

Surficial sediment sample and seismic records indicate tat the last major depositional event was the progradation of the St. Bernard Delta lobe. This delta lobe covered the northwestern and central regions. Surficial sediments in most of the study area are the product of the reworking of the San Bernard Delta lobe and previous progradations.

INTRODUCTION

A geologic study was undertaken in 1981 in the Louisiana-Mississippi OCS area for the Bureau of Land Management. This area, east of the Mississippi River delta, covers the southeastern part of the Mobile quadrangle and the eastern half of the Breton Sound quadrangle (Fig. 1). The purpose of the study was to provide an interpretation of the geologic framework and geologic history of the area since the middle Pleistocene, and to present the regional distribution of geologic features that can be hazardous to offshore gas and oil production. The project was funded by the Bureau of Land Management as part of their program to map geologic features that may affect offshore development and to locate geomorphic features that may indicate possible cultural resource sites. Maps and reports from this study will become part of the Marine Geologic Atlas Series for the Gulf of Mexico OCS.

The main aspect of the field data collection was the utilization of several types of high-resolution, single channel seismic-reflection systems. In addition, a grid pattern was used to collect surficial sediment samples, and to drop drifters for establishing the surface current system.

Through personal communication with H. L. Berryhill, stratigraphic units of similar time frame and sedimentological characteristics to those in the western Gulf of Mexico were selected for this study. Interpretation and organization of presentation were patterned after Berryhill, 1980.

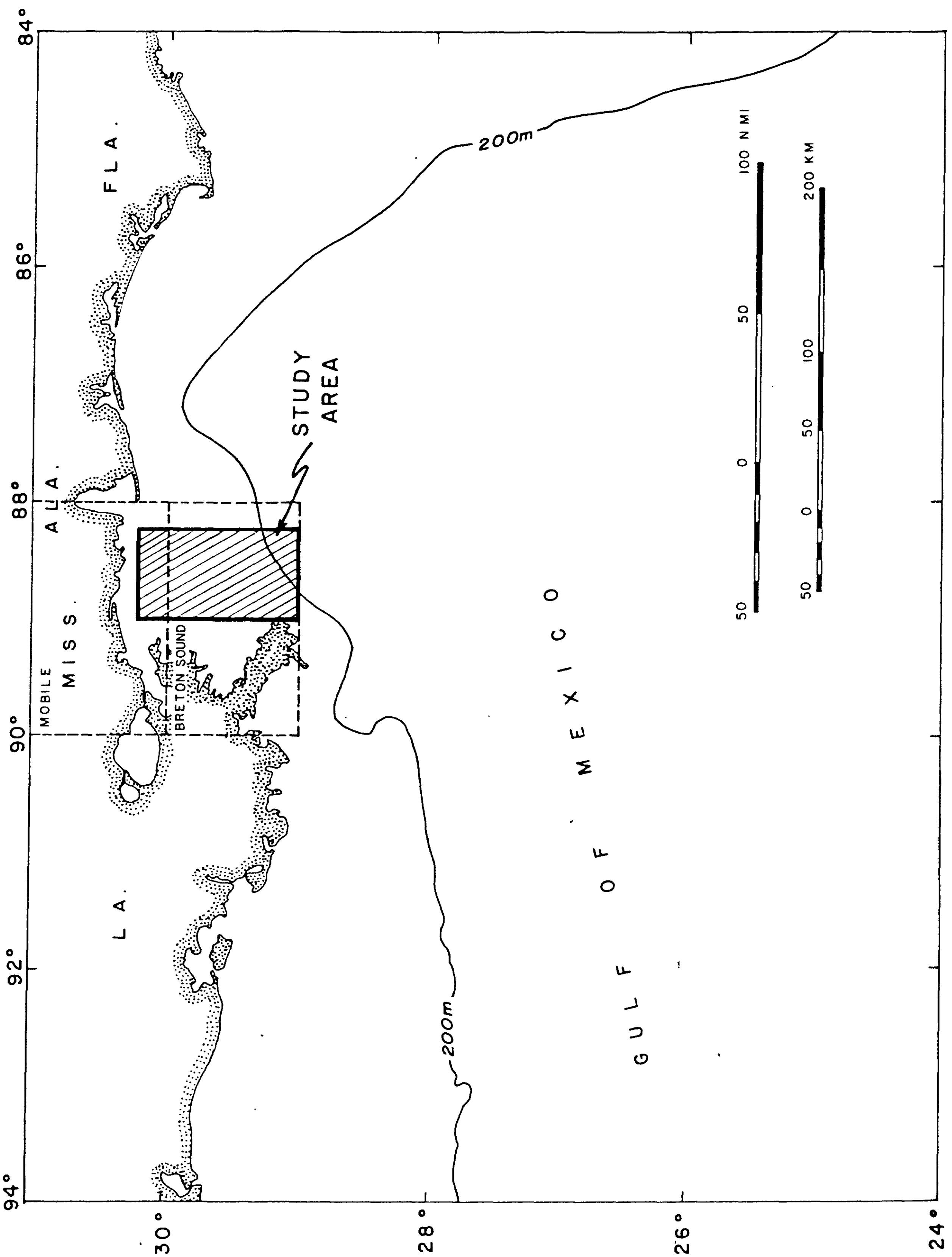

Figure 1. Index map of study area, showing 2° sheets used in mapping.

The majority of the maps produced from this study are presented separately on plates at a scale of 1:250,000. To facilitate reading, photographic reductions are inserted in the text with reference in each caption to which plate the illustration refers.

METHODOLOGY RELATED TO THE COLLECTION OF SEISMIC DATA

Seismic data were compiled during three phases. The first phase consisted of obtaining high-resolution seismic records from archives at the U.S. Geological Survey, Conservation Division, Metairie, Louisiana. These records provided preliminary information and helped to establish the most advantageous seismic grid for an overall survey. The second phase dealt with the collection of high-resolution seismic data by the U.S. Geological Survey aboard the R/V GYRE (Cruise 81-G-6) in April 1981. Using the survey grid established during phase one, the R/V GYRE ran tracklines parallel and perpendicular to the shelf break, with 5 km spacings. The third phase was the completion of seismic tracklines into waters too shallow for the R/V GYRE. For this the R/V CARANCAHUA was used during which a total of 700 km of high resolution seismic data was collected by U.S. Geological Survey personnel in July 1981. In total, 3200 km of high-resolution seismic reflection data were collected by both vessels (Fig. 2).

During the 2500 km of tracklines run by the R/V GYRE, the following seismic systems were operated:

1) 400-joule minisparker
2) 3.5-kHz subbottom profiler
3) 40-in^3 and 5-in^3 airguns
4) 12-kHz precision depth recorder (PDR)

The minisparker system provided mid-range penetration (0-500 m). The recorder setting was at 1/2 second sweep and the filter settings were placed at 200 Hz to 2000 Hz. Bubble pulse interference in the upper sediments in the minisparker records made it necessary to use a 3.5-kHz subbottom profiler to obtain data in that zone. The penetration ranged from 0 to as much as 100 m; the recorder sweep was set at 1/4 second. The 40-in^3 airgun provided deep penetration (0-1500 m) and was used in water depths greater than 100 m. In waters shallower than 100 m, a 5-in^3 airgun was used because although it gave less penetration than the large airgun, its multiples were not as overwhelming. Filter settings for both sizes of airguns were 20 Hz to 120 Hz. The 12-kHz precision depth recorder provided continuous bathymetry of area. Analog records were made for each system in addition to taping all information consisting of the seismic systems, voice annotation, time and navigation data. Navigation for the R/V GYRE was an integrated system consisting of Loran C, Satellite, and Gyro compass. The navigation system also marked the analog seismic records every 300 m. Navigators kept the trackline maps up-to-date by plotting in real time the positions of the shot points. Regularly updated copies were used by the seismic interpreters.

The third phase of seismic data gathering was carried out aboard the R/V CARANCAHUA using an ORE monopulse boomer system, which was very successful in shallow water. This system, ideal for small boat use, provided high-resolution seismic records of both shallow and moderate depth of penetration (0-250 m). The analog recorder was set at a 1/4 second sweep and the filter settings at 200 Hz-4000 Hz. All information was taped

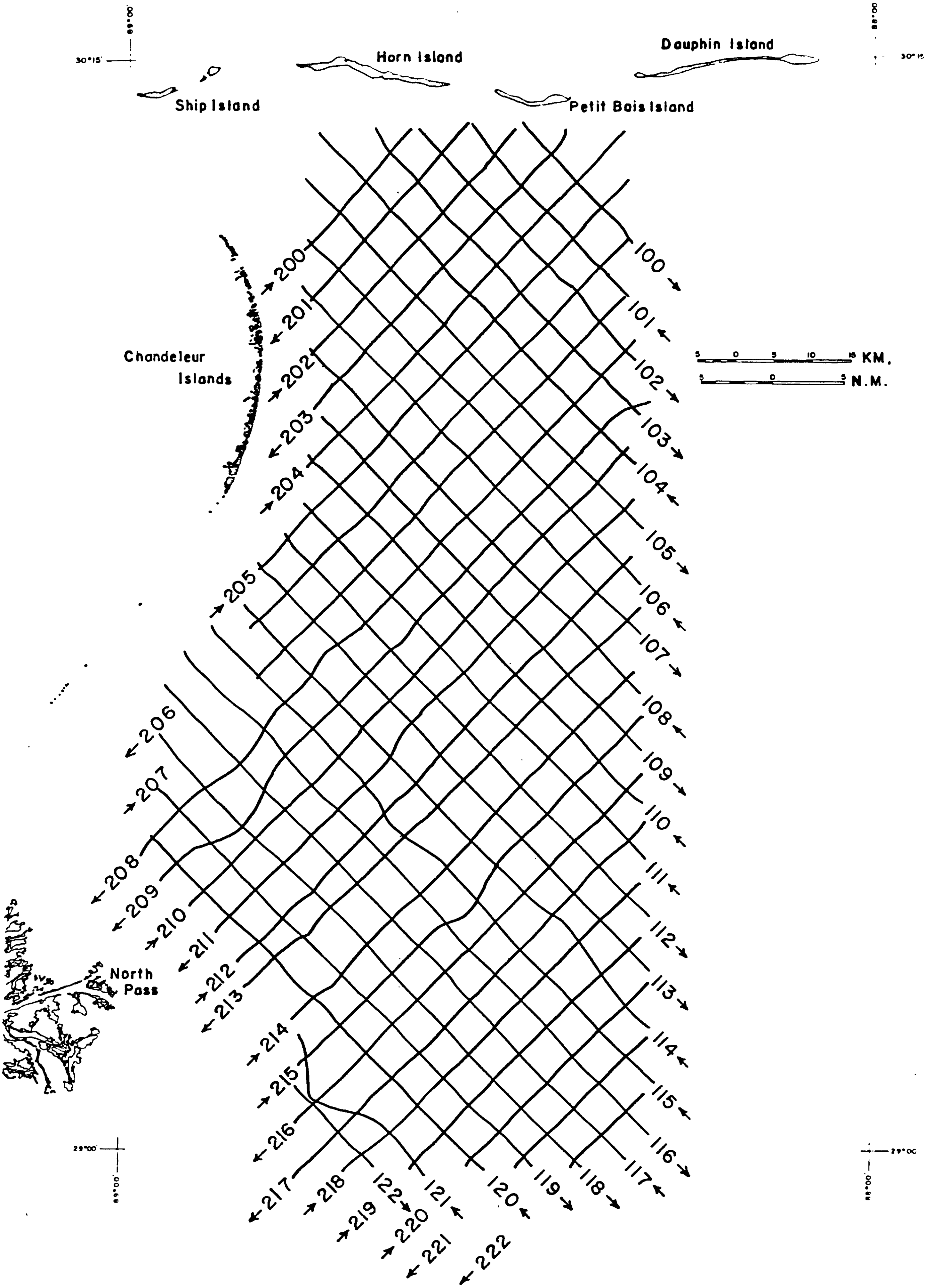

Figure 2. Trackline map of study area.

including seismic signals, time, shotpoint, and navigation. Navigation was obtained from a Northstar Loran C receiver and the navigators provided a real-time track map. Shotpoints were plotted every 5 minutes and also annotated on the analog records.

Interpretation of seismic records collected by the R/V GYRE started as soon as work copies of the analog records were available. Most interpretation activities were directed toward correlation of stratigraphic units throughout the area, and preliminary isopach maps were prepared. Bathymetry and trackline maps were completed in rough draft. All this preliminary work provided valuable assistance when more detailed interpretations and finalizing of statigraphic units began using post-plotted navigation maps.

Trackline Map

A trackline-shotpoint map was produced plotting all seismic lines collected aboard the R/V GYRE and the R/V CARANCAHUA. Two sets of preplotted tracklines for the principal cruise aboard the R/V GYRE were chosen. One ran northwest-southeast, and the other ran northeast-southwest. The main reason for deviation line headings from the traditional north-south and east-west headings was to obtain seismic lines parallel and perpendicular to the shelf-break. To avoid confusion with shotpoint numbers, tracklines running in northwest to southeast directions were numbered from 100 to 122, and those lines running from northeast to southwest from 200 to 222. In both cases, numbering started at the northern end of the area and increased toward the south. Tracklines were spaced 5-km apart, and shotpoints were labelled at 300-m intervals. The navigation post-plot system of the U.S. Geological Survey plotted every second point and labelled every tenth shot point. Seismic lines were positioned near preploted tracklines except in cases where avoidance of course obstacles, such as platforms, was necessary for ship safety. The additional seismic lines collected aboard the R/V CARANCAHUA increased the accuracy of geologic interpretation and filled in missing areas. Line headings were chosen according to geology as well as to provide tie lines with the seismics collected aboard the R/V GYRE. Shotpoints were numbered consecutively. The combined postplots of both vessel operators are presented in Figure 2.

GEOLOGIC SETTING

The topography and subsurface sediment characteristics of the Louisiana-Mississippi continental shelf and upper continental slope are the result of depositional sequences of delta outbuilding over transgressive sediments with intervening periods of erosion during low sea level stands. Little evidence of structural deformation such as faults, diapirs, and shallow gas is present on the shelf. In contrast, the upper slope has indications of occasional diapirs with associated faulting. In addition, the upper sedimentary column of the continental slope contains a few minor faults and scarps resulting from sediment slumping. Surface sediments over the entire area relate to several different depositional periods and can be seen as complete sequences, although they are not present at all locations of the shelf and upper slope (Frazier, 1974).

PRODUCT PRESENTATION

All original seismic data records were microfilmed and good quality vellum copies were made. Navigational post-plots were used to produce a trackline map with numbered shotpoints and labeled line numbers. Using the information from the 12-kHz precision depth recorder, a bathymetry chart was prepared. Interpretation of seismic records resulted in the following maps:

1) surface and near-surface structure
2) diapir and fault distribution
3) buried stream channels
4) shallow gas and buried oyster banks
5) buried delta lobes
6) isopachs of two stratigraphic units, and
7) structure contour of three stratigraphic horizons.

In addition to the above-mentioned products, we produced surface sediment distribution and surface water current maps along with base maps of the sampling and drift bottle drop stations.

BATHYMETRY

Bathymetric charts (Fig. 3) of the Louisiana-Mississippi continental shelf and upper continental slope were compiled using uncorrected velocities because of the shallowness of the area. Depth was calculated using the velocity of sound as 1500 meters per second and mean sea level as datum. These charts compare favorably to the National Ocean Survey 1972 map (NOS 0906N-14). Any differences are likely due to density differences of data points. The NOS data formed a considerably tighter grid than the 5-km grid of the present project. Our bathymetric charts were needed to facilitate the basic understanding of the area, and also because the data points for the NOS map were unavailable.

The bathymetry of the entire area is rather smooth. The area was divided arbitrarily into three regions on the basis of average slope gradient. The Louisiana-Mississippi continental shelf is a broad, flat, very gently sloping, sea floor ranging in water depth from about 10 to 75 m. The average slope gradient across the shelf is <0.1°. The shelf break is located at a depth of 75 m and its orientation is east-northeast to west-southwest. The second region between depths of 75 to 400 m is a gently sloping sea floor of relatively equal width with an average slope of 1.0°. The third region, covering water depths of 400 to 940 m, is located in the southeast corner of the area. This region has a relative steep slope with an average gradient of 2.0° to 2.5°.

SURFACE AND SHALLOW SUBSURFACE FEATURES

The high-resolution seismic records obtained with the 3.5-kHz system were used to produce a surface and shallow subsurface structure map (Fig. 4). Surface features mapped were principally areas of topographic relief and faults breaking the sediment surface or coming within 5 m of sediment surface (Fig. 5). The continental shelf in the area contains few significant faults and the main topographic features are sand waves or the remains of relic barrier beaches (Frazier, 1974) found at several locations. The largest and best defined area is just southeast of the Chandeleur

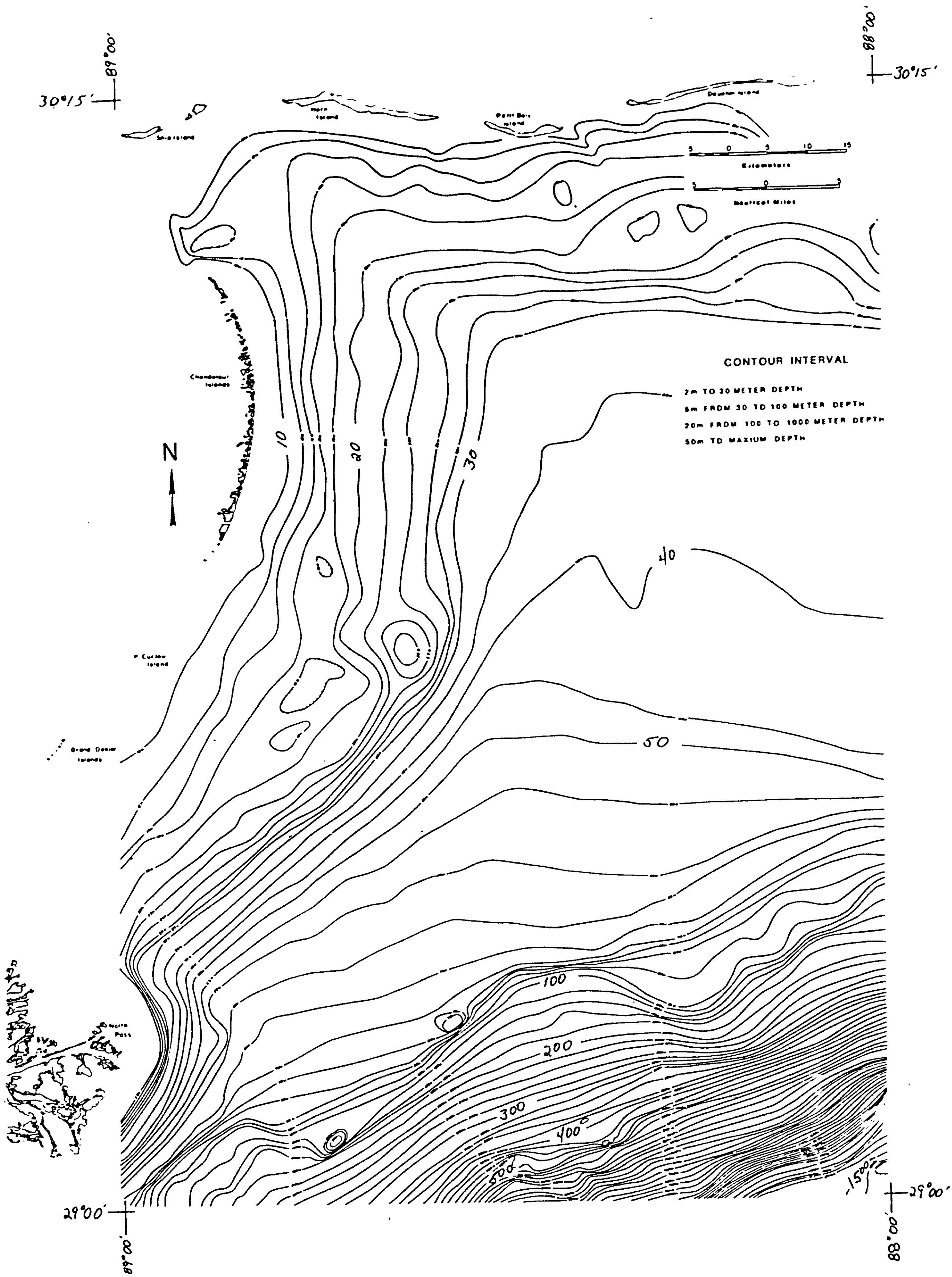

Figure 3. Bathymetric map of shady area.

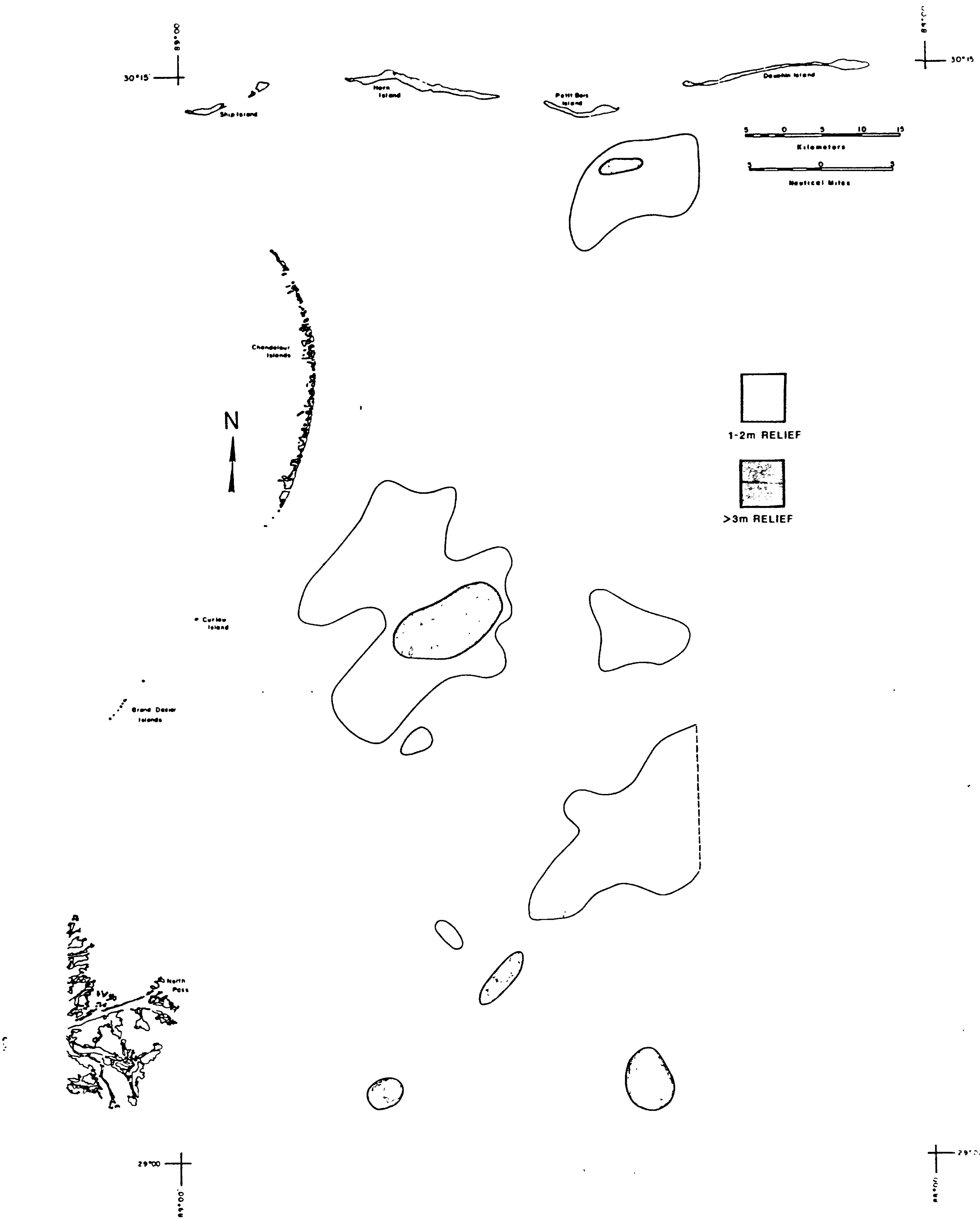

Figure 4. Surface and shallow subsurface structure map.

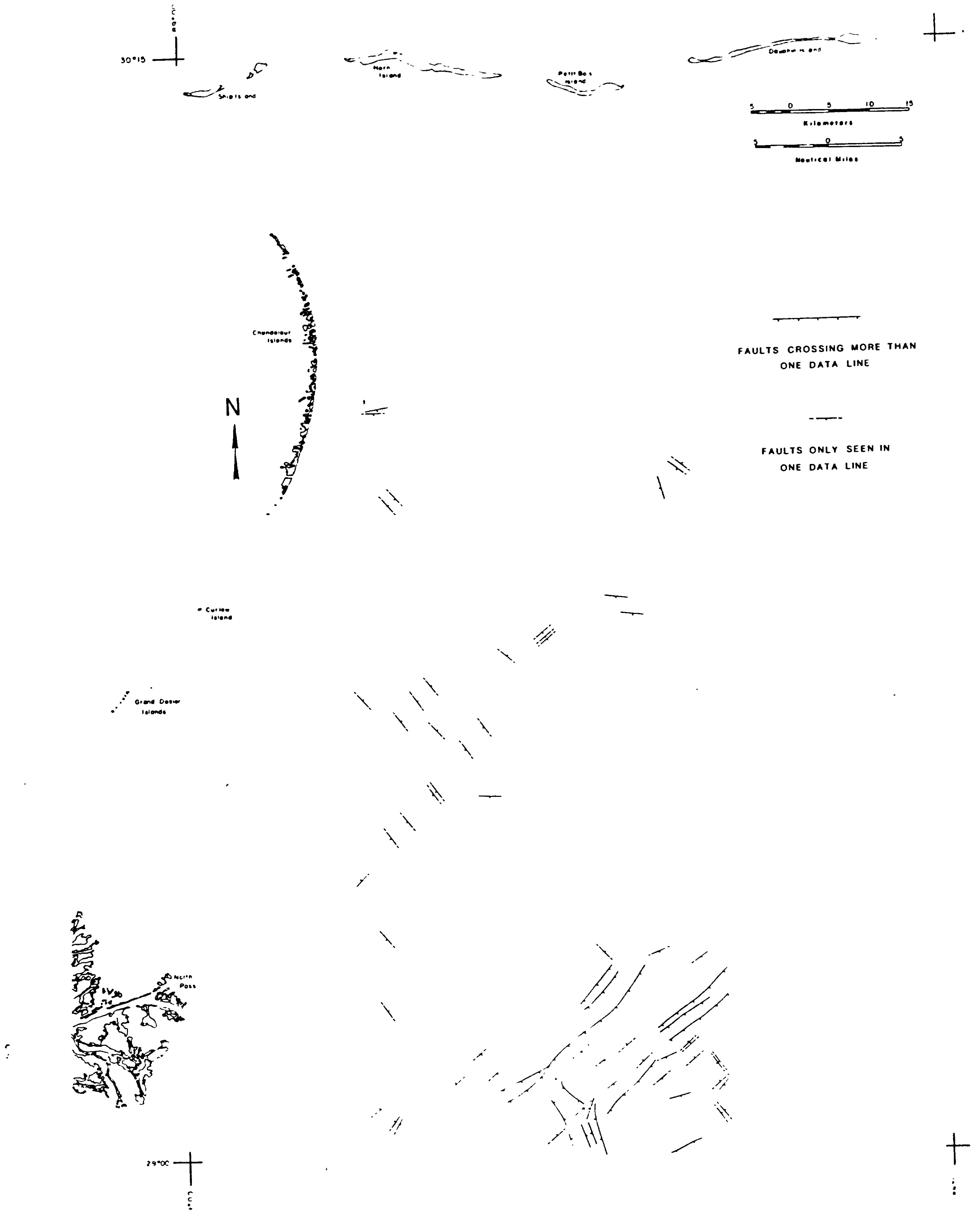

Figure 5. Surface faulting (within 5 ms of sediment surface). Hachures on downthrown side.

Islands. In this region the sand waves or relic barrier beaches trend northeast-southwest with several crest and trough sequences. The relief of these sandy features can be as high as 5 m, ranging from -1 m to +4 m when compared to the surrounding area. Not only were shelf faults uncommon, but associated structures were not obvious. Subsurface faults (not coming within 5 m of surface) appear scattered throughout most of the shelf (Fig. 6).

The upper slope, designated by the bathymetric gradient change, contains more faults and several large topographic features. Most of the faults are related to sediment movement perpendicular to the shelf break or with sediment shifting caused by diapiric action. An exception was the impressive graben system (Fig. 7) that is located perpendicular to the shelf break at the south end of the area. The graben extends down almost the entire slope (Jim Coleman, pers. commun.). Mass sediment movement such as slumping is not seen. Only minor faulting parallel to the shelf break indicates slight sediment movement down slope. The main features of the upper slope are six diapirs (Fig. 8). Three of these diapirs disrupt surface sediments and the others show topographic relief but do not disrupt surface sediments. The latter only shows sediment disturbance at depth and have intruded only near enough to bow-up surface sediments forming rounded minor topographic highs.

The three diapirs showing disruption of the sea floor exhibit different stages of development. The apparently oldest diapir is located at the shelf break and has approximately 15-m relief. The top of the uplift is planar and exhibits an angular unconformity on the seaward side. This indicates the top is an erosional surface. There are progradational sediments landward but are absent on top. The beds below the erosion show drag and truncation on the diapir's sides. The diapir appears to have principally moved previous to the last lowstand of sea level. Apparently during the lowstand, the emergent diapir was eroded to sea level and was submerged as sea level rose. The recent sediment disturbance along the diapir flanks indicate continuing movement. The second form of diapir is on the outer shelf and has a topographic relief of approximately 20 m with possibly an associated hard bank. There are fold-parallel beds on top of the diapir but the beds are not greatly deformed. The internal diapir mass is chaotic. The parallel beds surrounding the diapir show upward drag and truncation. There are progradational sediments on either side of the feature and no erosion is apparent. This indicates that the uplift movement occurred before the delta deposition of Unit 2 but after the most recent low stand of sea level. The third type and largest of the diapirs is located on the upper slope. The diapir has a very hummocky surface and a chaotic subsurface. This intrusion appears to have pushed up and then collapsed (Fig. 9). Even after collapse, topographic relief of some parts is approximately 100 m above the surrounding surface. There is no evidence of erosion. The surrounding beds are truncated and have been dragged up along the sides of the diapir. The top of the diapir does not have sediment drape or indication of recent sedimentation. This implies that movement of this diapir is very recent and may be continuing today.

SEDIMENTARY SEQUENCES

A sedimentary sequence is defined as a seismic stratigraphic unit containing a major regression and a major transgression, with all associated

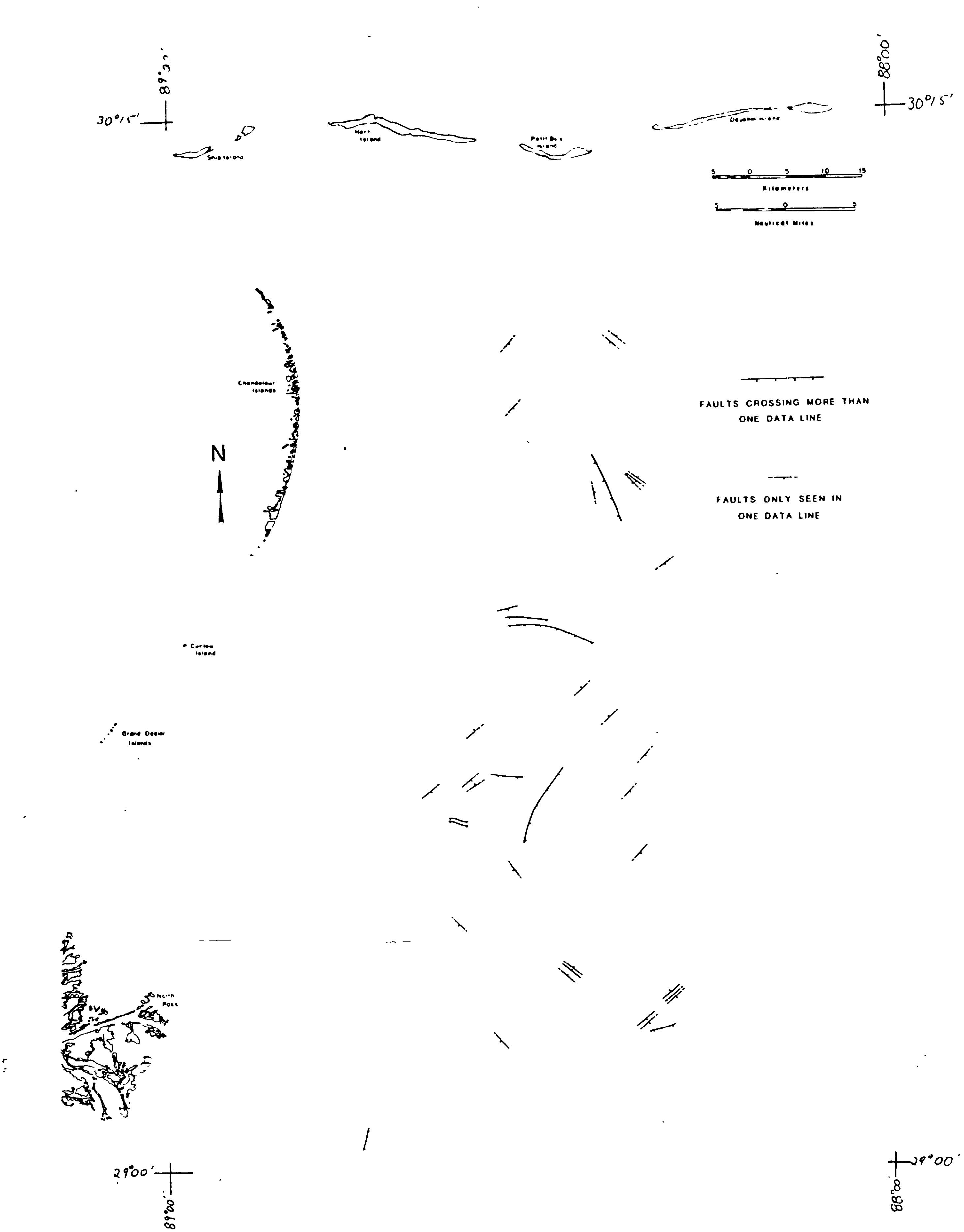

Figure 6. Subsurface faults (not reaching 5 ms of seafloor). Hachures on downthrown side.

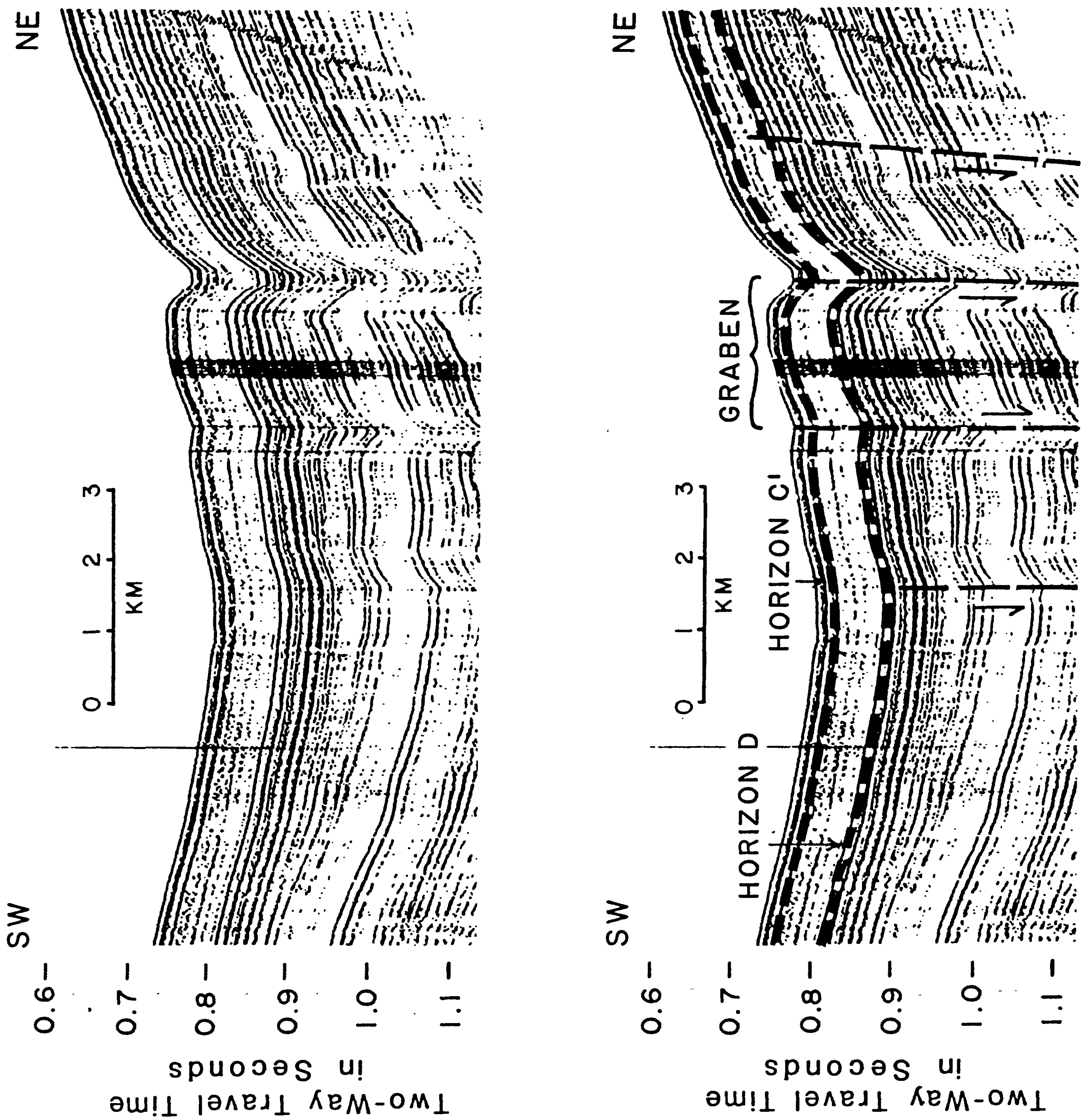

Figure 7. Graben of upper slope, described from air gun profile.

Figure 8. Diapiric activity of area.

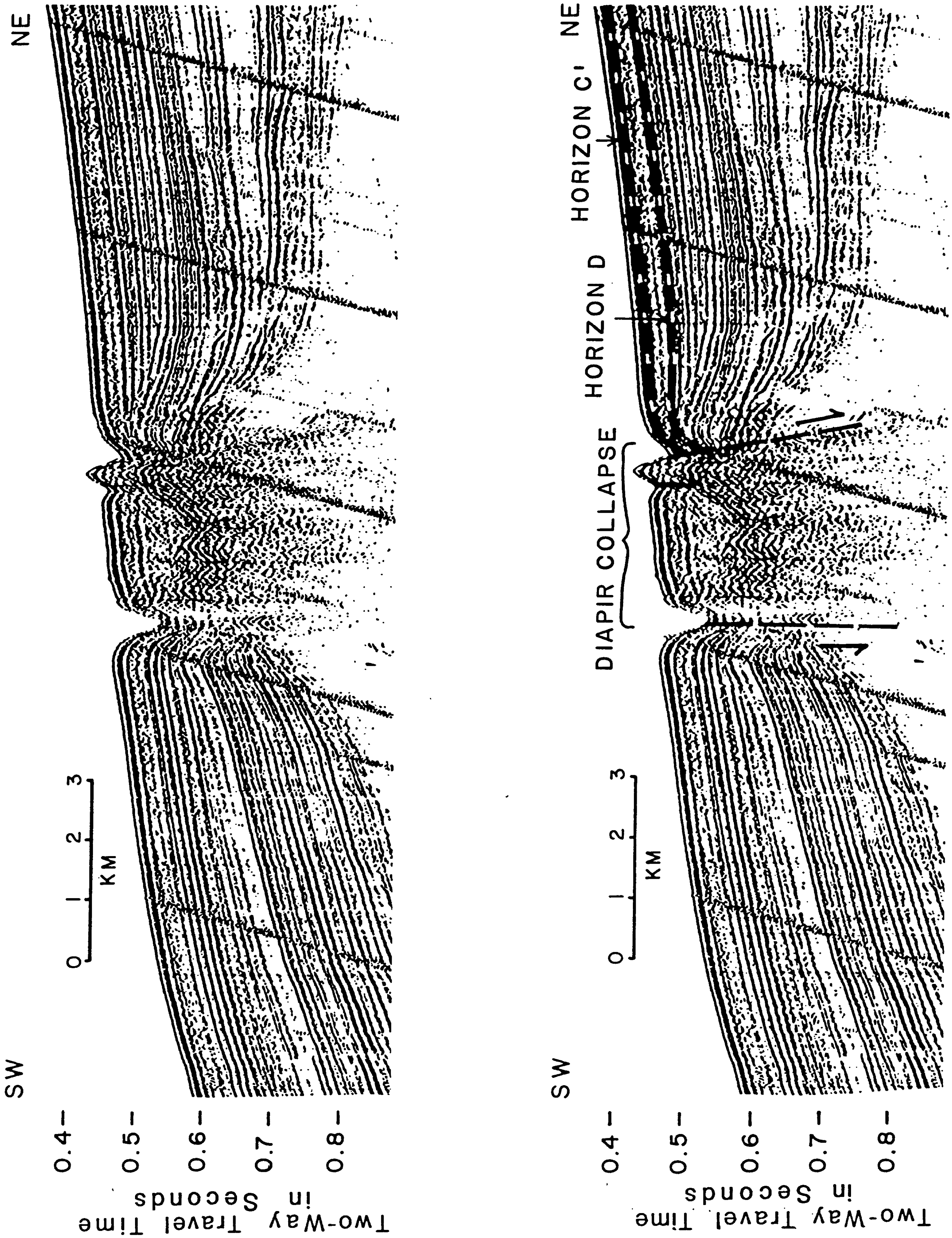

Figure 9. Diapir collapse located on the upper slope of the area.

events included. Therefore, the division of geologic events is controlled by the relative rise and fall of sea level (Beard and others, 1982). The base of the lower sequence is bounded by a shelf-wide erosional unconformity, and the majority of succeeding deposition was formed by transgressive sediments and progradational delta deposits. The upper sequence also has a shelf-wide erosional unconformity as its base, which is overlain by a major transgressive deposition and recent deltaic sediments of the St. Bernard Delta.

Four major unconformities were originally selected for mapping. They were called, from younger to older, horizons A, B, C, and D and correlated well with Berryhill (pers. commun., 1982). Erosion during the forming of horizon A and little deposition following the underlying horizon B made a consistent separation of these two horizons impossible and therefore the horizon A-B will be discussed as A only. Horizons A, C, and D were mapped throughout most of the area (Fig. 10). Horizon D is the only one that can be carried across the shelf break while horizons A and C disappear on the outer shelf. Although horizon C could not be mapped across the shelf break, a more or less parallel reflector (horizon C') could be mapped on the upper slope. The seismic character of the sediments deposited upon horizon C' indicates that their deposition may have occurred during the formation of horizon C.

The mapped horizon D is the base of the lower sequence designated here as Unit 2 (Fig. 11). This horizon, referred to as an erosional unconformity, is an even surface with little relief and with a very gentle slope toward the shelf break (Fig. 12). Although no evidence of horizon D can be found on the upper continental slope, it was probably related and partly formed by a low stand of sea level. With the shelf being eroded to a flat surface, a transgressive sea would quickly cover most of the shelf. This is evident in the thickness of transgressive sediments on the inner shelf and their relative thinness on the outer shelf (Frazier, 1974). Deposition on the inner shelf area is evidenced seismically by a parallel-type bedding (transgressive sediments) which shows heavy channels. This suggests that any stillstands of sea level following the transgression did not contribute much sediment to the area. The channeling of the inner and mid-shelf (Fig. 13), that occurred during the ensuing regression, can be divided into three groups according to the location of the channel within the unit (Figs. 14, 15, 16). These indicate at least three levels in channel patterns and may reflect pulses in the total regression of the sea.

The earliest stage of stream erosion occurred along the inner shelf with the channels cutting through the entire Unit 2. These streams showed little meandering and had a narrow flood plain. The second stage of erosion occurred when the regression stopped at the mid shelf. Most streams during this stage did not channel to the bottom of the unit, but reworked sediments deposited during the previous stage. The streams of this second stage meandered slightly more than during the first stage; however, they did not link with the streams of the first stage which suggests a change in the drainage pattern. The last stage of stream erosion of Unit 2 affected only the uppermost sediments, again indicating a reworking of the sediments deposited during the earlier stages. This set of streams terminated at what appears to be the shelf break of that time period. There was only a slight change in drainage pattern from the second stage with the sediments of the prograding delta controlling the drainage. A major stillstand occurred

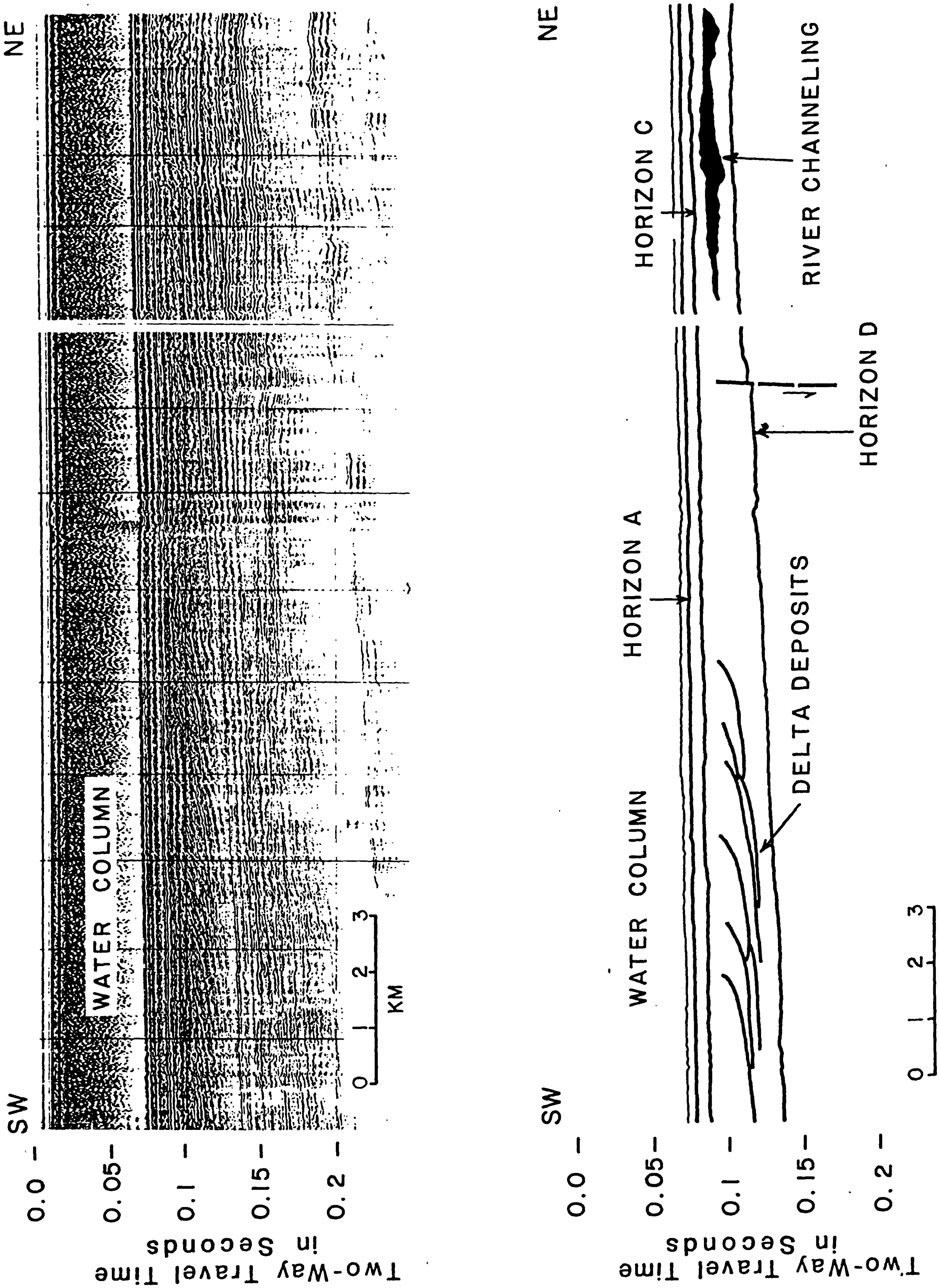

Figure 10. Horizons A, C, and D, as interpreted from a Minisparker seismic section.

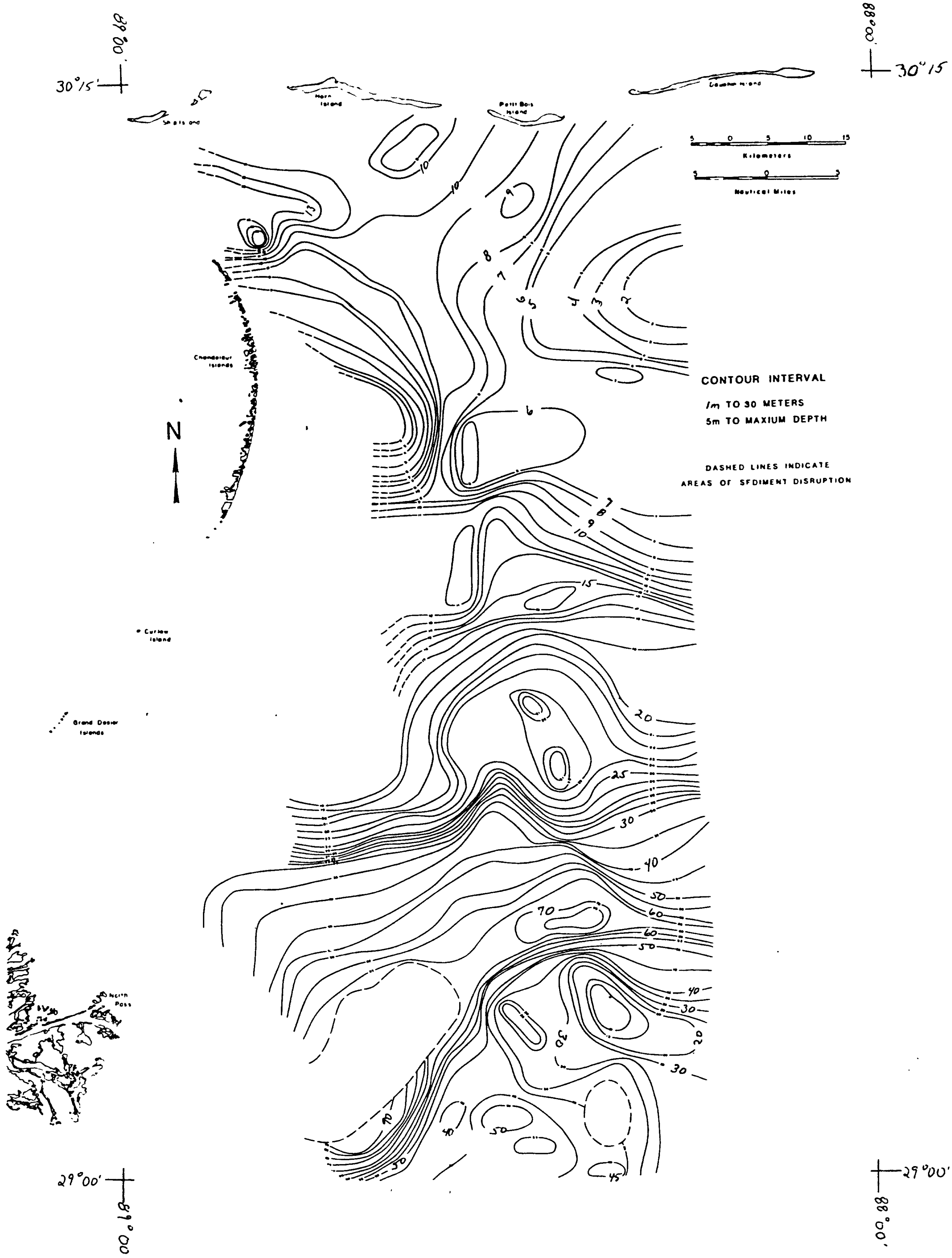

Figure 11. Isopach map of Unit 2.

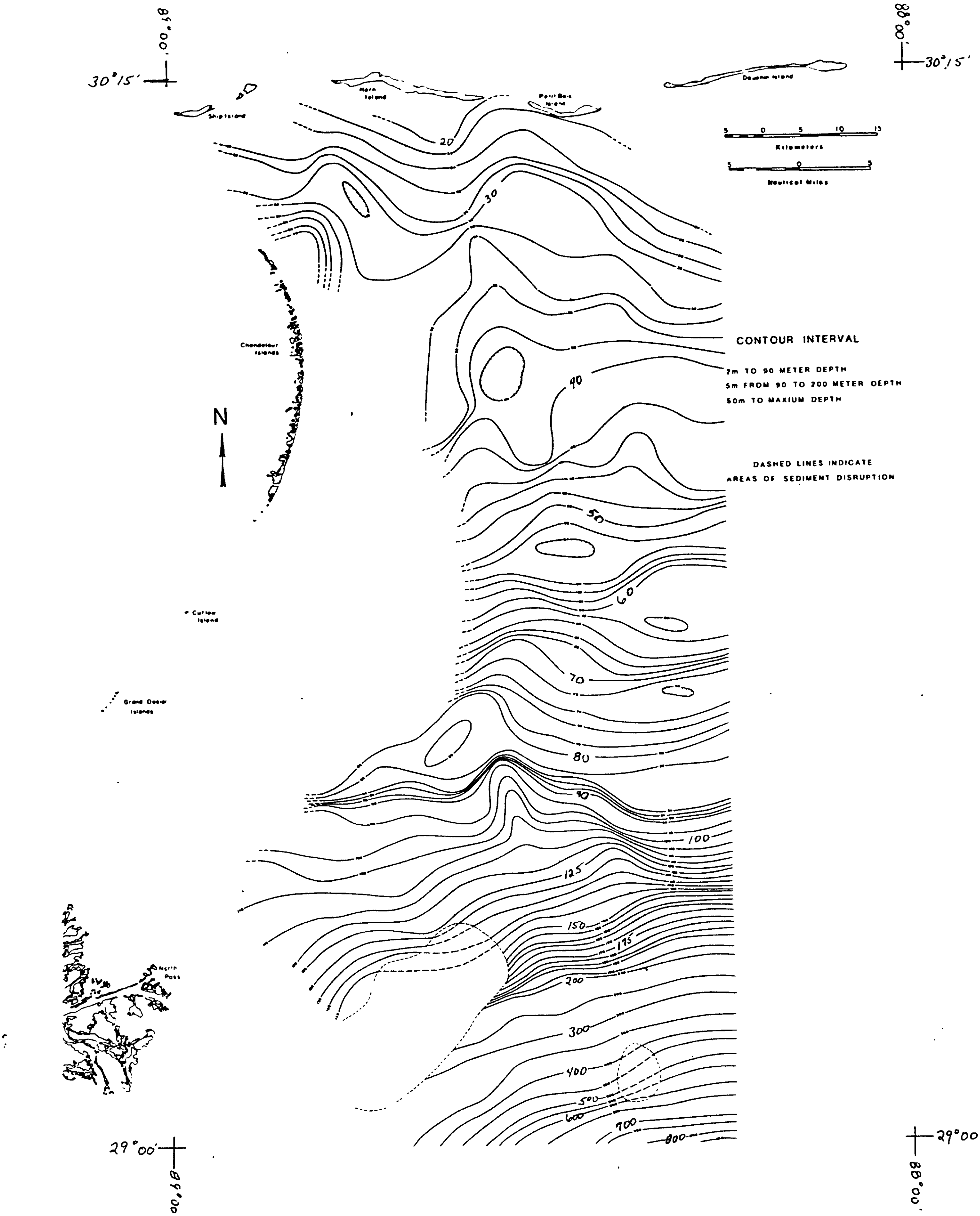

Figure 12. Structure contour map of Horizon D.

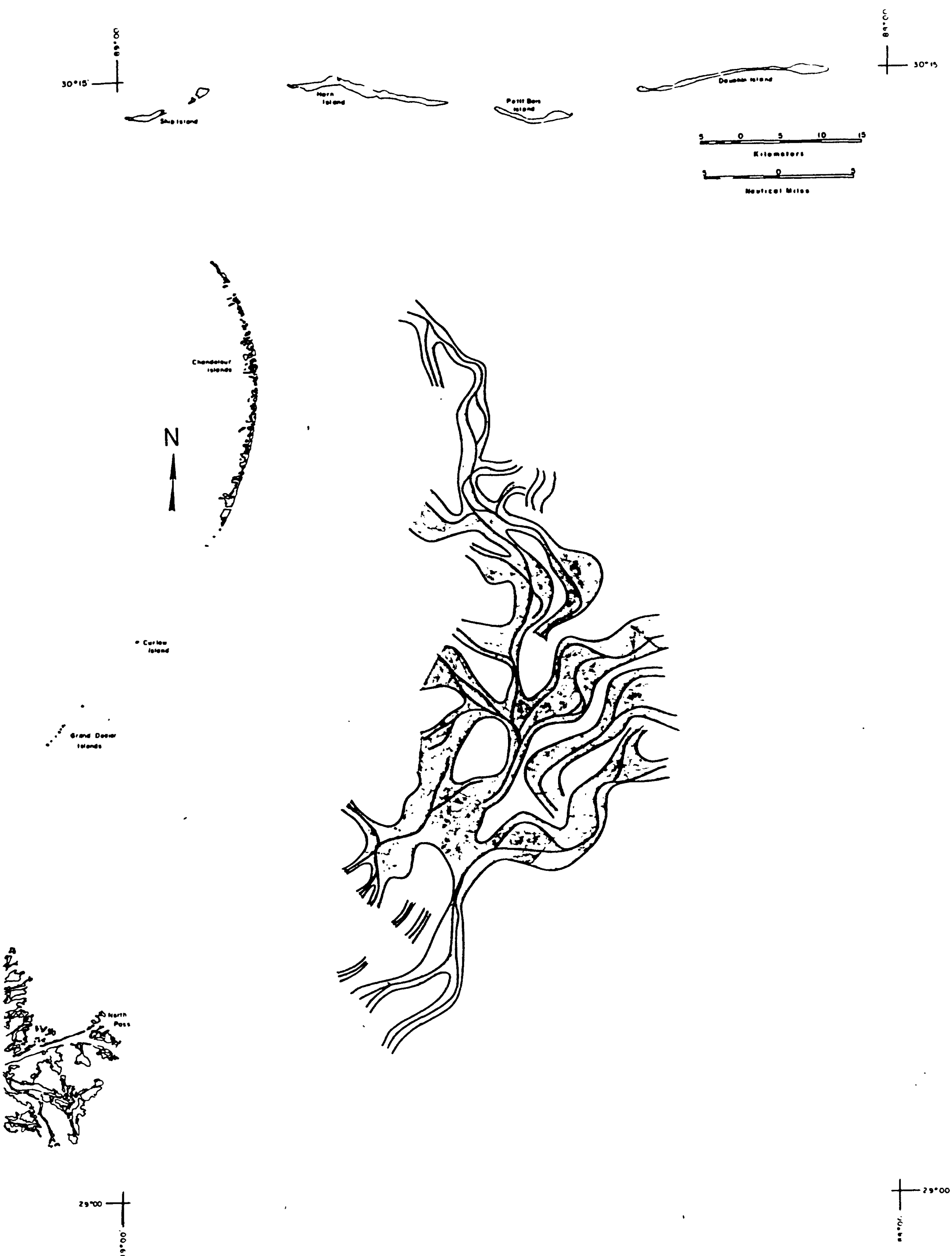

Figure 13. Channel pattern of entire Unit 2 inferred from seismic reflection profiles. Center lines = channel axes. Surface coverage of the channels is shaded.

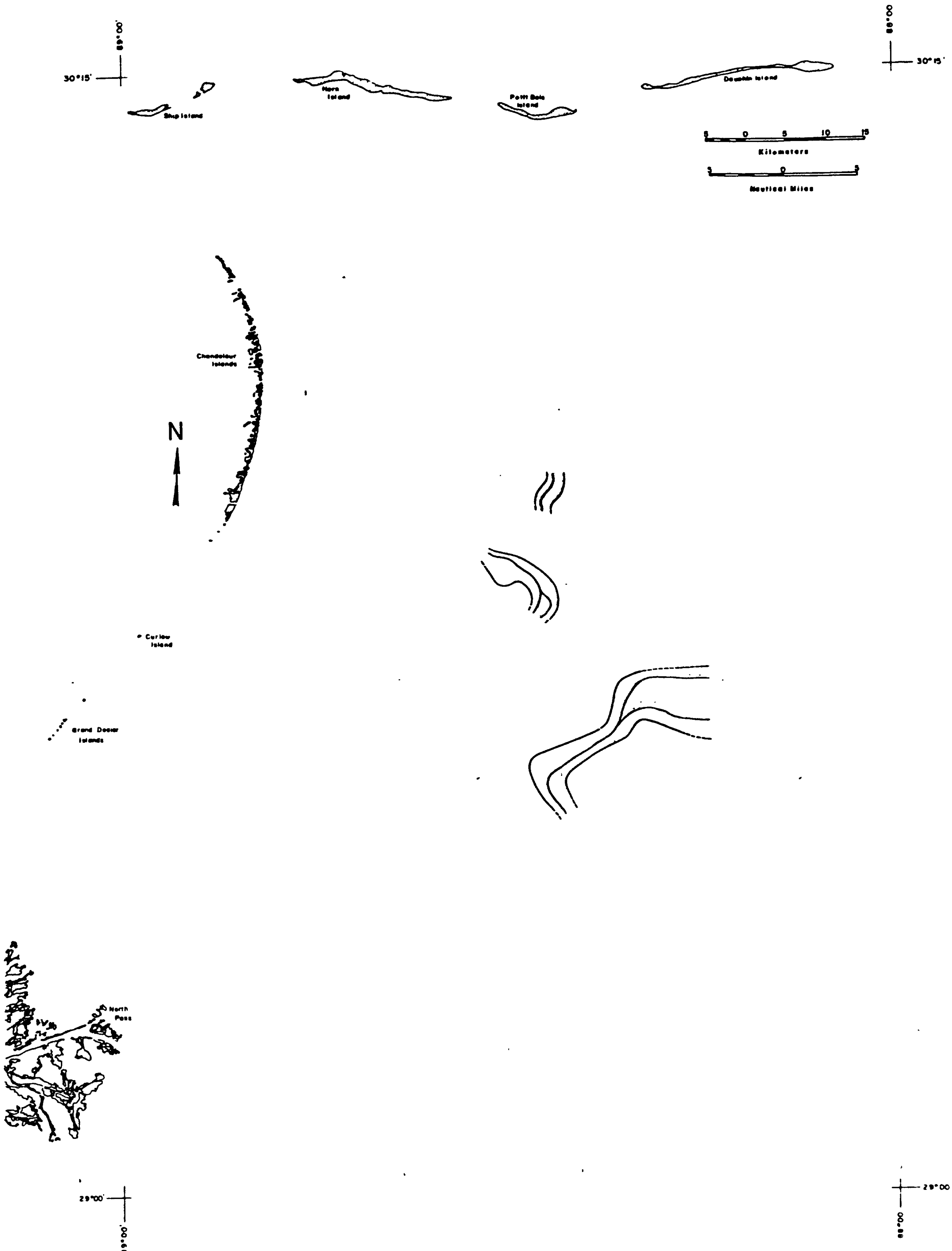

Figure 14. Channel pattern representing the earliest stage of stream erosion during the period of Unit 2.

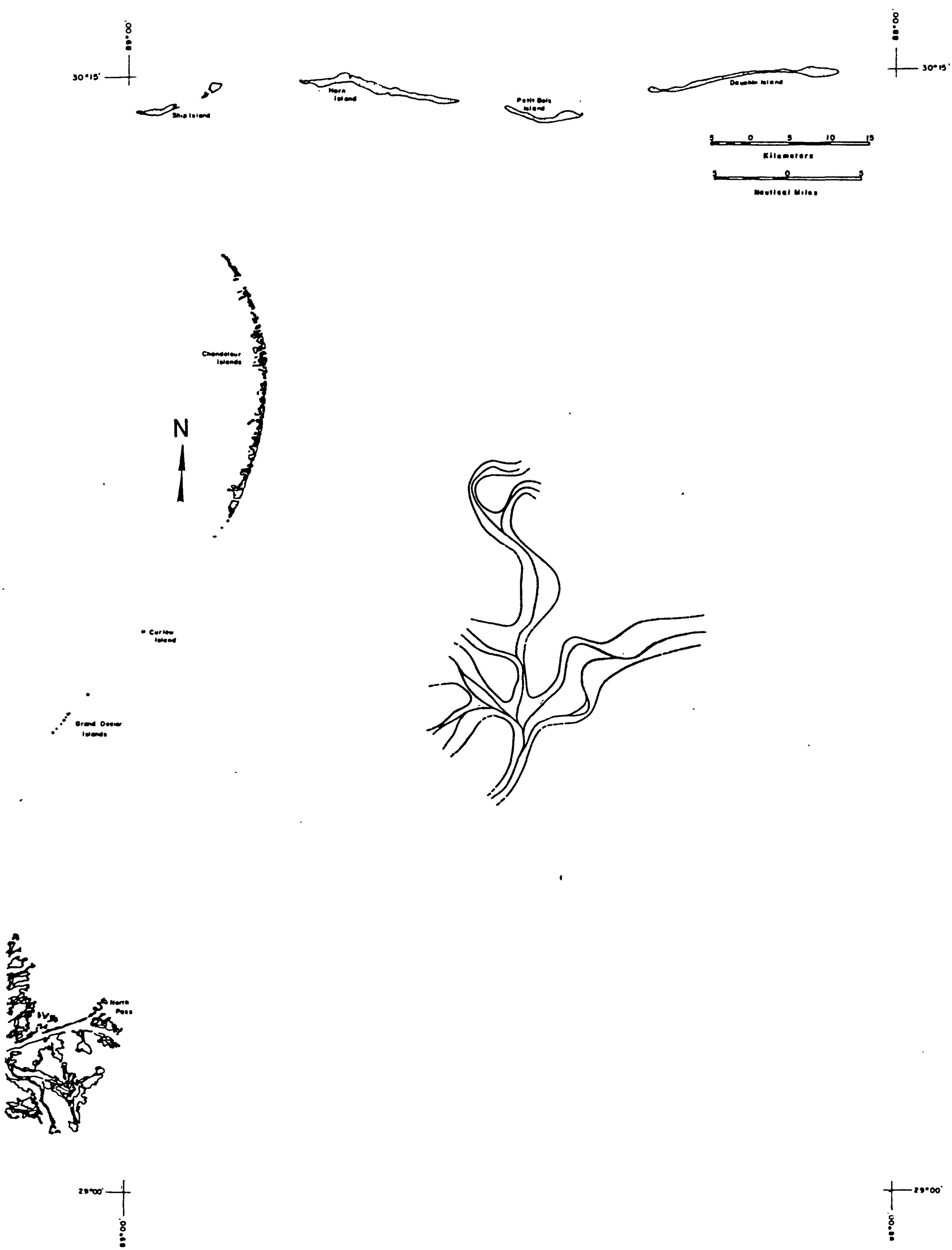

Figure 15. Channel pattern representing the middle stage of stream erosion during the period of Unit 2.

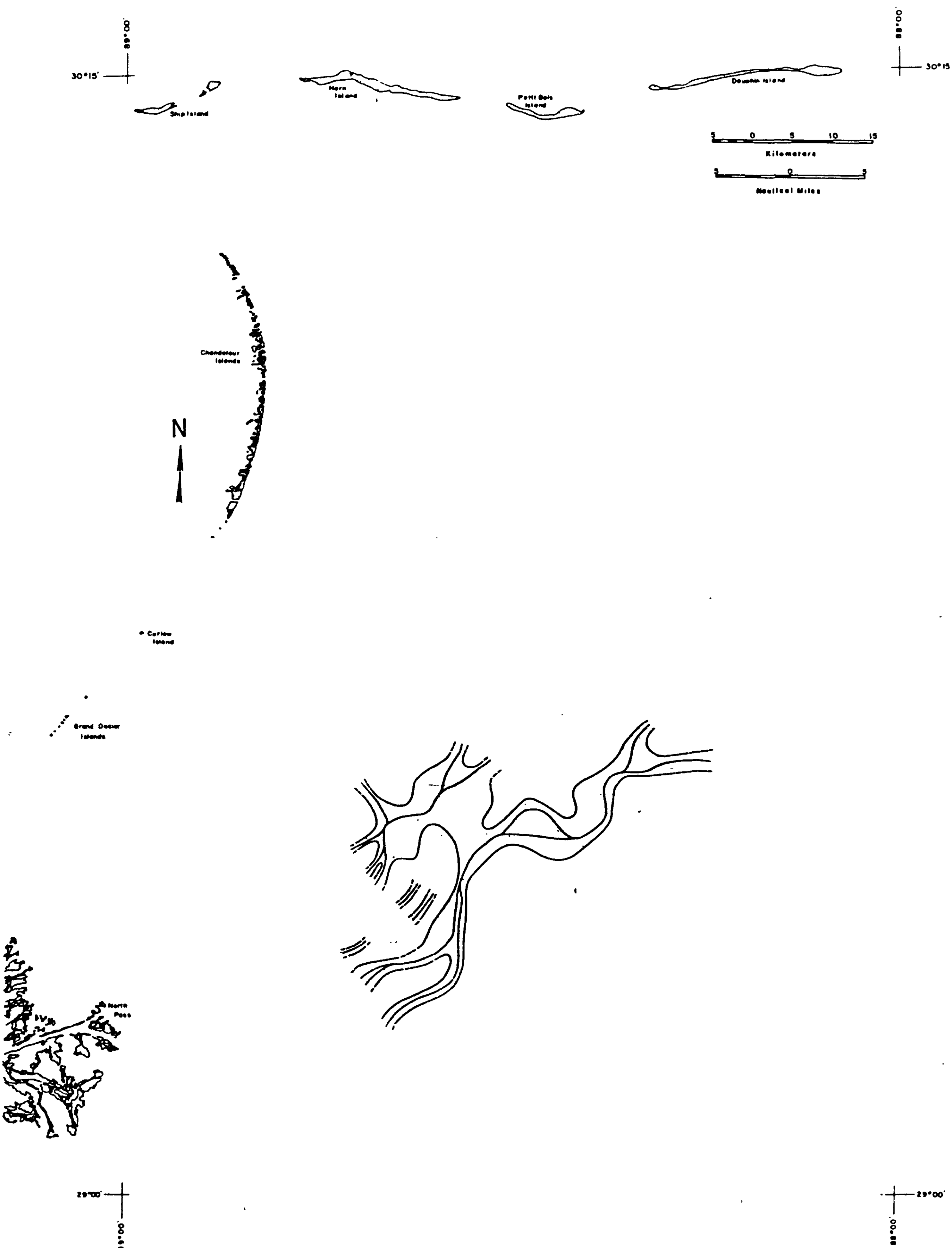

Figure 16. Channel pattern representing the youngest stage of stream erosion during the period of Unit 2.

midway through the regression leading to an outbuilding of a series of progradational deltaic deposits beginning at mid-shelf and building out laterally to the shelf break. These deltaic deposits formed the thickness portion of Unit 2 and are characterized by megaforeset and bottomset bedding. The lateral extent of the delta system to the east, south, and west is shown in Figure 17. The northern limit is not apparent because of the limitations of the survey coverage. In support of the seismic data, well borings in the general area cored through sediments from Unit 2 and suggest deltaic deposition (i.e. clay overlain by fine sandy clay with shells). Near the shelf break, delta lobes with topset, foreset, and bottomset bedding are discernible. The slope sediments in front of the delta deposition are seismically characterized by thinner parallel-type bedding. The final delta lobe appears to have been deposited during a higher stand of sea level indicating a temporary rise of sea level before the final plunge to the low stand near or beyond the shelf break.

Horizon C is an erosional unconformity formed during the low stand of sea level following deposition of Unit 2. The onlapping slope sediments (Fig. 18) overlying horizon C' were probably deposited during shelf erosion and the point of onlap on the slope was possibly just below the location of sea level during formation of horizon C. Again the shelf was eroded and horizon C was a relatively flat surface in this area (Fig. 19). The following transgression was probably rapid and only a thin drape of sediment was deposited on the outer shelf with no measurable deposit on the shelf break. The east side of the area shows a uniform increase in thickness of the transgressive sediments landward (Fig. 20) indicating a steady rise in sea level. Data from borings in this area show that the lower part of Unit 1 was made up of soft gray clayey silt.

Before reaching the present sea level, at least one minor regression occurred which lowered sea level to the mid-shelf. This formed a channeling system (Fig. 21) and horizon A which is an erosional unconformity that disappears at mid shelf (Fig. 22). Once the sea started to rise again, shallow areas in the northwest part of the area became covered with oyster reefs (Fig. 23). The reefs were interpreted from seismic records as hard jagged horizons with acoustic blank zones located directly beneath them (Fig. 24). The oyster reefs appear to have grown upon horizon A and therefore indicate an estuarine environment during the early Holocene.

As present day sea level was reached, very little deposition occurred in the area until the St. Bernard Delta complex started to form. This Mississippi River deposition was the most recent geologic event and covered the northwest corner of the region. It thins evenly from the northwest to the southeast and has very little internal seismic structure except for minor foreset bedding at pinchout on the shelf (Fig. 25). Almost all interpreted shallow gas occurs in the St. Bernard Delta sediments just offshore of the Chandeleur Islands chain (Fig. 26). Interpretation of gas pockets from high-resolution seismic records are based on the commonly accepted practice dealing with small areas with no acoustic return (Fig. 27). The rapid deposition of highly organic sediments during the St. Bernard Delta deposition was probably responsible for shallow gas formation. Coleman (1976) provided an extensive discussion of the St. Bernard progradation and subsequent reworking. Data from borings show normal deltaic sequences (i.e. clay with sandy silt overlain by clay with sand, overlain by a fine sand) which are still in the process of being reworked.

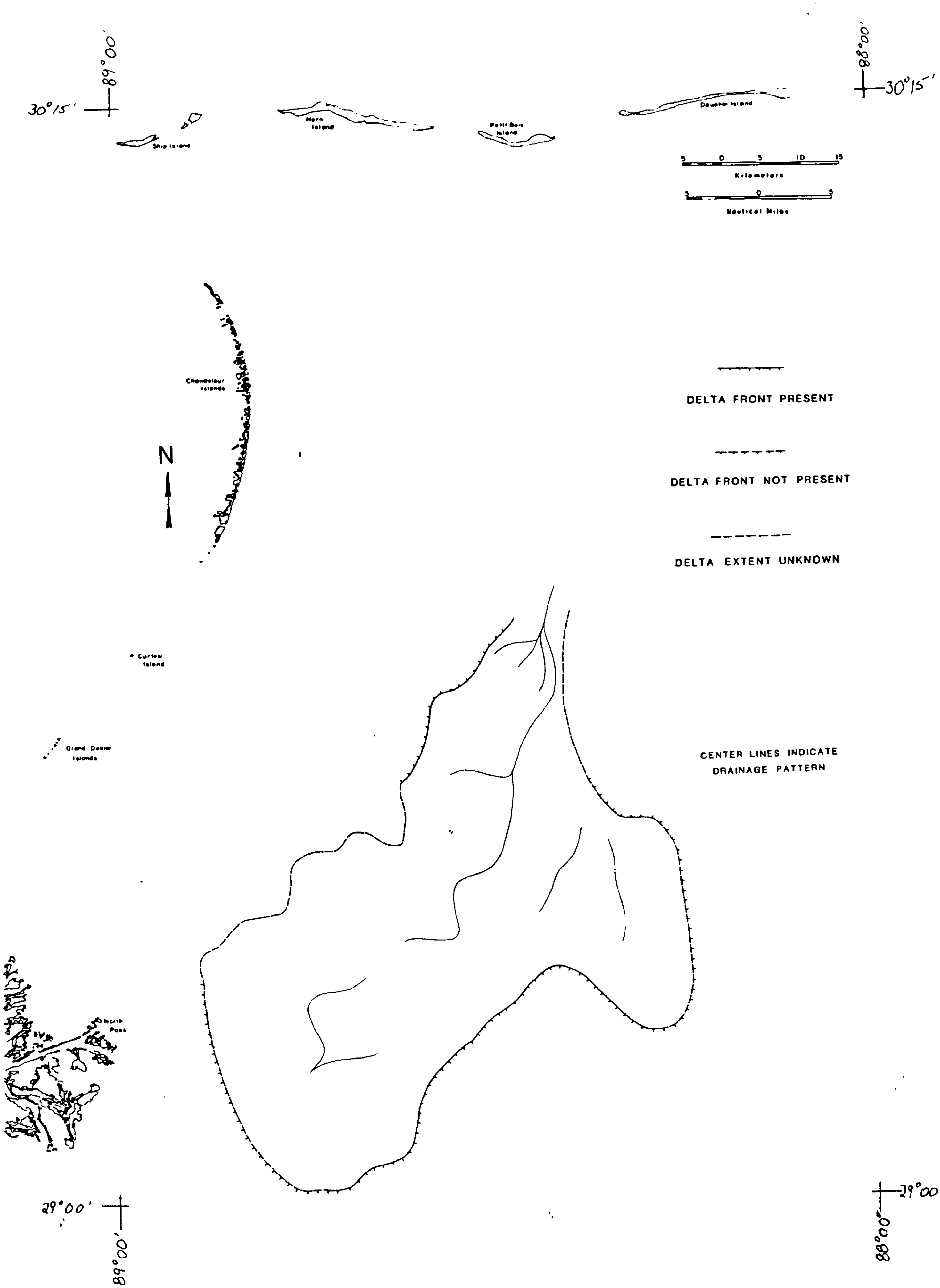

Figure 17. Extent of deltaic outbuilding of Unit 2.

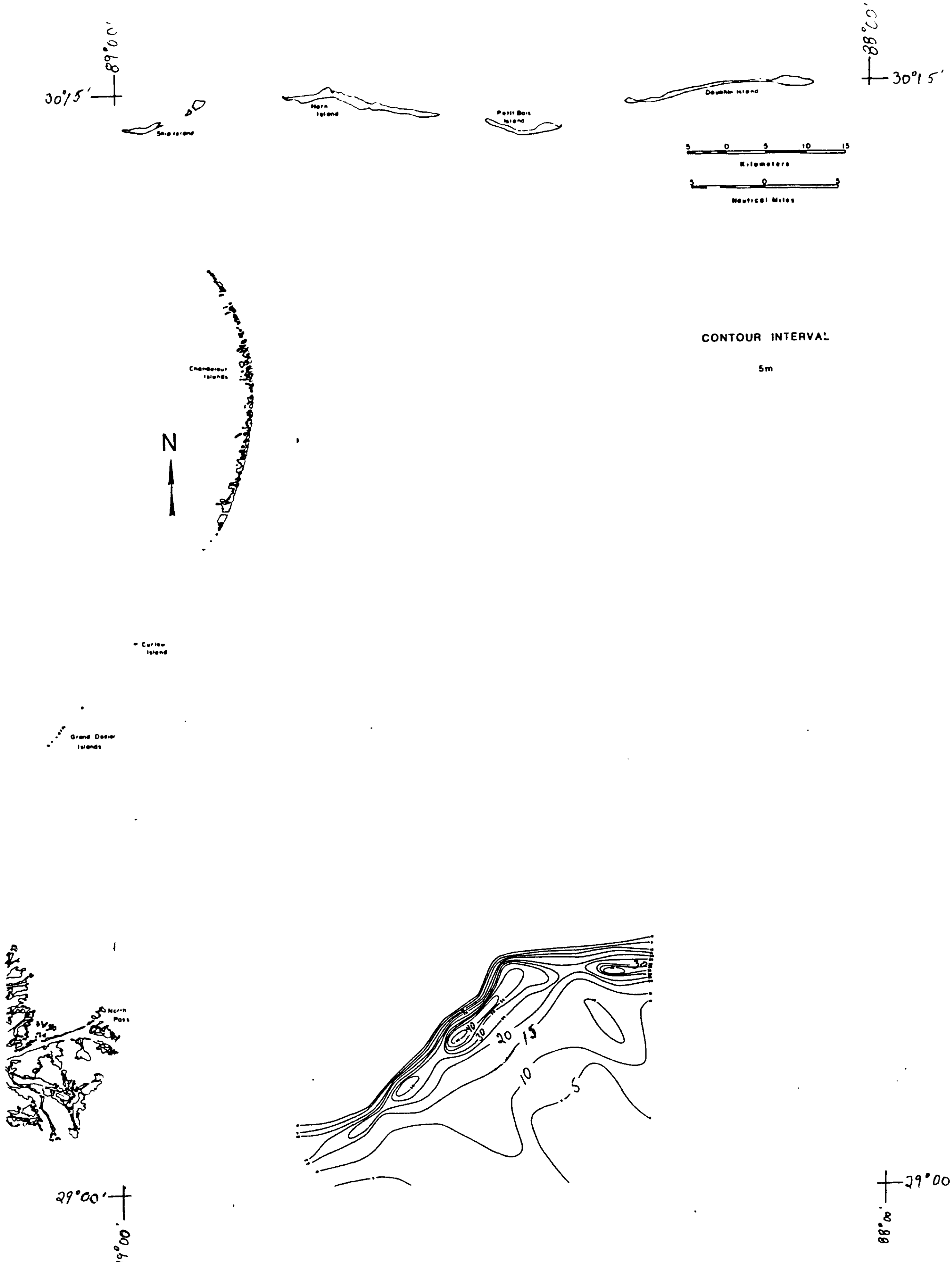

Figure 18. Isopach map of regressive sediments overlying Horizon C'.

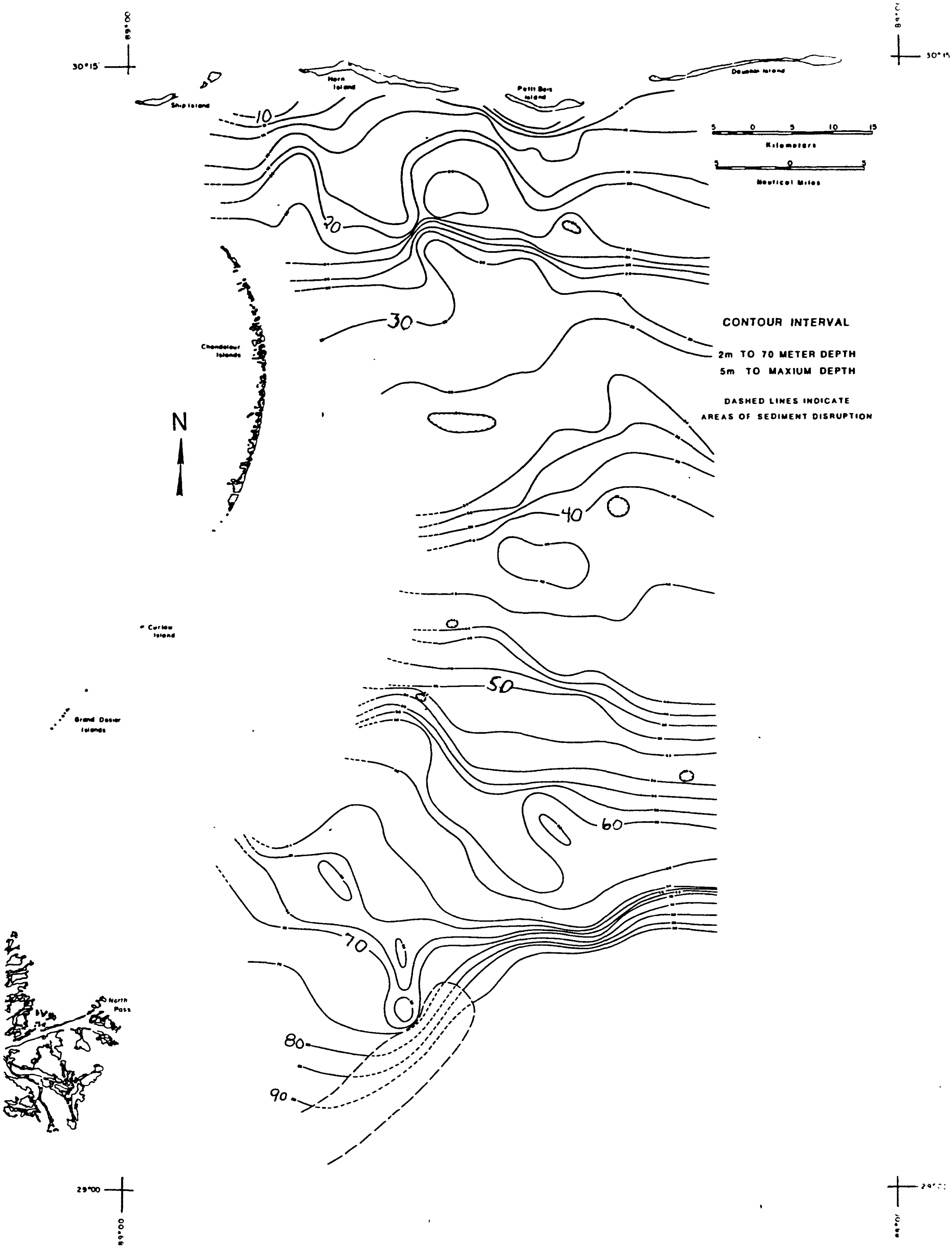

Figure 19. Structure contour map of Horizon C.

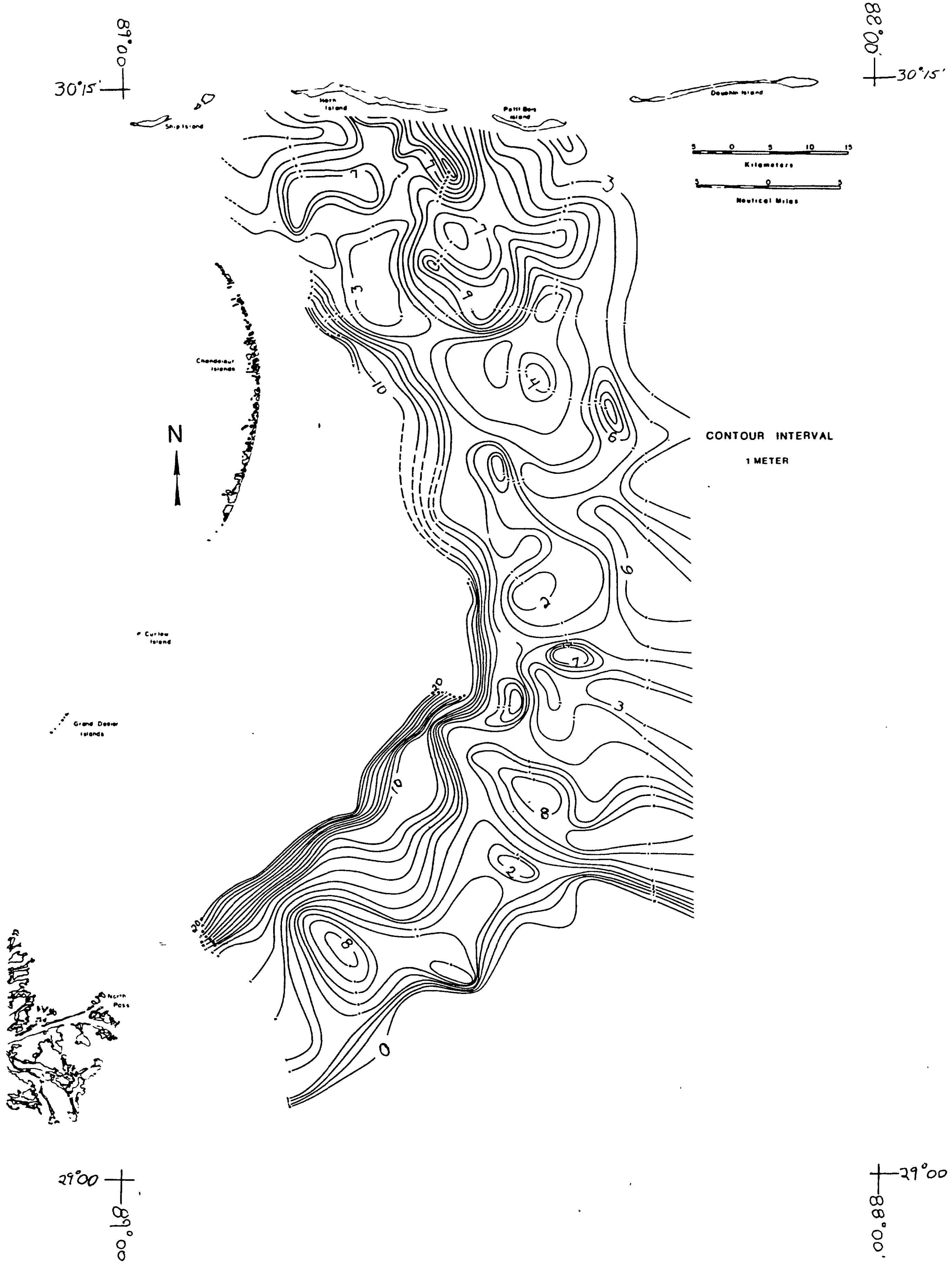

Figure 20. Isopach map of the transgressive sediments forming Unit 1.

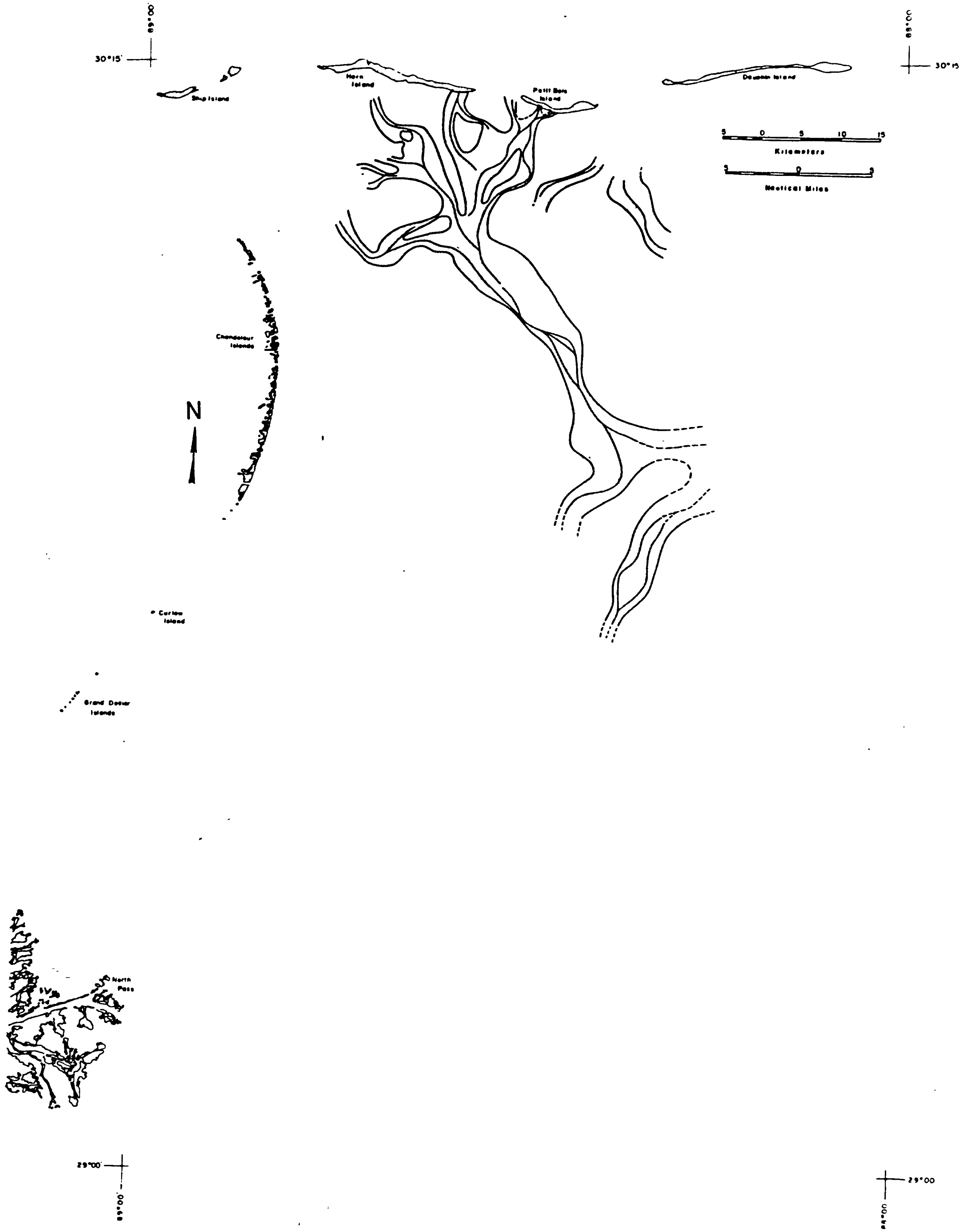

Figure 21. Channel pattern observed in Unit 1. Shaded area - channel surface. Center lines - channel axes.

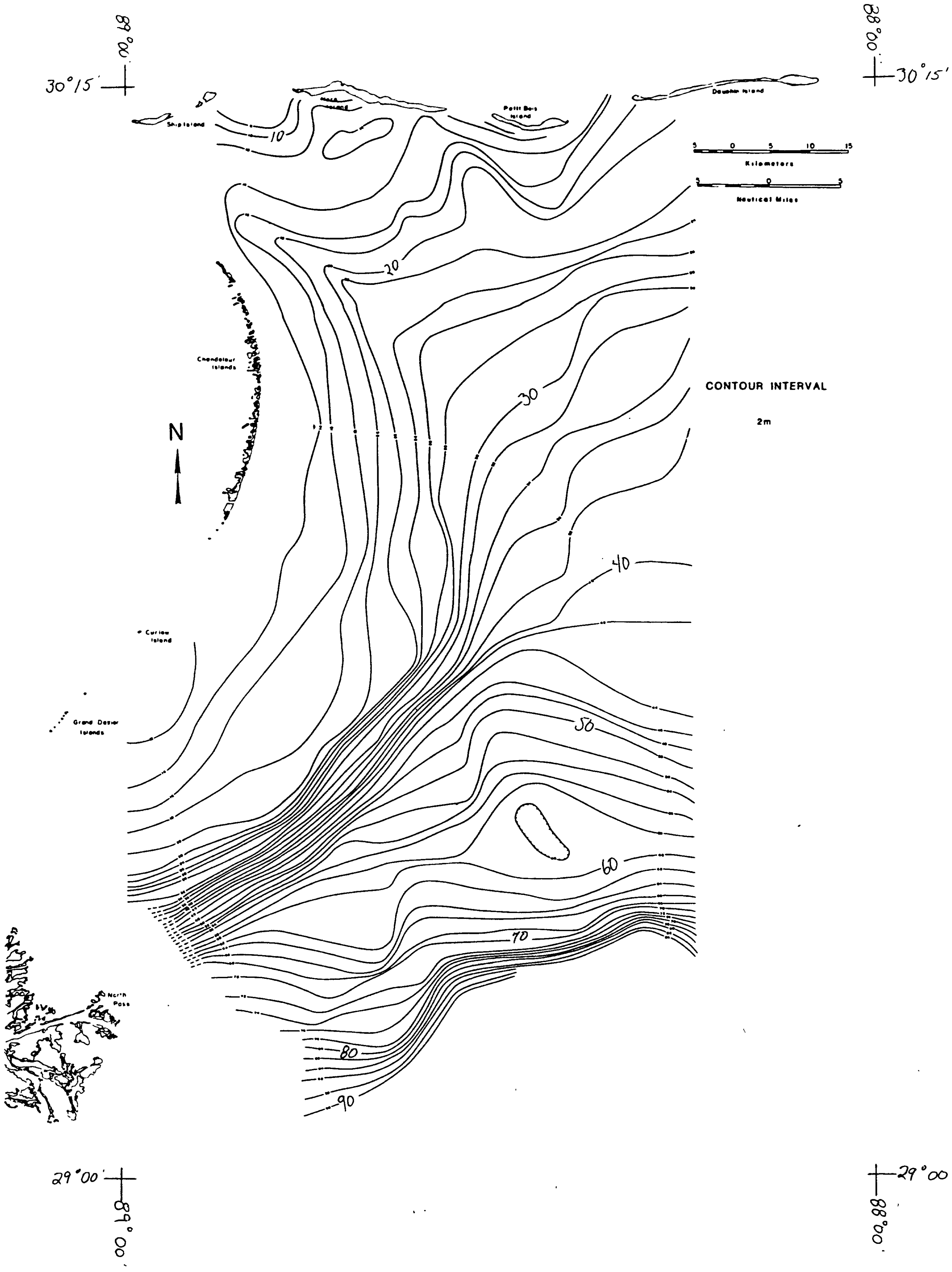

Figure 22. Structure contour map of Horizon A.

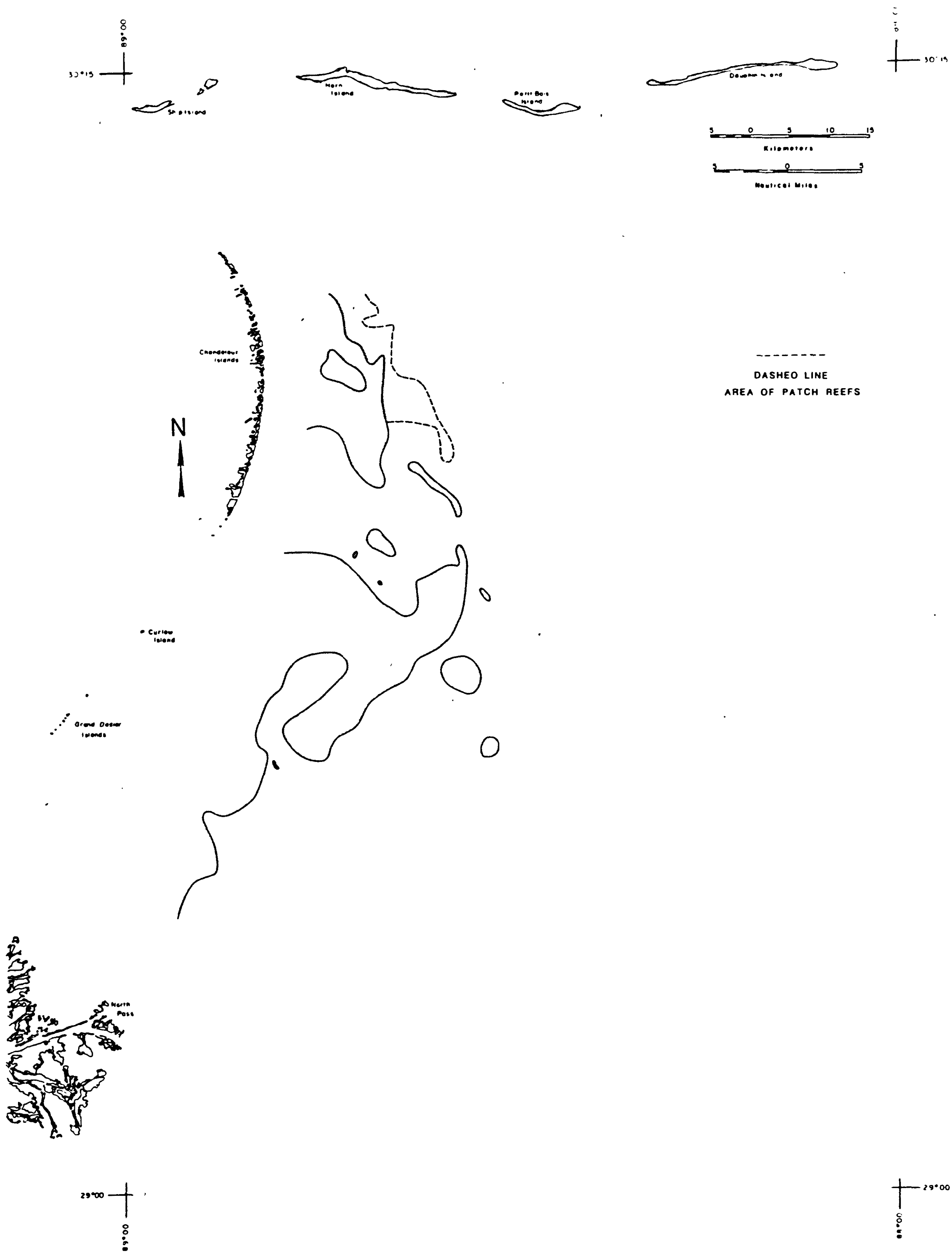

Figure 23. Distribution of buried oyster reefs (shaded area).

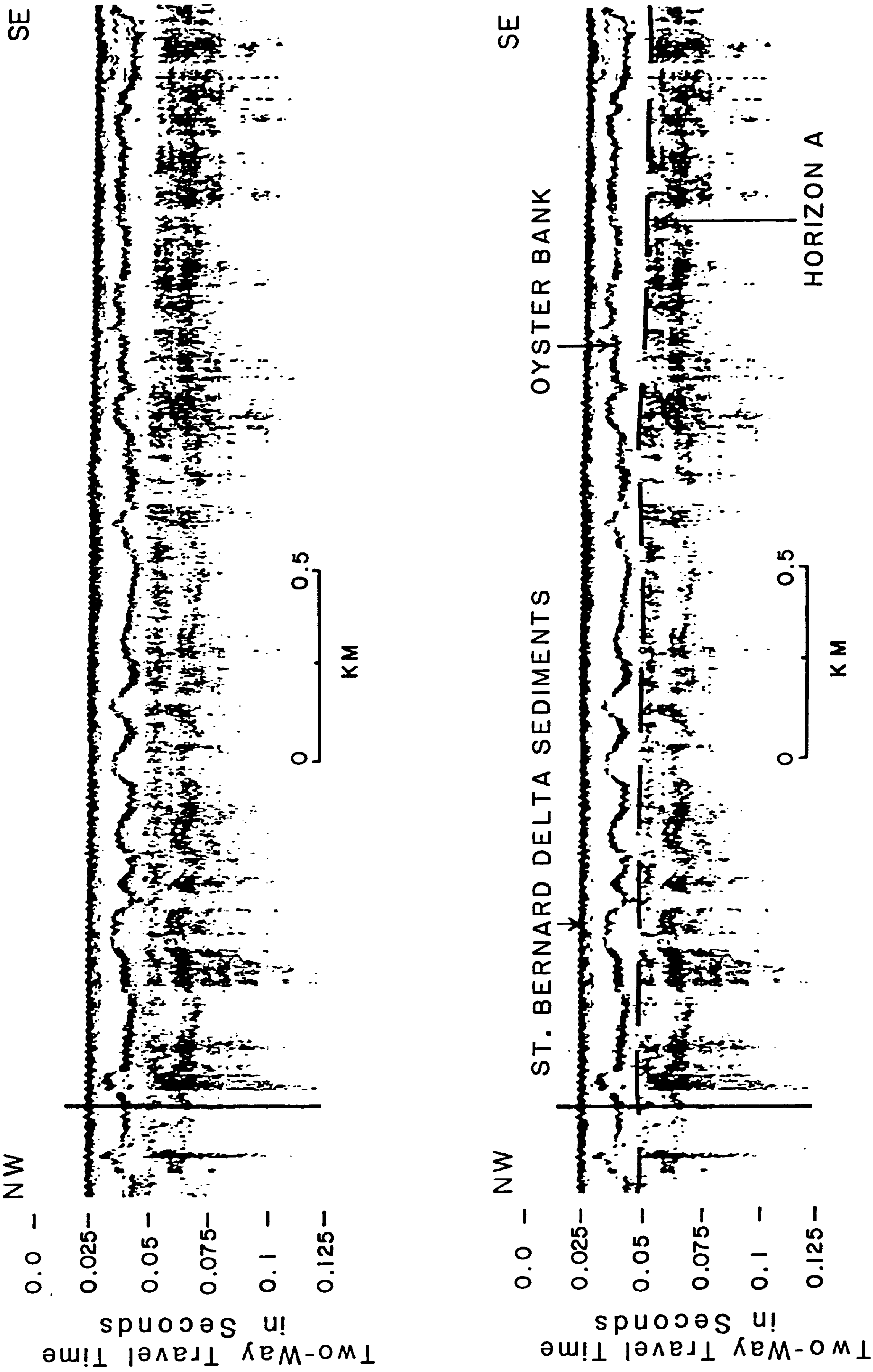

Figure 24. Oyster Reef interpretation from 3.5 kHz profiles.

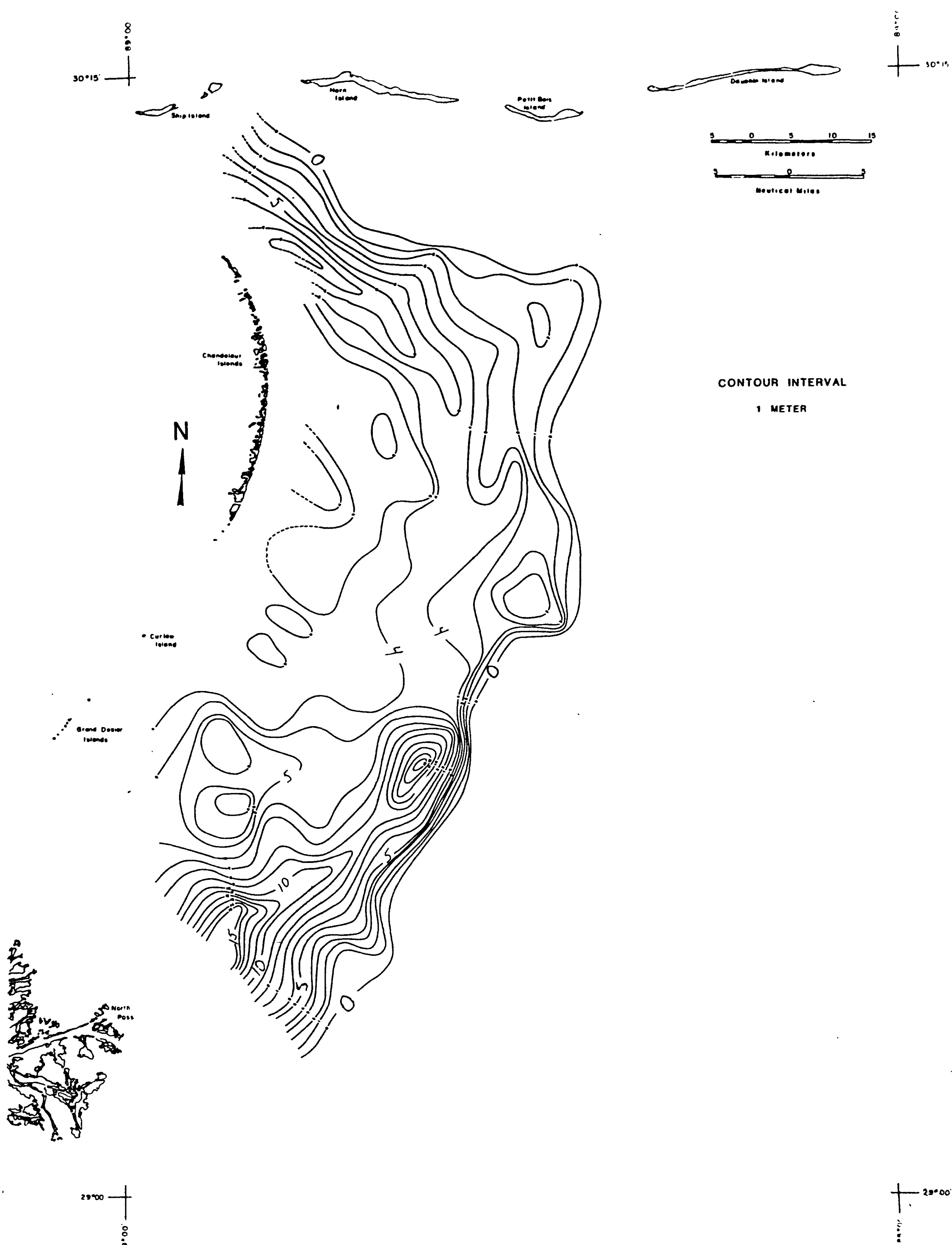

Figure 25. Isopach map of St. Bernard Delta.

Figure 26. Distribution of gas-charged sediments in Unit 2.

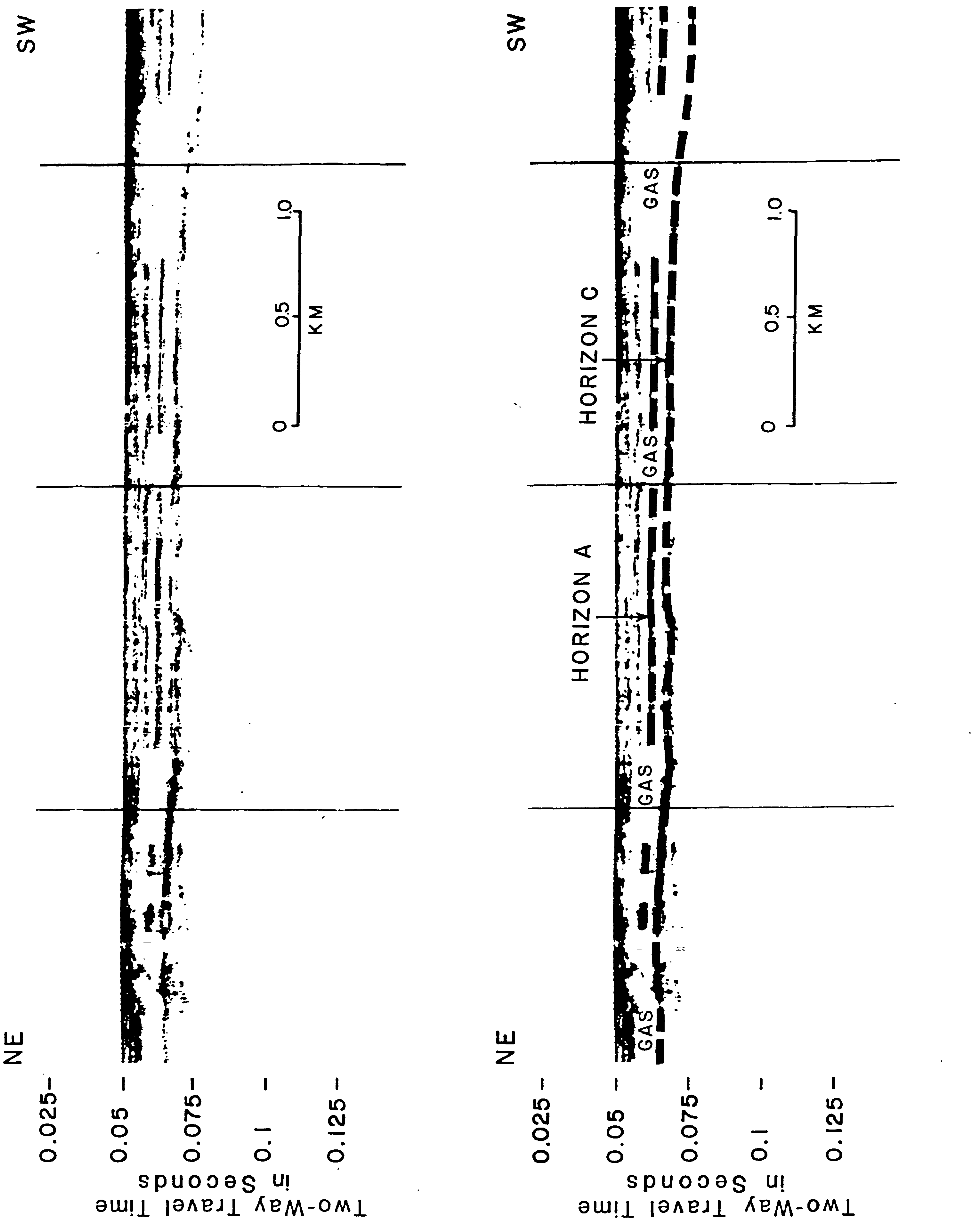

Figure 27. Example of shallow gas interpretations from 3.5-kHz profiles.

GEOLOGIC HISTORY

The geologic history of the eastern Louisiana-Mississippi continental shelf, indicated by this study, shows seven major stages of shelf development since the middle Pleistocene. Seismic interpretations were combined to form an idealized composite of shelf and upper slope stratigraphy (Fig. 28). The oldest stage was an erosional shelf surface probably exposed by a low stand of sea level (Fig. 29). This was followed by a rising sea depositing transgressive sediments (Fig. 30). The position of the high stand of sea level may have been higher than present sea level. The river channeling of the shelf transgressive deposits indicates that the third stage of development (Fig. 31) was begun by a lowering of sea level. This regression was probably not a smooth recession of the sea, but a stepped withdrawal producing at least three levels of river cutting. One stillstand produced progradational delta deposits and probably a minor transgression followed (Fig. 32). This development is considered a major event because of the directly related large volume of sedimentation. The slightly higher sea level partly backfilled river channels and produced a delta lobe at a slightly higher elevation than previous delta deposits. The fifth stage was formed during the most recent low stand of sea level (Fig. 33). During this time the exposed shelf was eroded and regressive sediments were deposited on the upper slope. Rising sea level brought transgressive sedimentation to the inner shelf and stage six of development (Fig. 34). A minor regression during this rise in sea level formed small river channels on the inner shelf and portions of the area developed oyster reefs. The most recent stage of shelf development was produced as the sea reached present day level (Fig. 35). The St. Bernard Delta was formed by the Mississippi River and prodelta deposits reached into the area. Since the depocenter of the Mississippi River is now outside the area and sea level is presently at a stillstand, little deposition is occurring on the Louisiana-Mississippi continental shelf.

Geologic Features

This study provides geologic information important to offshore development of the Louisiana-Mississippi continental shelf and upper slope. The shelf surface is relatively flat with only minor areas of slight relief. The only surface features of interest that appear on the upper slope are diapiric action that has created a few large protrusions on the sea floor. Shelf faulting is random and in most cases is minor. The upper slope has a few apparently active faults mainly associated with diapiric uplift. Some upper slope faulting is found parallel to the shelf break indicating slumping but most of these faults are small and no sign of mass movement is found. Relatively large progradational delta sediment lobes are found at the shelf break and shoreward for several kilometers. Although delta sediments are usually formed rapidly and may be somewhat unstable, no indications of sediment adjustment are seen. Shelfwide river cutting produced outer shelf delta deposition and inner shelf erosion, but main river channels were not greatly developed. The shelf rivers seem to have been shallow and widely distributed. Further inshore, oyster reefs appear to have developed on a high area in the northwestern part of the study area. These reefs appear rugged and blanketing sediments seem disturbed but no surface indications are seen. These sediments are thought to be part of St. Bernard Delta deposition. The only shallow gas pockets observed are in the sediments of the St. Bernard. Although almost no gas was seen escaping from

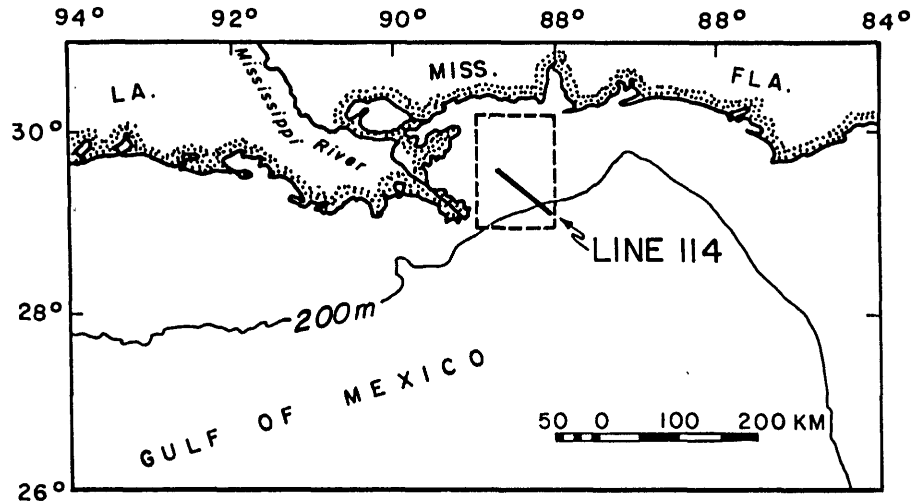

Figure 28. Location of line 114.

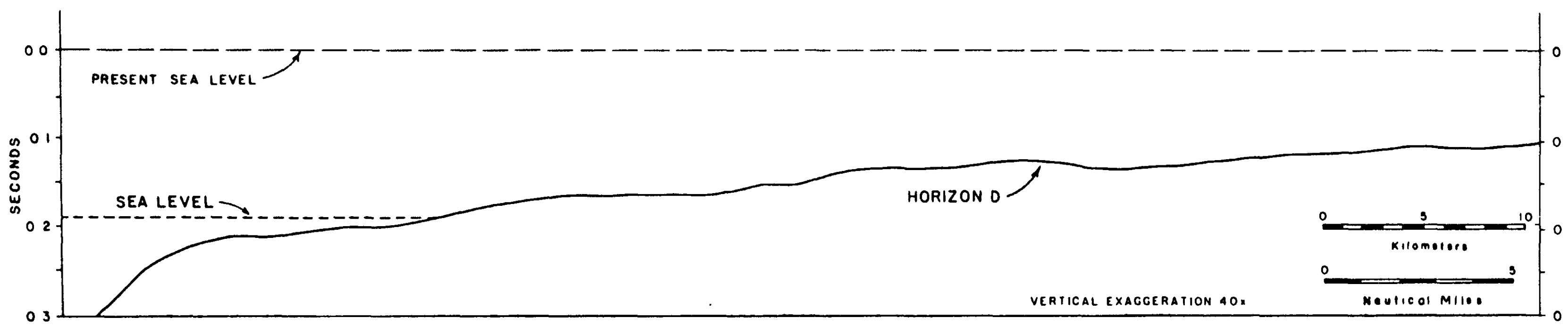

Figure 29. Profile of Horizon D described from line 114. Depth in seconds: two-way travel time.

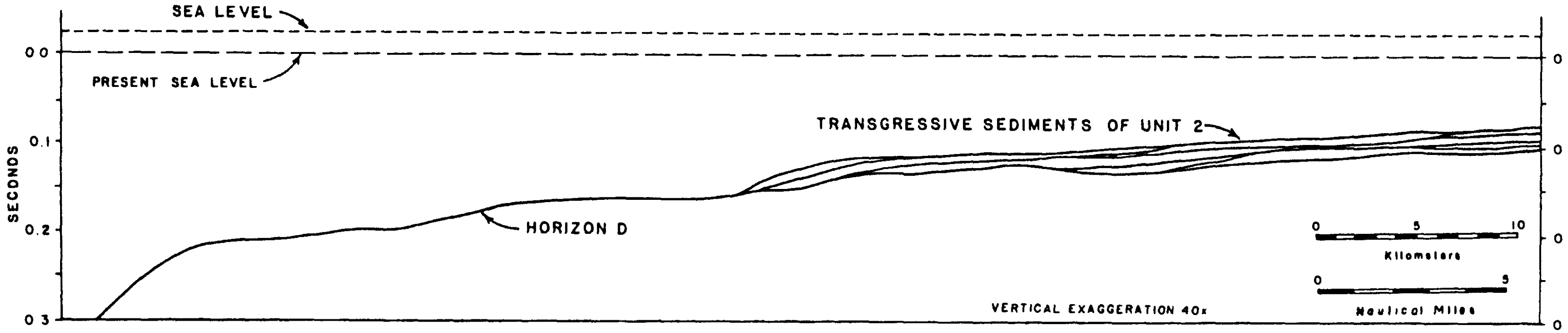

Figure 30. Stage two of shelf development, described from line 114. Depth in seconds: two-way travel time.

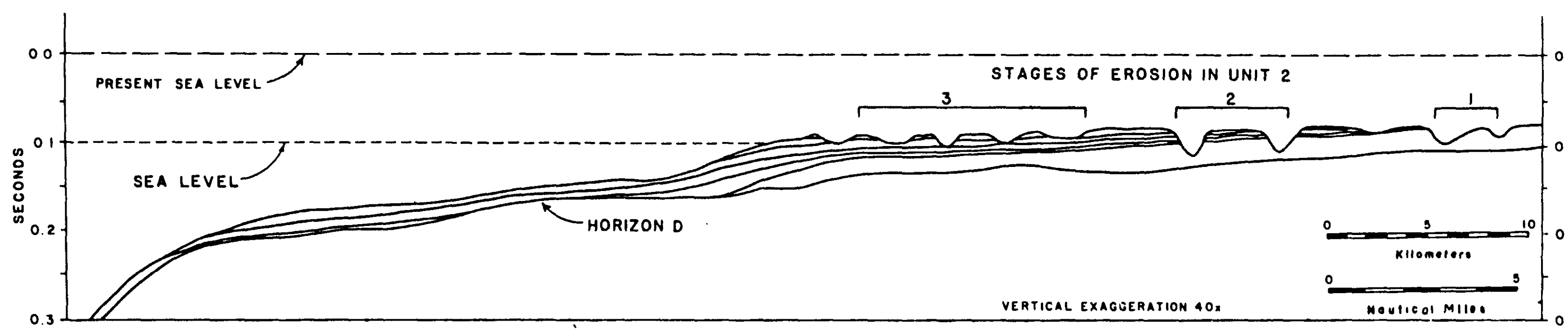

Figure 31. Stage three of shelf development, described from line 114. Depth in seconds: two-way travel time.

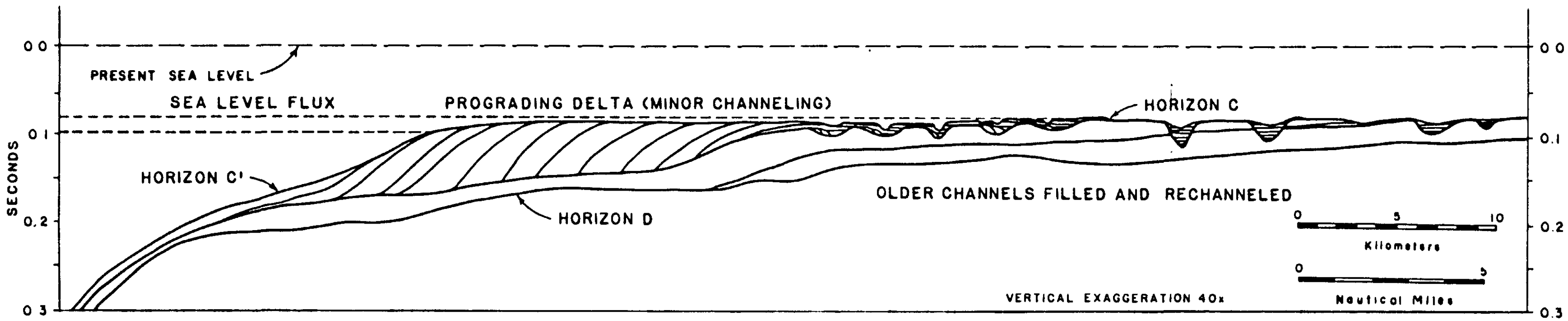

Figure 32. Stage four of shelf development of line 114. Depth in seconds: two-way travel time.

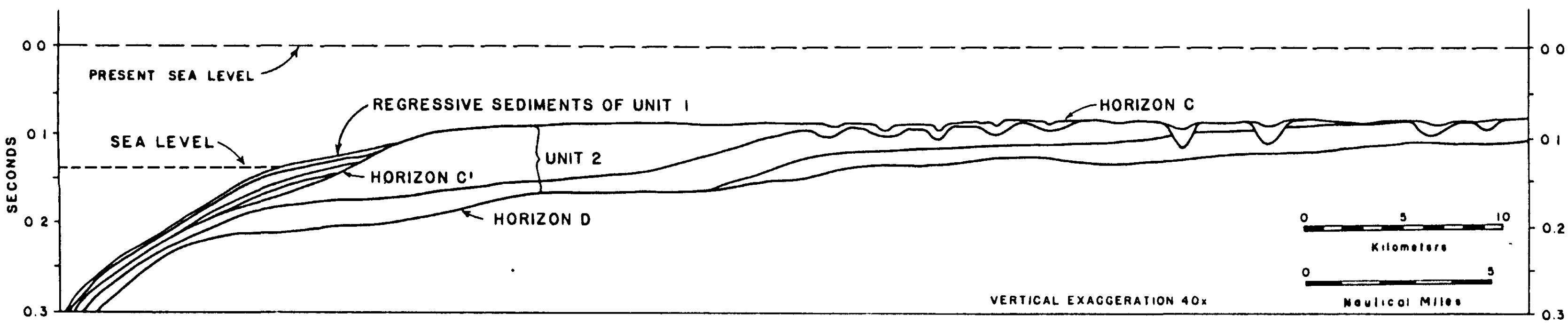

Figure 33. Stage five of shelf development of line 114. Depth in seconds: two-way travel time.

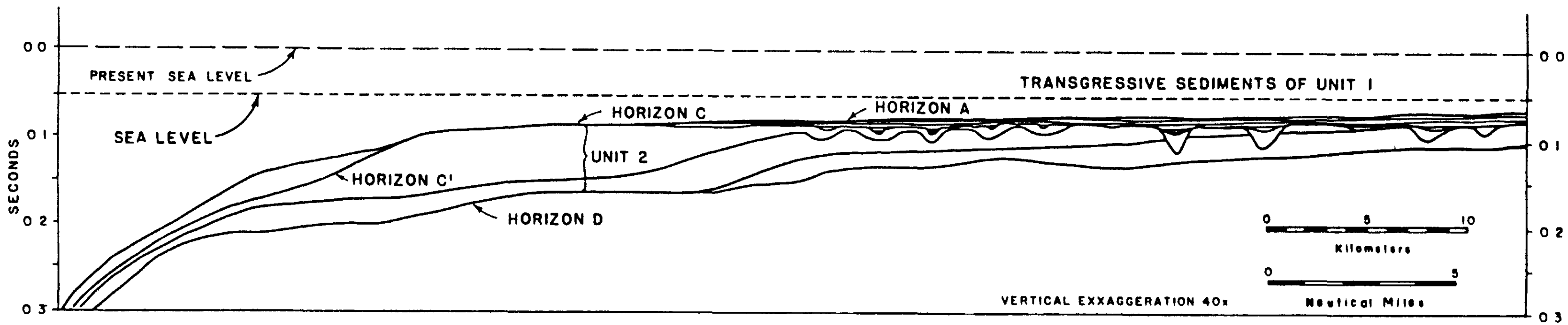

Figure 34. Stage five of shelf development, described from line 114. Depth in seconds: two-way travel time.

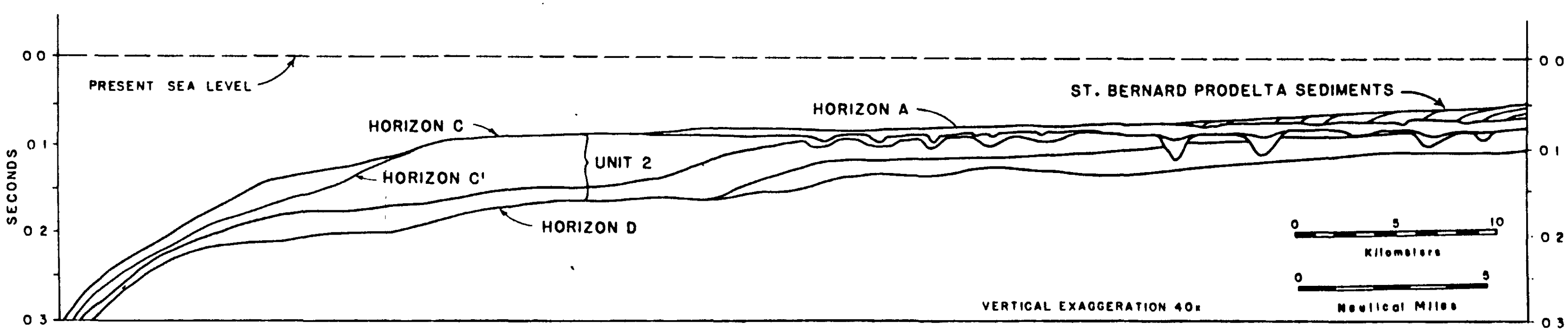

Figure 35. Stage six of shelf development, described from line 114. Depth in seconds: two-way travel time.

the sediment into water column, apparently gas disturbed areas are observed very near the seafloor surface. In general, the study area is stable with almost no sediment movement on the shelf and only a few localized areas of movement on the upper slope. The geologic features of the entire area are almost all minor with only the diapirs of the upper slope creating any possible problems.

SEDIMENT DISTRIBUTION

Methods

Sediment samples were collected from 75 sites throughout the Louisiana-Mississippi OCS area (Fig. 36). Sites were located at alternating intersections of the seismic grid (10 km spacings), and were selected to provide a reasonable coverage of the continental shelf and upper continental slope areas. Samples were collected from the upper 18 cm of sea-floor sediment by means of a clam-shell grab sampler. Fifty-eight samples were collected during R/V GYRE cruise G-18-6 in April 1981; the remaining 17 samples were collected during R/V CARANCAHUA cruise C-81-2 (Appendix 1). Navigation during the R/V GYRE cruise was accomplished with an integrated navigation system, while LORAN-C was used during the R/V CARANCAHUA cruise.

Textural analyses were performed in the laboratory on representative splits of the sediment samples. The organic matter was removed by oxidation in a 30 percent hydrogen peroxide solution. The samples were washed to remove soluble salts, and then dispersed in a 0.5 percent calgon (sodium hexametaphosphate) solution. After dispersion, the samples were separated by means of wet-sieving into gravel (>2 mm), sand (2 mm-63 um), and mud (<63 μm) fractions. The term "mud" as used in this report covers the combined silt and clay-sized fractions of the sediment.

Grain-size distributions of the mud fractions were determined using a 16-channel model TA-II Coulter Counter. All Coulter analyses were conducted using a combination of 200-μm and 30-μm tube apertures, thus providing for an effective composite analytical range of 64 μm-0.630 um size range. The electrolyte consisted of a 4 percent calgon solution prefiltered through a 0.45 μm filter. For a more detailed description of the techniques of sediment analyses by the Coulter Counter, the reader is referred to Shideler (1976).

Grain-size distributions of the sand fraction were determined using a Rapid Sediment Analyzer settling tube similar to the instrument described by Schlee (1966). Sediment particle fall times were converted to phi-size cumulative percentages at a 0.5ϕ interval.

The analyses of the sand and mud fractions were integrated to produce a composite grain-size distribution at a 0.5ϕ interval over a 2 mm-0.49-um size range. The following textural relationships were derived using a computer program: 1) single component percentages - gravel, sand, silt, and clay (Appendix 1); 2) two component ratios - sand/mud and silt/clay; 3) composite classification based on mixed percentages of sand-silt-clay; and 4) statistical grain-size parameters—moment measures of mean diameter, standard deviation, skewness, kurtosis, and modal diameters. The description of sediment properties given here is restricted to the composite classification based on mixed percentages of sand—mud.

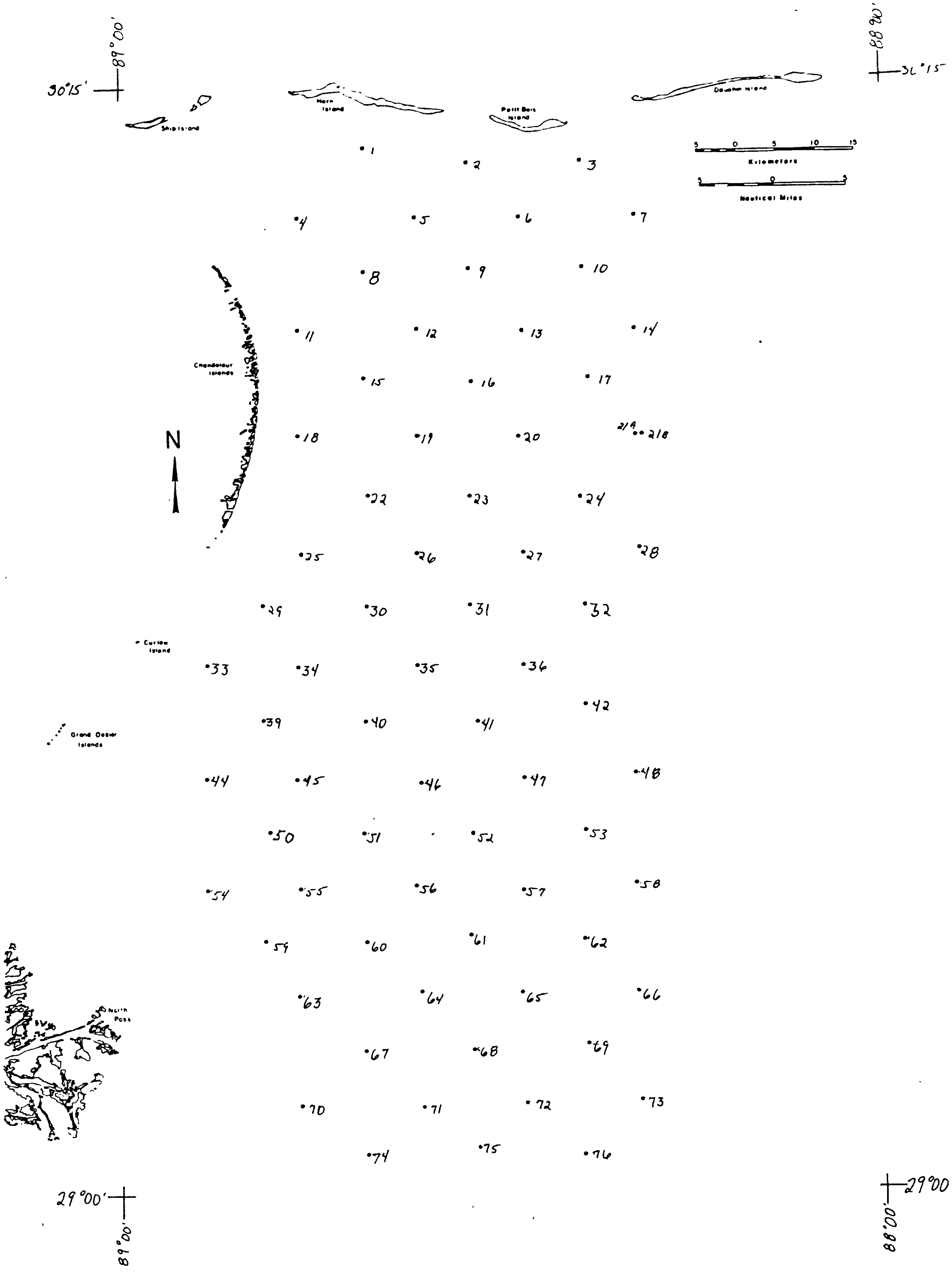

Figure 36.. Distribution of grab sample stations.

DISCUSSION

Surficial sediments in the Louisiana-Mississippi OCS area are generally sand enriched. The average sand percentage of samples collected on the continental shelf (stations 1-66) is 56 percent; the average sand/mud ratio for those same set of samples is 8.88 percent. Accordingly, distribution of the surficial sediments is best illustrated by a composite classification emphasizing the sand-size fraction. Sediment type was determined using a two-component diagram (triangle) with the intervals patterned after Shepard (1954). The terminology for each sediment type is based on the percentage of sand-size material. Sediment types (Appendix 1) used in this report are: sand (75-100%); muddy sand (50-75%); sandy mud (25-50%); and mud (0-25%).

The distribution of the surficial sediments (Fig. 37) in the Louisiana Mississippi OCS area is the product of fluctuating sea level during late Quaternary. The sands on the southeast side and in the northeast corner are the oldest sediments in the study area. These orthoquartzite sands were derived from the Cretaceous and younger sedimentary mantle of the Appalachians (van Andel and Poole, 1960), and were emplaced as fluvial and/or beach deposits on the subaerial continental shelf during the last major low stand 18,000 years B.P. (Ludwick, 1964; Frazier, 1974). Ludwick reports these sands are probably a continuation of the sand basal facies of the central and Rio Grande shelf areas of the northwestern Gulf of Mexico (Curray, 1960). The seismically determined sand waves in the southeastern area have been interpreted as relic shoreline deposits formed during a temporary stillstand about 18,500-15,000 years B.P. (Frazier, 1974). Our findings are consistent with Frazier's interpretation.

The next major event affecting surficial sediments of the Louisiana-Mississippi OCS area was the progradation of the St. Bernard Delta lobe over the eastern sands (Ludwick, 1964). The muds extending over most of the central region are prodelta clays. These muddy sediments are the approximate basinward limit of the finite zone of clay deposition during Recent times (Frazier, 1974). The muddy sands to the north, east, and south of the muds occur in a transition zone where lateral and vertical mixing of the prodelta clays and eastern sands has taken place. The two small areas of sandy mud within the prodelta clay are the result of mixing with the eastern sands (north) and Chandeleur Island sands (south). The southern end of the muddy sediment is a mixture of St. Bernard sediment and sediment presently being deposited by the active birdfoot delta of the Mississippi Delta. Seaward of this transition zone, the muddy sediment becomes finer, and the clay-sized muds of the continental slope are mainly pelagic.

About 450 years B.P., sea level rose transgressing over the St. Bernard subdelta, and the Mississippi River altered its course. Sand from the distributary-mouth sand bars was reworked in a landward direction by wave attack on the subsiding delta. Sand from the coalescing sand bars form the Chandeleur Islands, and Chandeleur and Breton Sound behind them (Ludwick, 1964). The sand waves located in the sandy area southeast of the Chandeleur Islands are a relic shoreline that probably formed during a temporary stillstand. Murray (1976) reports that ebb-directed tidal flushing of the turbid Chandeleur-Breton Sounds estuary waters flow to the north and south of the Chandeleur Island chain. The patch of muddy sand, therefore, either represents settling of this finer-grained sediment into the naturally occurring depression, or may possibly be reworked lagoonal/tidal flat

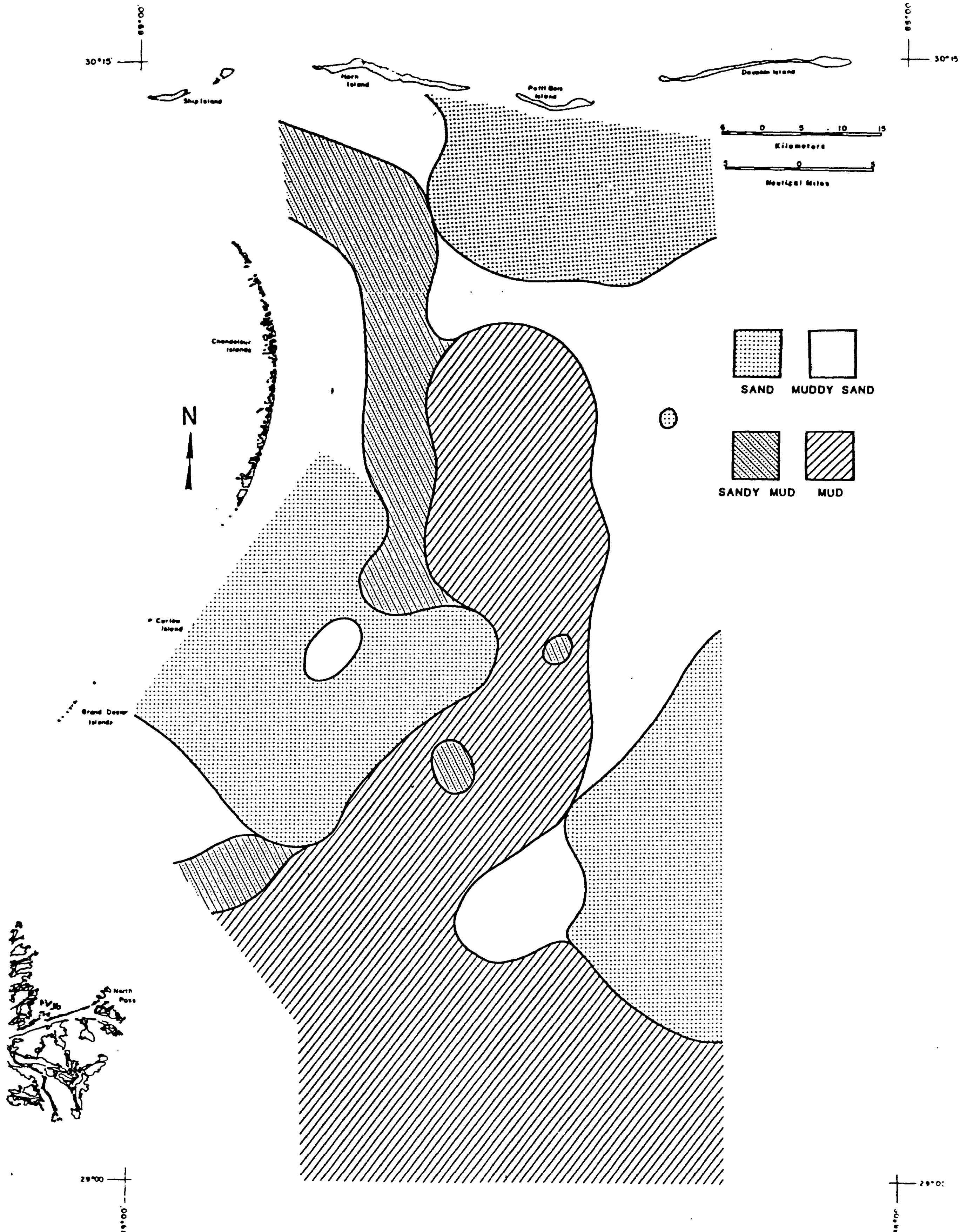

Figure 37. Surficial sediment distribution of area.

sediments deposited behind the barrier ridge. The muddy sand and sandy mud north of the Chandeleur Island sands represent mixing with the prodelta clays. Modern sediments from the Chandeleur-Breton Sounds estuary and from the Mississippi Sound are also being deposited within the transition zone. The muddy sand and sandy mud south of the Chandeleur Island sands reflect the mixing of both the Chandeleur Island sand and St. Bernard prodelta clays with silty clays from the modern Mississippi Delta.

SURFACE DRIFT PATTERNS

In order to gain more insight into the surface circulation patterns of the Louisiana-Mississippi OCS area, three ballasted surface drifter bottles were released at 76 stations (Fig. 38) during R/V GYRE cruise G-81-6 in April 1981. Because of the paucity of circulation data in the area, comparison to previous studies was not possible. The purpose herein, is to report the results of this drifter study relative to the conditions during the study period.

A total of 228 bottles was released, and 79 (35%) bottles were recovered. The surface current patterns shown in Figure 39 are based on all returns, regardless of recovery interval. Drift bottles recovered within 100 km of the release point are plotted with a medium arrow if recovered in 0-42 days, and with a fine arrow if recovered more than 42 days after release. Drift bottles recovered over 100 km from the release point are plotted with the boldest arrow. Most of the bold arrow drifters were recovered beyond 42 days as they were recovered on the west coast of Florida (7 bottles), Florida Keys (1 bottle), east coast of Florida (3 bottles), or west of the Mississippi delta (Louisiana-7 bottles, Texas-15 bottles). The only bold arrow drifters recovered in less than 42 days were released from stations 38 (35 days), 60 (20 days), and 74 (13 days); the second bottle recovered from station 74 was recovered in 47 days. Release and recovery information for each bottle recovered is listed in Appendix 2.

The current patterns show four sectors of varying drift direction. The bottles released at the northeast stations drifted to the east along the Mississippi-Alabama-Florida coast. Movement in an easterly direction is consistent with the semi-permanent currents in this area (Scruton, 1956). The bottles at the five stations in the northwest corner were released on April 19, 1981, except for station 18 (April 15) and all bottles drifted to the southwest. Those five stations reflect a northeast wind for that date as recorded in Mobile, Alabama. Bottles released in the central portion of the study area were set to the northwest except for stations 38, 41, and 53 which drifted to the southwest. Finally, the bottles released in the southern portion of the study area drifted to the southwest, and were recovered west of the delta, except station 63 which was set to the northwest.

Daily wind speed and azimuth as compiled by the National Oceanic and Atmospheric Administration (Daily Weather Maps, Week Series) indicate that the winds at Mobile, Alabama, were generally blowing from the northeast during the period from April 11-June 5, 1981. Comparison of wind speed and azimuth at New Orleans, Louisiana, in the same publication indicated the same general wind pattern.

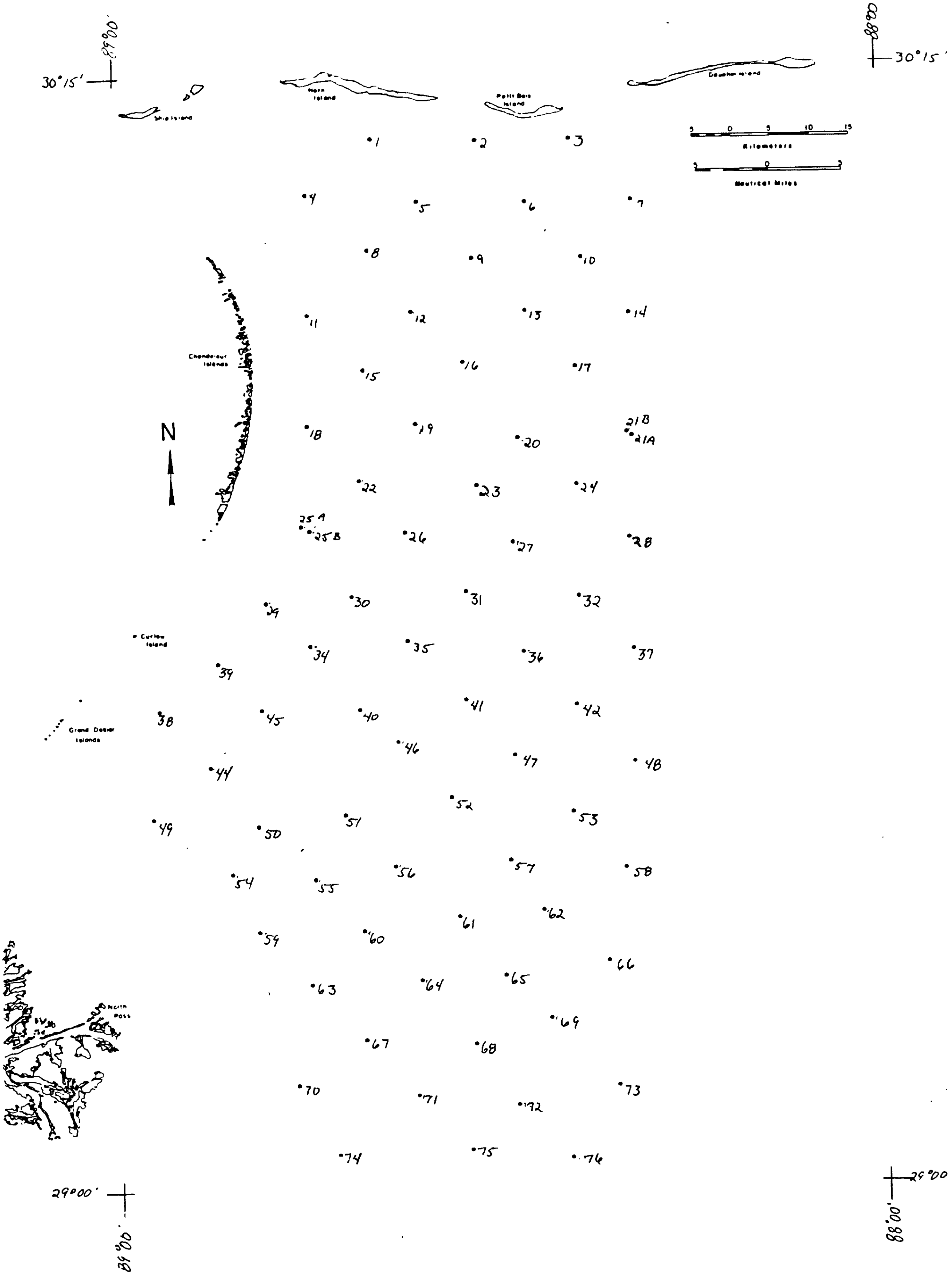

Figure 38. Current drifter release stations.

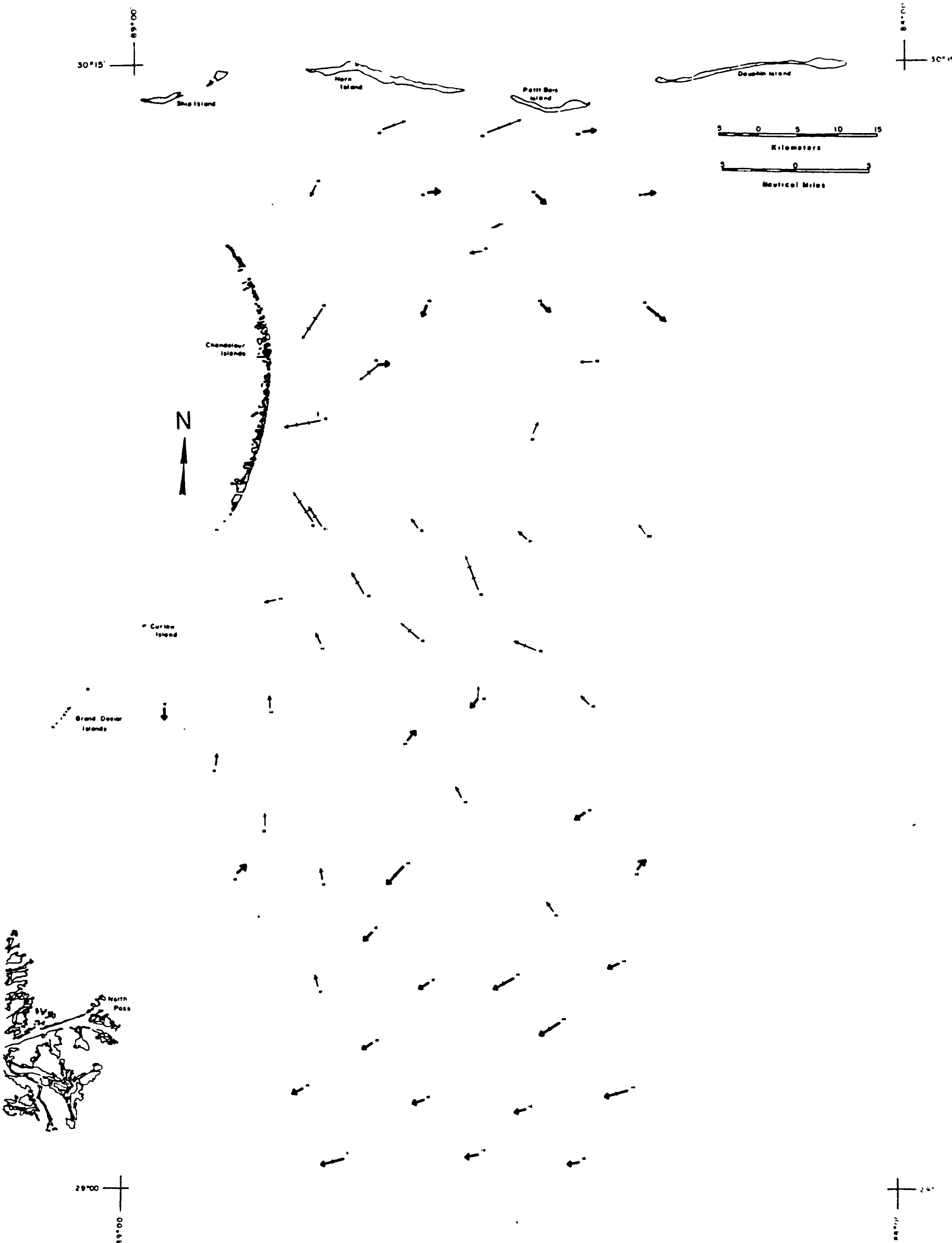

Figure 39. Surface current patterns of the area. Large arrows - greater than 100 km. travel. Small arrows - less than 100 km. travel. Arrow/segments equal number of drifters recovered.

The general circulation pattern suggests that a combination of wind-stress induced circulation, semi-permanent currents discharge of water from the Mississippi River, and tidal motion around the Chandeleur-Breton Sounds estuary and the Mississippi Sound were interacting to produce a clockwise gyre in the study area. Drift bottles released in the southern area were not affected by discharge from the eastern distributary channels, and were driven by the wind to the west of the delta. River discharge and tidal motion north of the delta resulted in a northerly longshore current that deflected surface waters along the Chandeleur Islands and bent east along the Mississippi-Alabama barrier island chain. The recovery of a bottle released from station 12 on the west side of the delta could have resulted from movement from the northern end of the study area clockwise in the gyre to an area where the wind-induced northeast currents set it south of the delta.

Recoveries stretched from Freeport, Texas (356 miles to the west) to Flagler Beach, Florida (828 miles to the east). The results of this one drift bottle study indicates that substantially more studies are required in this area.

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APPENDIX 1. Surficial sediments: Station locations, sediment type, gravel percentage (by weight), and sand, silt, clay percentage (percentages of nongravel (<2mm) fraction)

Station number	Latitude (N)	Longitude (W)	Sediment type	Gravel percentage	Sand percentage	Silt percentage	Clay percentage
1*	30°10.0'	88°41.1'	Muddy sand	0.72	74.46	16.75	8.80
2*	30°10.0'	88°32.7'	Sand	0.81	97.62	1.25	1.14
3*	30°10.0'	88°23.9'	Sand	0.23	98.58	0.73	0.69
4*	30°06.3'	88°46.4'	Sandy mud	4.34	38.87	48.83	12.30
5*	30°06.3'	88°36.9'	Sand	0.95	92.79	5.11	2.10
6	30°06.26'	88°28.61'	Sand	0.17	98.81	0.52	0.67
7	30°06.17'	88°19.74'	Sand	0.38	98.67	0.53	0.81
8*	30°02.7'	88°41.1'	Sandy mud	0.35	44.50	38.89	16.61
9	30°02.71'	88°32.69'	Sand	2.43	78.66	11.00	10.34
10	30°02.60'	88°24.06'	Sand	0.60	94.24	2.93	2.83
11*	29°58.7'	88°46.4'	Muddy sand	3.86	51.22	39.81	8.97
12*	29°58.7'	88°36.9'	Muddy sand	0.17	51.86	35.65	12.48
13	29°58.80'	88°28.62'	Muddy sand	1.24	62.96	23.07	13.97
14	29°58.48	88°19.81'	Muddy sand	1.46	74.40	14.10	11.50
15*	29°55.4'	88°41.1'	Sandy mud	2.49	30.98	46.75	22.27
16	29°55.57'	88°32.70'	Mud	0.26	20.82	50.90	28.28
17	29°54.90'	88°23.98'	Muddy sand	1.16	61.22	18.36	20.42
18*	29°51.6'	88°46.4'	Muddy sand	0.05	68.38	25.74	5.89
19	29°51.70'	88°36.86'	Mud	0.03	11.25	48.78	39.96
20	29°51.74	88°28.61'	Mud	0.28	21.03	31.03	47.94
21A	29°51.64'	88°19.72'	Sand	0.41	75.55	11.32	13.13
21B	29°51.64'	88°19.47'	Muddy sand	1.22	72.91	12.95	14.14
22	29°47.30'	88°40.99'	Sandy mud	1.98	32.96	48.37	18.67
23	29°47.49'	88°32.83'	Mud	0.21	9.11	54.90	35.99
24	29°47.14'	88°24.02'	Muddy sand	0.50	59.14	16.12	24.74
25	29°43.65'	88°46.36'	Sand	2.29	96.38	2.87	0.74
26	29°43.53'	88°36.78'	Mud	0.17	14.37	54.21	31.42
27	29°43.23'	88°28.69'	Mud	0.10	9.48	53.69	36.83
28	29°43.59'	88°19.50'	Muddy sand	1.34	68.02	14.82	17.15
29*	29°40.0'	88°49.2'	Sand	0.03	95.46	3.20	1.34
30	29°40.07'	88°40.98'	Sandy mud	0.39	47.32	40.32	12.37
31	29°40.09'	88°32.83	Mud	0.17	12.26	59.82	27.92

*Samples collected during R/V CARANCAHUA Cruise C-81-2; other samples collected during R/V GYRE Cruise G-81-6.

Station number	Latitude (N)	Longitude (W)	Sediment type	Gravel percentage	Sand percentage	Silt percentage	Clay percentage
32	29°39.88'	88°23.82'	Muddy sand	0.19	57.28	20.17	22.55
33*	29°35.9'	88°53.6'	Sand	0.03	94.78	4.01	1.21
34	29°35.74'	88°46.49'	Muddy sand	0.26	51.63	36.61	11.75
35	29°36.00'	88°36.96'	Sand	0.01	95.11	3.18	1.71
36	29°35.84'	88°28.40'	Sandy mud	0.74	46.13	26.78	27.10
39*	29°32.2'	88°49.2'	Sand	0.18	74.98	20.93	4.10
40	29°32.16'	88°40.95'	Sand	0.44	97.37	1.94	0.70
41	29°31.99'	88°32.09'	Mud	0.13	14.56	58.82	26.63
42	29°33.07'	88°23.70'	Muddy sand	1.57	64.05	16.80	19.15
43*	29°28.3'	89°02.0'	Muddy sand	0.05	72.38	25.20	2.41
44*	29°28.3'	88°53.6	Sand	0.03	97.86	1.35	0.79
45	29°28.21'	88°46.10'	Sand	0.38	92.39	5.52	2.08
46	29°27.87'	88°36.68'	Sandy mud	0.10	29.41	53.78	16.81
47	29°28.26'	88°28.48'	Mud	0.14	21.08	28.03	50.88
48	29°28.33'	88°19.80'	Sand	1.33	86.76	6.34	6.90
49*	29°45.5'	88°57.5'	Muddy sand	0.01	52.15	42.45	5.40
50	29°24.60'	88°48.45'	Sand	0.04	75.04	16.95	8.02
51	29°24.53'	88°41.20'	Mud	0.03	11.04	48.95	40.01
52	29°24.42'	88°32.46'	Mud	0.75	21.38	38.40	40.22
53	29°24.62	88°23.77'	Sand	0.54	81.41	10.41	8.18
54*	29°20.8'	88°53.6'	Sandy mud	0.05	47.92	39.74	12.34
55	29°20.87'	88°46.24'	Mud	0.02	3.07	63.71	33.22
56	29°20.94'	88°36.97'	Mud	0.02	9.54	47.83	42.62
57	29°20.67'	88°28.50'	Muddy sand	1.75	67.70	11.62	20.68
58	29°20.84'	88°19.79'	Sand	2.90	95.08	2.56	2.36
59	29°17.21'	88°49.08'	Mud	0.02	2.71	59.29	38.00
60	29°17.17'	88°41.04'	Mud	0.10	3.13	47.46	49.40
61	29°17.48'	88°32.74'	Muddy sand	0.96	71.75	12.37	15.88
62	29°17.20'	88°23.83'	Sand	0.33	93.60	2.80	3.60
63	29°13.45'	88°46.30'	Mud	0.00	0.83	44.69	54.48
64	29°13.47'	88°36.72'	Mud	0.07	21.84	34.88	43.27
65	29°13.69'	88°28.77'	Mud	0.02	7.50	42.71	49.79
66	29°13.59'	88°19.76'	Sand	5.07	86.52	5.92	7.56
67	29°09.67'	88°41.06'	Mud	0.46	5.00	32.49	62.51
68	29°09.76'	88°32.59'	Mud	0.00	41.46	56.90	0.02
69	29°09.99'	88°23.68'	Mud	0.04	1.07	28.03	70.90
70	29°05.79'	88°46.34'	Mud	0.09	5.82	34.08	60.10
71	29°05.77'	88°36.57'	Mud	0.05	0.68	27.87	71.45

Station number	Latitude (N)	Longitude (W)	Sediment type	Gravel percentage	Sand percentage	Silt percentage	Clay percentage
72	29°05.93'	88°28.41'	Mud	0.02	1.13	41.70	57.17
73	29°06.06'	88°19.61	Mud	0.01	2.41	32.63	64.97
74	29°02.53'	88°40.91'	Mud	0.06	0.62	29.03	70.35
75	29°02.90'	88°32.29'	Mud	0.02	0.75	29.49	69.75
76	29°02.39'	88°23.97'	Mud	0.04	1.53	30.13	68.34

APPENDIX 2. Surface Drift Patterns: Station location, drift bottle numbers, and release and recovery data

Station number	Latitude (N)	Longitude (W)	Drift bottle number	Release date	Recovery date	Recovery interval	Recovery location
1	30°10.74'	88°39.47'	3394	4-18-81	5-3-81	15	Dauphin Island (west end)
1	30°10.74'	88°39.47'	3395	4-18-81	7-1-81	74	Horn Island (east end)
2	30°10.41'	88°31.35'	3397	4-18-81	5-23-81	35	Petit Bois Island (east end, in lake)
2	30°10.41'	88°31.35'	3398	4-18-81	6-9-81	52	Petit Bois Island (south side, at HWL)
2	30°10.41'	88°31.35'	3399	4-18-81	5-3-81	15	Dauphin Island (north side, 1/2 mi. from west end)
3	30°10.44'	88°24.01'	3424	4-20-81	6-4-81	45	Destin, Florida (4 mi. east)
4	30°06.94'	88°44.83'	3489	4-19-81	5-23-81	34	Curlew Island (south side)
5	30°06.66'	88°35.73'	3391	4-18-81	6-5-81	48	Destin, Florida (2 mi. east)
6	30°06.36'	88°27.57'	3401	4-18-81	7-15-81	88	Sugarloaf Key, Florida (2 mi. west of American Light)
7	30°06.26'	88°19.24'	3430	4-21-81	6-5-81	45	Pensacola Beach, Florida
8	30°03.20'	88°40.89'		4-19-81			No bottles returned.
9	30°02.79'	88°31.73'	3389	4-18-81	5-9-81	21	Chandeleur Islands (3 mi. south of lighthouse)
10	30°02.50'	88°23.24'		4-18-81			No bottles returned.
11	29°58.99'	88°44.60'	3502	4-19-81	7-4-81	76	Chandeleur Islands (Monkey Bayou)
11	29°58.99'	88°44.60'	3503	4-19-81	5-2-81	13	Chandeleur Islands (east shore)
11	29°58.99'	88°44.60'	3504	4-19-81	5-3-81	14	Chandeleur Islands (15 mi. south of lighthouse)
12	29°59.20'	88°36.54'	3493	4-19-81	6-4-81	46	Grand Isle, LA (on beach)
13	29°59.01'	88°27.66'	3387	4-18-81	11-8-81	204	Flager Beach, Florida
14	29°58.77'	88°19.29'	3403	4-18-81	6-12-81	48	Lauderdale-By-The-Sea, Florida
14	29°58.77'	88°19.29'	3405	4-18-81	9-29-81	164	Titusville, Florida (Playlinda Beach, cross over #11).
15	29°55.26'	88°40.46'	3409	4-19-81	4-30-81	11	Curlew Island
15	29°55.26'	88°40.46'	3410	4-19-81	8-1-81	98	Chandeleur Islands (Monkey Bayou)
15	29°55.26'	88°40.46'	3411	4-19-81	6-14-81	56	St. Andrew Sound, Florida
16	29°55.57'	88°32.51'		4-19-81			No bottles returned.
17	29°55.15'	88°23.67'	3482	4-18-81	6-2-81	45	Chandeleur Islands (beach)
18	29°51.63'	88°44.86'	3517	4-15-81	4-18-81	3	Chandeleur Islands (29°50.8'N, 88°50.0'W)
18	29°51.63'	88°44.86'	3518	4-15-81	4-18-81	3	Chandeleur Islands (29°50.8'N, 88°50.0'W)

Station number	Latitude (N)	Longitude (W)	Drift bottle number	Release date	Recovery date	Recovery interval	Recovery location
18	29°51.63'	88°44.86'	3519	4-15-81	4-18-81	3	Chandeleur Islands (29°50.8'N, 88°50.0'W)
19	29°51.38'	88°36.25'		4-19-81			No bottles returned.
20	29°51.68'	88°28.28'	3501	4-19-81	6-1-81	43	Dauphin Island (3 mi. west of Gulf pier)
21A	29°51.29'	88°19.45'		4-19-81			No bottles returned.
21B	29°51.75'	88°19.66'		4-21-81			No bottles returned.
22	29°47.88'	88°40.86'		4-15-81			No bottles returned.
23	29°47.42'	88°31.97'		4-19-81			No bottles returned.
24	29°47.35'	88°23.91'		4-21-81			No bottles returned.
25A	29°44.76'	88°45.39'	3514	4-15-81	4-18-81	3	Chandeleur Islands (12 mi. south of lighthouse)
25A	29°44.76'	88°45.39'	3515	4-15-81	9-5-81	143	Horn Island (300 yd. east of west end; north side)
25A	29°44.76'	88°45.39'	3516	4-15-81	5-2-81	17	Chandeleur Islands (southern end)
25B	29°44.24'	88°44.70'	3427	4-21-81	5-2-81	11	Chandeleur Islands (1/2 mi. south of southern pipeline)
25B	29°44.24'	88°44.70'	3428	4-21-81	5-2-81	11	Chandeleur Islands (1/2 mi. south of southern pipeline)
26	29°44.39'	88°37.10'	3523	4-15-81	4-18-81	3	Chandeleur Islands (1/2 mi. south of lighthouse)
27	29°43.42'	88°28.66'	3545	4-21-81	6-1-81	41	Cat Island (on beach)
28	29°43.80'	88°19.60'	3541	4-22-81	6-7-81	46	Deer Island (south side)
29	29°39.82'	88°48.16'	3474	4-14-81	4-18-81	4	Curlew Island
30	29°40.72'	88°41.14'	3512	4-15-81	5-3-81	18	Chandeleur Island (between Holly-wood and Monkey Bayous)
30	29°40.72'	88°41.14'	3513	4-15-81	5-30-81	45	Chandeleur Islands (Tarpon Hole)
31	29°40.27'	88°32.55'	3526	4-15-81	8-15-81	122	Horn Island (south side)
31	29°40.27'	88°32.55'	3527	4-15-81	5-3-81	18	Horn Island (2 mi. from west end; south side)
31	29°40.27'	88°32.55'	3528	4-15-81	4-29-81	14	Chandeleur Islands (north light)
32	29°39.90'	88°23.88'		4-19-81			No bottles returned.
34	29°36.71'	88°44.90'	3476	4-14-81	4-25-81	11	Chandeleur Islands (near Redfish Pt.)
35	29°36.95'	88°37.10'	3509	4-15-81	12-15-81	244	Chandeleur Islands (oil pipe line)
35	29°36.95'	88°37.10'	3510	4-15-81	4-25-81	10	Chandeleur Islands (south end of chain)
36	29°36.03'	88°28.19'	3530	4-15-81	4-24-81	9	Curlew Islands (Gulf Beach)

Station number	Latitude (N)	Longitude (W)	Drift bottle number	Release date	Recovery date	Recovery interval	Recovery location
36	29°36.03'	88°28.19'	3531	4-15-81	4-25-81	10	Chandeleur Islands (near Redfish Pt.; Gulfside)
37	29°36.03'	88°19.65'		4-19-81			No bottles returned.
38	29°32.48'	88°56.76'	3342	4-12-81	5-17-81	35	Elema Island, LA (2-3 mi. west of Caminada Pass)
39	29°32.74'	88°52.15'		4-14-81			No bottles returned.
40	29°32.95'	88°40.82'		4-14-81			No bottles returned.
41	29°33.00'	88°32.89'	3505	4-15-81	7-29-81	105	Grand Isle, LA (Four Bayou)
41	29°33.00'	88°32.89'	3506	4-15-81	12-16-81	245	Pt. aux Chenes, MS
42	29°32.53'	88°24.19'	3534	4-15-81	5-7-81	22	Chandeleur Islands (8 mi. south of lighthouse)
44	29°28.49'	88°52.66'	3339	4-12-81	5-14-81	32	Chandeleur Islands (1 mi. south of Redfish Pt.)
45	29°32.36'	88°48.54'	3467	4-14-81	4-25-81	11	Chandeleur Islands (near Redfish Pt.)
46	29°30.19'	88°37.91'	3435	4-14-81	6-8-81	55	Mobile Bay, AL (east side of Weeks Bay)
47	29°29.20'	88°28.96'		4-15-81			No bottles returned.
48	29°28.43'	88°19.86'		4-15-81			No bottles returned.
49	29°25.20'	88°57.26'		4-12-81			No bottles returned.
50	29°24.68'	88°48.60'	3336	4-12-81	5-30-81	48	Chandeleur Islands
51	29°26.40'	88°42.20'		4-14-81			No bottles returned.
52	29°26.37'	88°33.91'	3438	4-14-81	5-16-81	32	Chandeleur Islands (1/2 mi. south of Redfish Pt.)
53	29°25.27'	88°24.65'	3451	4-15-81	6-9-81	55	Timbalier Island, LA (west end)
54	29°21.44'	88°51.17'	3345	4-12-81	6-4-81	53	Perdido Pass, AL (Alabama Pt.)
55	29°20.93'	88°44.50'	3331	4-12-81	4-25-81	13	Chandeleur Islands (near Redfish Pt.)
56	29°21.87'	88°38.31'	3460	4-14-81	6-1-81	48	High Island, TX (south of Hwy 87 and 124 intersection)
56	29°21.87'	88°36.31'	3461	4-14-81	7-4-81	81	Bolivar Peninsula, TX (1/2 mi. west of Rollover Pass)
57	29°22.15'	88°29.39'		4-14-81			No bottles returned.
58	29°21.54'	88°20.52'	3449	4-15-81	6-12-81	58	Florida beach (15 mi. west of Pensacola)
59	29°17.67'	88°49.08'		4-12-81			No bottles returned.
60	29°17.48'	88°40.75'	3324	4-12-81	5-2-81	20	Grand Isles, LA (Quatre Bayou Pass)
61	29°18.39'	88°33.59'		4-14-81			No bottles returned.
62	29°18.86'	88°26.98'	3444	4-14-81	5-23-81	39	Chandeleur Islands (1/2 mi. south of pipeline)
63	29°13.78'	88°44.93'	3352	4-12-81	5-16-81	34	North Islands (west side)

Station number	Latitude (N)	Longitude (W)	Drift bottle number	Release date	Recovery date	Recovery interval	Recovery location
64	29°13.39'	88°36.40'	3327	4-12-81	5-31-81	49	Boilers Beach, Texas (150 yd. east of road to Freeport)
65	29°14.40'	88°29.43'	3382	4-14-81	6-1-81	48	High Island, TX (south of Hwy 87 and 124 intersection)
65	29°14.40'	88°29.43'	3383	4-14-81	6-1-81	48	McFaddin Beach, TX (5 mi. west of Sea Rim State Park)
66	29°15.06'	88°21.91'	3445	4-14-81	5-29-81	45	McFaddin Beach, TX (5 mi. west of Sea Rim State Park)
67	29°10.01'	88°40.82'	3355	4-12-81	6-9-81	58	Crystal Beach, TX (7 mi. east of Port Bolivar)
68	29°09.62'	88°32.47'		4-12-81			No bottles returned.
69	29°11.36'	88°26.23'	3379	4-14-81	5-31-81	48	High Island, TX (5 1/2 mi. east of Hwy 124)
69	29°11.36'	88°26.23'	3380	4-14-81	6-4-81	51	High Island, TX (2 mi. east of Hwy 124
70	29°07.00'	88°45.94'	3375	4-13-81	6-7-81	55	Cameron, LA (3 1/2 mi. west of Cameron Ship Channel)
71	29°06.19'	88°36.79'	3360	4-13-81	6-6-81	54	High Island, TX (1/2 mi. east of Shorty's Pier)
72	29°05.64'	88°28.18'	3320	4-12-81	6-3-81	52	Alligator Pt., TX (Brazoria County)
73	29°06.79'	88°21.37'	3376	4-14-81	6-3-81	50	High Island, TX
73	29°06.79'	88°21.37'	3377	4-14-81	6-3-81	50	Cameron Parish, LA
74	29°02.39'	88°42.88'	3371	4-13-81	4-26-81	13	Grand Isle, LA (3 mi. west of Baratari Pass)
74	29°02.39'	88°42.88'	3372	4-13-81	5-30-81	47	Galveston, TX (beach)
75	29°02.29'	88°32.50'	3362	4-13-81	6-29-81	77	High Island, TX
76	29°01.95'	88°24.10'	3316	4-12-81	7-4-81	83	Galveston, TX (Condominium Beach)