1-1-1989

Distribution patterns and accumulation rates of fine-grained sediments in upper Tampa Bay, Florida

Gregg R. Brooks

Scholar Commons Citation
Brooks, Gregg R., "Distribution patterns and accumulation rates of fine-grained sediments in upper Tampa Bay, Florida" (1989). *Reports.* Paper 85.
http://scholarcommons.usf.edu/basgp_report/85

Distribution Patterns and Accumulation Rates of Fine-Grained Sediments in Upper Tampa Bay, Florida

Gregg R. Brooks[1], Larry J. Doyle[1], Roger Johansson[2],
Andy Squires[3], Hepsi D. Zsoldos[1], and Robert H. Byrne[1]

ABSTRACT

Tampa Bay, a drowned river valley, is the largest estuary on Florida's west coast, and almost completely surrounded by heavy urban development. A series of eleven sediment cores and high resolution seismic reflection data as collected in Hillsborough Bay, the northeast lobe of Tampa Bay, in order to determine the processes controlling sediment distribution patterns and accumulation rates throughout the recent geologic past.

Surface sediments consist of a mixture of carbonate and terrigenous clastic sands and muds. Mud-size sediments in the open bay are concentrated in low energy bathymetric depressions. Accumulation rates determined by carbon-14 methods for the past several thousand years average 31-49 cm/1,000 years. Rates for approximately the past 100 years, determined by ^{210}Pb and ^{137}Cs methods, range from 0.13 to 0.42 cm/year. Sediment texture, gross mineralogy and organic content show no major variations, but a weak tendency toward increasing organic and carbonate contents, and an accompanying decrease in grain size in the upper 20-30 cm of some cores suggests that there may have been an alteration in sedimentation patterns beginning approximately 100 years ago.

[1] Department of Marine Science, University of South Florida, St. Petersburg.

[2] Bay Study Group, City of Tampa, Florida.

[3] King Engineering Assoc., Tampa, Florida.

Results indicate a major control on the distribution of fine-grained sediments in Hillsborough Bay is bathymetry, as broad, shallow depressions have acted as fine-grained sediment sinks for the past several thousand years. The apparent recent increase in accumulation rate, as well as observed alterations in sedimentation patterns beginning approximately 100 years ago, is consistent with early urban development of the Tampa Bay area.

INTRODUCTION

Estuaries act as depositories, either on a temporary or permanent basis, for modern fluvial and marine-derived sediments. Because estuaries are often attractive sites for heavy urban development, estuarine sediment accumulations are valuable in that they provide a record of how the environment has been impacted in the recent past, whether by natural or anthropogenic processes. Recent studies have shown that many Gulf of Mexico estuaries have undergone alterations in sediment distribution patterns accompanied by increased sediment accumulation rates that can be attributed directly to urban development (George, 1989; Isphording et al., 1989).

The objectives of this study are to determine accumulation rates and processes controlling the distribution of fine-grained sediments in Hillsborough Bay, a heavily developed segment of Tampa Bay, Florida; evaluate the extent to which accumulation rates and sediment distribution patterns have changed in the recent geologic past, and; assess the impact of urban development recorded in Bay sediments.

Hillsborough Bay is the northeast lobe of Tampa Bay, a multi-lobed estuary located along the west central coast of Florida (Fig. 1) at approximately 27°50'N and 82°30'W. It is 14.5 km long by 7.2 km wide and comprises approximately 10% of Tampa Bay (Willis, 1984). Like other bays and estuaries on Florida's west coast, Hillsborough Bay is relatively shallow. Approximately 40% of the Bay is less than 1.8m in depth (Taylor, et al., 1970) and its modal depth is 2m (Willis, 1984). Circulation is tidally controlled but sluggish. The tidal range is 0.9m and maximum tidal currents reach 51 cm/sec (Taylor, et al., 1970). Fluvial input from the Hillsborough and Alafia rivers, the two largest rivers entering the bay, has little effect on circulation (Stahl, 1970). Urban development has resulted in extensive dredging and physical alterations to the Bay and surrounding environment (Taylor, et al., 1970). Ship channels, originally constructed in the 1950's and 1960's, are dredged to an average depth of 13m (Fehring, 1985). Dredged material, consisting predominantly of fine-grained sediments that have settled in the channel, is placed on several spoil islands adjacent to the channels. Goodwin (1984) attributes a decrease in tidal prism and an increase in both volume and depth to recent development activities surrounding Hillsborough Bay. Fluctuations in sediment accumulation rates or alterations in sedimentation patterns resulting from this relatively recent urban development have not yet been evaluated.

METHODS

A total of eight sediment cores were collected in Hillsborough Bay in 1988. Sites were concentrated in areas identified by Johansson and Squires (1988) as having mud-dominated surface sediments (Fig. 1). One core (3-7) was collected from a sand-dominated area for comparison purposes. Samples were collected with a portable vibra corer using 3" diameter aluminum tubing. Cores were split longitudinally, visually described and subsampled for analyses. The top 50cm of each core was slabbed into a 1 to 3 cm thick section and x-rayed in order to evaluate the extent of vertical mixing from bioturbation or core disturbance. Samples from all cores except core 10-8 were collected at 20cm intervals and at additional selected intervals representing distinct lithologic units identified during visual descriptions. Core 10-8 was interpreted to consist entirely of dredge spoil based upon the large amount of sand and large shell fragments and, therefore, was sampled at only three intervals. A total of 120 samples were collected from the cores.

All samples were analyzed for texture at whole phi(ϕ) intervals using standard seive and pipette methods (Folk, 1965). Phi mean and standard deviation were computed for each sample by the method of moments (Folk, 1965). Calcium carbonate content (%CO_3) was determined for all samples by the acid leaching method (Milliman, 1974). Total Organic Content (TOC) was determined for all samples by loss on ignition at 550°C (Dean, 1974).

Eight samples were sent to Beta Analytic, Inc., of Coral Gables, Florida, for radiocarbon age dating. One sample was collected from each core except 10-8 and 10-20. Core 10-8 was excluded because of the determination that it represented dredge spoil. Core 10-20 was sampled twice (one at 110cm and one at 210cm) to provide better chronologic resolution. Core 10-20 was chosen to be sampled twice because its location in the uppermost region of the bay immediately adjacent to heavy development makes it the one most likely to exhibit variations in sediment distribution patterns reflecting urban development. Samples were collected from the base of the uppermost lithologic unit (determined by visual inspection) in each core at depths believed to reflect pre-anthropogenic conditions. This unit, ranging from approximately 95 cm to 2.5 m in thickness, will be referred to in the following text as the 'Surficial Unit.' It is assumed, therefore, that accumulation of the Surficial Unit was relatively continuous throughout the geologic past, although rates of accumulation may have varied.

Based upon results of the eight vibracores collected initially, four additional cores were collected at selected sites for ^{210}Pb and ^{137}Cs dating. Three of the cores (3-30, 3-13 and 10-20) were collected at original vibracore sites. Core OTB3 was collected from adjacent Old Tampa Bay (Fig. 1) for comparison purposes.

As a result of the unusually large amount of sediment required for analyses an 8" diameter "push corer" was developed specifically for this project. Each core was subsampled at 2cm intervals and transported back to the laboratory for individual analyses.

Sedimentological analyses were performed on all samples by the same methods as those performed for vibracore samples. Analyses were performed on the same samples that underwent radiochemical analyses.

All samples for radiochemical analyses were weighed, measured for bulk-density (g/cm^3) and dried at 95° (C) to determine water content. Samples were then powdered, sieved through a 500 um screen to ensure uniformity of size, sealed in 160 mL aluminum cans, and allowed to equilibrate for 17-21 days (5-6 half lives of ^{222}Rn) so that the daughter products of ^{222}Rn could come into equilibrium with ^{226}Ra. Because there are variations in bulk density throughout the core, compaction corrections were used when analyzing lead and cesium profiles. Samples were analyzed for radionuclide content using an extended range intrinsic germanium (Ge(l)) detector (Canberra Model GX 1518). Accumulation rates were calculated using ^{210}Pb and ^{137}Cs profiles.

Data from both sets of cores were integrated with 7.5 kHz seismic reflection data collected by the authors in 1986, in order to determine relationships and lateral extent of stratigraphic units.

RESULTS AND DISCUSSION

Vibracores

Vibracore recovery ranged from 1.5m to 4m in length, and sediments appeared to be undisturbed by the coring process. Fragile tubes produced by the amphipod Ampelisca at the top of core 5-15 were intact and undisturbed. Additionally, core x-radiographs showed no disturbance that could be attributed to the coring procedure. Burrows were observed but in no cores were the upper 50cm completely mixed, suggesting that bioturbation was active but did not completely rework the uppermost sedimentary layers.

Textural and compositional sedimentary parameters (Figs. 2-8) show a broad range of values between cores, but less of a variation within each specific core. Mean grain size ranges from 1.6 ϕ (medium sand) at 380cm in core 3-13 to 9.4 ϕ (clay) at 200cm in core 13-6. Calcium carbonate content ranges from 0.8% at 240cm in core 5-15 to 85% at 325cm in core 3-30. Total Organic Content (TOC) ranges from 0.7% at the surface (3cm) of cores 10-8 and 3-7, and at 240cm in core 3-22; to 80.6% in a peat layer at 280cm in core 10-20.

Radiocarbon ages of selected samples are presented in table 1 along with average accumulation rates of overlying sediments. Average accumulation rates range from 31 to 49 cm/1000 yrs. It should be noted that accumulation rates are based upon one or two radiocarbon analyses per core and are averaged over several thousand years. Results, therefore, are intended to be general and may not be used to represent a particular point in time. Rates are consistent with those calculated previously for west central Hillsborough Bay. Radiocarbon analyses on the calcium carbonate fraction yielded an average accumulation rate of 63 cm/1,000 yrs (Doyle et al., 1985).

Downcore, or vertical sediment distribution patterns, represent the sedimentological history of the Bay. Figures 2-8 show the downcore

Table 1. Radiocarbon age dates of selected samples and average accumulation rates of overlying sediments.

Core	Depth Downcore (cm)	C-14 Age Years B.P. ± 1σ	Average Accumulation rate of overlying sediments
5-15	230	4700 ± 130	49 cm/1000 yrs
10-20	210	5770 ± 140	*45 cm/1000 yrs
10-20	110	3560 ± 110	31 cm/1000 yrs
13-6	190	5200 ± 410	37 cm/1000 yrs
3-7	95	2460 ± 90	39 cm/1000 yrs
3-13	250	5420 ± 80	46 cm/1000 yrs
3-22	190	6180 ± 180	31 cm/1000 yrs
3-30	230	6530 ± 80	35 cm/1000 yrs

*Average accumulation rate for 210 cm to 100 cm interval only.

distributions of mean grain size; relative percentages of sand, silt, and clay; percent calcium carbonate (%CO_3); and, total organic content (TOC). Major deviations are the result of spikes in mean grain size and %CO_3. These correlate with layers or concentrations of either whole shells or shell fragments. Examples include core 10-20 at 68cm, core 13-6 at 210cm, core 3-22 at 240cm, and core 3-7 at approximately 110cm (Figs. 2, 4, 6 and 8). Several additional shell layers are present and have been identified during visual description but not necessarily sampled. With the exception of spikes produced by shell layers, there appears to be less variation in parameters measured in the Surficial Units of the cores than underlying layers. Thicknesses of Surficial Units vary and may be a result of different sediment accumulation rates or environments of deposition. Discussion will concentrate on the Surficial Units of cores because it is in these units that alterations in sediment distribution patterns resulting from urban development will be evident.

Core 3-7 was collected from a sand-dominated zone in the northwest central portion of the bay (Fig. 1). The upper 95cm (Surficial Unit) was deposited at a rate of 39cm/1,000 yrs. Sediments are dominantly sand size. With the exception of a mud peak at 60 cm, over 75% of the upper meter consists of fine to very fine-grained sand (Fig. 2). Both %CO_3 and TOC values show little variability over the upper meter. TOC values are all less than 3% and %CO_3 values are all less than 6%.

Core 3-13 was collected from the mud zone in the west central bay (Fig. 1). The Surficial Unit consists of approximately the upper 250cm which has accumulated at an average rate of 46cm/1,000 yrs (Table 1). Mean grain size ranges between approximately 6ϕ and 8ϕ, with the exception of a peak to 9ϕ at 180cm. TOC shows little variability ranging from approximately 10% to 15%. The carbonate fraction ranges from approximately 28% to 46%, with the exception of a peak to over 50% at 180cm. This peak in $\%CO_3$ corresponding to the peak in mud-size sediments is difficult to explain but it appears to result in an acoustic horizon as a seismic reflector identified at this depth (Fig. 3).

Core 13-6 was collected from a relatively small and narrow mud-dominated zone near the mouth of the Hillsborough River (Fig. 1). The Surficial Unit consists of the upper 2m and has accumulated at approximately 37cm/1,000 yrs (Table 1). Mean grain size has varied between 6.5ϕ and 9.4ϕ and samples consist almost entirely of silt and clay-size material (Fig. 4). The slight increase in grain size from 40 cm to the surface reflects an increase in silt-size particles as the sand-size fraction changes little. Both TOC and $\%CO_3$ show little variation, with TOC ranging between 13% and 16%, and $\%CO_3$ ranging between approximately 15% and 26%.

Grain size values in core 3-30 appear to be more variable than in other cores (Fig. 5). Core 3-30 was collected from the mud-dominated zone in the south central portion of the bay (Fig. 1). The Surficial Unit represents the upper 230cm and has accumulated at approximately 35cm/1,000 yrs (Table 1). Mean grain size has varied between 4.6ϕ and 8.3ϕ and the sand-size fraction ranges between 3% and 62% showing a general increase up core. Calcium carbonate content ranges from 20% to 42% and shows a gradual increase from 240cm to 80cm, then a decrease from 80cm to 20cm. Total organic content shows little variation ranging from 5% to 17%. A decrease in mean grain size reflecting a relative increase in clay-size particles, and slight increases in TOC and $\%CO_3$ from 20 cm to the surface may reflect a recent alteration of sedimentation patterns.

Core 3-22 was collected from the mud-dominated zone in the south central portion of the bay immediately north of core site 3-30 (Fig. 1). The upper

190cm, representing the Surficial Unit, has accumulated at an average rate of 31cm/1000 yrs (Table 1). Mean grain size ranges from 5.6ϕ to 8.6ϕ and has decreased from 5.6ϕ to 7.5ϕ from 40 cm to the surface (Fig. 6). This represents a relative increase in clay-size material and a corresponding decrease in sand-size material, as the silt-size fraction remains relatively constant. Total organic carbon content also remains relatively constant over the top 190 cm varying from 8% to 15%. Calcium carbonate content ranges from 12% to 37%. As in adjacent core 3-30 the decrease in grain size from 40 cm to the surface may represent a geologically recent alteration in sedimentation patterns.

Core 5-15 was collected from a mud-dominated zone in the southeast portion of Hillsborough Bay adjacent to a dredge spoil island (Fig. 1). The Surficial Unit is represented by the upper 230cm and has accumulated at an average rate of 49cm/1000 yrs (Table 1). Core 5-15 is the only core analyzed that exhibits what could be described as a distinct trend throughout the Surficial Unit (Fig. 7). From 160cm to the surface, the mean grain size declines from 3.4ϕ (very fine-grained sand) to 7.9ϕ (very fine-grained silt). The percentage of sand decreases over this interval from 83% to 14%. Total organic content remains low (<3%) from 180cm to 80cm then steadily increases to 11% at the surface. Calcium carbonate content decreases from 18% at 160cm to 3% at 80cm then steadily increases to 27% at the surface. The spike in $\%CO_3$ of 18% at 160cm corresponds to the largest mean grain size (3.4ϕ) and highest sand content (83%), and correlates to a reflection horizon identified on the seismic records (Fig. 7). The steady upcore trend toward finer grained sediments and higher TOC and $\%CO_3$ values represents a gradual, localized alteration in sediment distribution patterns. Such a gradual alteration may represent a decrease in depositional energy accompanying increasing water depth during the Holocene sea-level rise. Decreasing energy permits the deposition of finer sized material, along with organic matter. During sea-level rise, the adjacent Alafia River would become less competent with rising base level and, therefore, would not have the ability to contribute coarser grained material to the depositional site. Accompanying rising sea level and subsequent deepening, more open marine conditions would prevail, which may account for the increase in $\%CO_3$.

Core 10-20 was collected from the northern part of the west central mud-dominated zone (Fig. 1) immediately adjacent to a heavily developed area of Tampa. The Surficial Unit is represented by the upper 210cm. Because of the close proximity to heavy development, core 10-20 was dated twice (210cm and 110cm). Average accumulation rates declined from 45cm/1000 yrs between 5770 and 3560 YBP, to 31cm/1000 yrs between 3560 YBP and the present (Table 1). With the exception of a spike in grain size and $\%CO_3$ representing a shell layer at 68cm, there appear to be little variation in all parameters in the Surficial Unit (Fig. 8). Mean grain size range between 5.4ϕ and 8.6ϕ with the mud-size fraction (silt and clay) consistently making up greater than 50% of the sediment. Total organic content range from 6% to 15% and $\%CO_3$ range from 8% to 28%.

Sediments below the Surficial Unit in general show much greater variation in all parameters (Figs. 2-8). Major spikes in grain size and $\%CO_3$ reflect shell concentrations as previously described. Major spikes in TOC often represent layers of peat (e.g., core 10-20 at 280cm) some containing wood fragments or roots possibly representing mangrove colonization. Some spikes in $\%CO_3$ do not correspond with shell layers, but consist of a tan-colored carbonate-rich mud. The basal samples of cores 3-30 and 3-22 (Figs. 5 and 6) are characterized by this carbonate-rich mud. The origin is not known but based upon the texture and unusually high carbonate content it may be an alteration product derived from subaereal weathering of underlying limestone units (Esteban and Klappa, 1983) during periods of lowered sea level. The base of core 10-20 consists of at least a 30cm thick layer of peat containing root fragments, which is immediately overlain by a 10cm thick layer of whole oyster shells (Fig. 8), interpreted to reflect the onset of marine conditions during a relative rise of sea level. The bases of cores 3-7 and 13-6 (Figs. 2 and 4) are characterized by a blue-gray clay so compact that in both cases it constituted refusal during the coring process. This clay unit is interpreted to represent the upper portion of the Miocene Hawthorn Formation (Stahl, 1970; Campbell, 1973). Sediments overlying the blue-gray, clay-rich unit and underlying those of the Surficial Unit, represent several million years of sea-level fluctuations and changing geologic conditions, thereby accounting for the great variability identified within these intervals.

Seismic Data

High resolution seismic reflection data show highly irregular sub-bottom horizons in the study area. Because of the irregularity of reflection surfaces, it is impossible to trace a specific horizon from one core site to another. Reflection horizons can be correlated with specific layers within the same core however.

The most prominent reflection horizon is the blue-gray, clay-rich layer encountered at the base of cores 3-7 and 13-6 (Figs. 2 and 4), interpreted to represent the top of the Miocene Hawthorn Formation. The reflection surface is extremely irregular (Fig. 9), possibly as a result of numerous periods of subareal exposure resulting from sea-level fluctuations during the late Tertiary and Quaternary. It is stratigraphically the deepest reflector and, therefore, represents the basal reflection horizon identified in the study area. The majority of overlying reflection surfaces correlate to layers of either whole shells, or shell fragments interpreted as storm deposits. Examples include core 3-30 at 220-240 cm, core 3-22 at 240cm; core 5-15 at 150-170cm, and core 10-20 at 68cm and 200cm (Figs. 5-8). Although the latter is offset, it probably correlates to an oyster assemblage identified at 260cm. Other reflection surfaces correlate only to subtle visual changes in lithology. Examples include core 3-13 at 300cm, core 3-30 at 320cm, and core 5-15 at 210cm (Figs. 3, 5, and 7). Since reflection surfaces often correspond to localized events (such as storm deposits, living assemblages, or even subtle lithologic changes), they may not represent the same event from core to core. Therefore, present available data are not sufficient to correlate horizons throughout the study area.

Seismic data collected from surficial mud-dominated zones in the open bay commonly exhibit sub-bottom depressions (Fig. 10). Since core data show that mud-dominated sediments are not just surface features but often extend 1-3m into the subsurface (Figs. 2-8), it is suggested that fine-grained sediment deposition throughout the recent geologic past is controlled to a large extent by bathymetry.

Push Cores

Hillsborough Bay push cores 3-30, 3-13 and 10-20 show the same general patterns as the upper portions of corresponding vibra cores (Figs. 11-13). Core 10-20 appears to be coarser grained but exhibits a similar pattern. Core 3-13 on the other hand, consists of finer-grained material but exhibits a similar pattern (Fig. 11).

Calcium carbonate content ranges from less than 5% to approximately 35% of the total sediment (Fig. 12). Hillsborough Bay cores 3-30, 3-13 and 10-20 have much higher percentages (10-35%) than Old Tampa Bay core OTB3 (<6%) and also show more variation. Cores 3-30 and 10-20 have similar percentages (10-30%) and a similar tendency toward declining from the core base at 50-70cm, and then increasing from approximately 20cm to the surface. Core 3-13 exhibits the highest percentages ranging from approximately 10 to 35% are a weak tendency toward increasing carbonate upcore. Old Tampa Bay core OTB3 consists of less than 6% calcium carbonate. Percentages show little vertical variation and no trends are evident. In comparison to the upper sections of vibracores, patterns are generally similar. Cores 3-13 and 3-30 are very similar and core 3-30 is somewhat similar but values are a bit higher than for the corresponding vibracore.

Total Organic Content (TOC) percentages range from less than 1 to over 18% (Fig. 13). Cores 3-30 and 3-13 have highest percentages ranging from almost 10 to over 18% and both show a weak tendency toward increasing upcore. Core 10-20 TOC percentages range from <1 to almost 10%, but all but one sample have greater than 6%. Core 10-20 samples show a weak tendency toward decreasing upcore. Old Tampa Bay core OTB3 percentages range from 2% to a little over 5% TOC. Little variation exists and there is a slight tendency toward increasing from approximately 20cm to the surface. In comparison with vibracore data, TOC percentages for core 10-20 are very similar, with values mostly in the 5-10% range and showing a slight tendency toward decreasing upcore. Cores 3-30 and 3-13 both appear to have higher percentages than for vibracores and also exhibit a weak tendency toward increasing upward where none was evident in vibracores.

Results of ^{210}Pb and ^{137}Cs analyses suggest that Tampa Bay is a somewhat less than ideal site for determining accumulation rates based upon this method. Among the principal reasons for this are the locally elevated radium levels produced by local geological conditions, or possibly the active phosphate industry immediately adjacent to the study area. Additionally, the large amount of bay activity may result in the vertical mixing of sediments or disruption of natural depositional patterns. Keeping this in mind, however, we were able to extract tentative accumulation rates from some of the cores.

Station 3-30 had a relatively stable ^{226}Ra profile, with the exception of a high ^{226}Ra activity at approximately 10 cm. A least squares fit yields a sedimentation rate of 0.47 cm/yr. Old Tampa Bay Station 3 (OTB 3) had the best radiochemical profile yielding an accumulation rate of 0.33±0.082 cm/yr.

It is important to keep in mind that the ^{210}Pb dating method gives average accumulation rates for the past 100 years while the ^{137}Cs method yields accumulation rates only for the past 25-30 years. Two out of four Tampa Bay stations had ^{137}Cs profiles that were potentially useful for dating very recent sediments. Station 3-13 had a peak that fell between 1.9 and 4.9 cm. The accumulation rate was determined by taking the mid-point of the two depths and dividing by 27 years. This gives an accumulation estimate of 0.13 cm/yr. ^{137}Cs activity was highest at 5.1 cm at Station 3-30. This maximum was assumed to be the 1963 peak and yields an accumulation rate of 0.19 cm/yr. However, ^{137}Cs was found throughout the core. This could be interpreted as either mobilization of ^{137}Cs downcore or extensive bioturbation.

Sediment Distribution Patterns

Hillsborough Bay sediments consist of a mixture of marine and land-derived carbonate and terrigenous clastic sands and muds. Marine carbonate generally comprise the coarser-grained sands whereas the land-derived quartz-dominated sediments comprise the fine-grained sand and mud fractions. Shell-rich layers intercalated within otherwise muddy sediments probably represent storms or other high energy events that have acted to winnow the fines and concentrate the coarser grained carbonate shell debris at various times throughout the geologic past.

In west central Hillsborough Bay, mud deposits, no distinct alterations in sediment distribution patterns from the period ranging from approximately 2500-6500 years ago to the present could be detected. Mud-dominated sediments have been accumulating, with no observable disruption, since being flooded by the Holocene transgression, which probably began for Hillsborough Bay about 6,000 years ago (Scholl and Stuiver, 1967; Neumann, 1971).

The primary control on sediment distribution for these muds appears to be bathymetry as mud-size sediments have been deposited in bathymetric depressions for the past several thousand years.

The sand-dominated zone sampled by core 3-7 in the northwestern portion of the bay also shows no distinct alterations in sediment distribution patterns in the recent geologic past. Average sediment accumulation rates are consistent with rates calculated for mud-dominated zones.

The southeast mud-dominated zone sampled by core 5-15 shows a steady decrease in grain size and increase in TOC and $\%CO_3$ over the recent geologic past. No dramatic alterations are observed, however, suggesting that there has been a steady, gradual shifting in sedimentation patterns over the last several thousand years. The reason for this shifting is not known but it appears to be localized as this shift is not observed in other cores. The gradual shift is suggestive of a long term event such as rising sea level, as opposed to a dramatic event.

Data from closely spaced samples collected from pushcores show similar patterns to those of corresponding vibracores. Although no strong trends exist, weak tendencies for a variety of cores and parameters were noticed with the vast majority beginning in the 20-30cm range. Hillsborough Bay cores 3-30 and 3-13 show the greatest tendency toward changes in the upper 20-30cm with increases in TOC and calcium carbonate content and a corresponding decrease in grain size, thereby signifying an alteration in sedimentation patterns at some time in the recent geologic past. The upper 20cm (approximate) of fine-grained sediments in west central Hillsborough Bay contain an increased amount of fine-grained material rich in organics and calcium carbonate. Core 10-20 does not show this tendency, indicating that the Hillsborough Bay basin as a whole may not have experienced this alteration in sediment distribution patterns.

Old Tampa Bay core OTB3 is considerably different from Hillsborough Bay cores. Distinctly larger mean grain sizes and lower TOC, and calcium carbonate content percentages indicate Old Tampa Bay (at least the portion where OTB3 was collected), is under different influences and possibly an entirely different sedimentologic regime. A distinct increase in TOC over the upper 10-20cm of core, however, indicates that there has been an increased input or preservation of organics, which is consistent with what was found for Hillsborough Bay cores 3-30 and 3-13.

Lead-210 and ^{137}Cs data show sediment accumulation rates in the 0.13 to 0.42 cm/yr range. Assuming an average accumulation rate of 0.25 cm/yr, observed trends in cores beginning in the 20-30 cm (downcore depth range) would have begun about 100 years ago. Hence, the tendencies noticed toward decreasing grain size, increasing TOC, and to some extent an increase in calcium carbonate content, signify a change in sedimentation patterns, which would be coincidental with early development of the Tampa Bay area.

Comparing sediment accumulation rates of the upper 50-100 cm of sediment calculated from this study to average rates over the last several thousand years, suggest an increase by approximately one order of magnitude over the recent geologic past. As mentioned, accumulation rates determined by ^{210}Pb and ^{137}Cs methods yield an average rate of approximately 0.25 cm/yr over the past 100 or so years. Average rates calculated using radiocarbon methods for the same deposits range from 31-49 cm/1,000 yrs over the past 2,500 to 6,500 years. Such an increase may represent a substantial increase in the input of fine-grained sediments into the bay that may be attributable to early development of the bay area. It must be pointed out, however, that this increase may be an artifact of the different time scales involved. For example, the rates calculated over the last several thousand years are average rates that may include periods of rapid deposition, periods of no deposition, or possibly even erosion. The result is that there may have been periods within this time interval where accumulation rates have been as high or maybe even surpassed those calculated for the last 100 years. Hence, the recent rate increase may be a result of a natural increase in sediment input and not a response to bay area development. The fact that data from different depths in cores yielded consistently similar rates over the past 2,500-6,500 years, however, suggest that there has been some increase in accumulation rate in the recent geologic past. Although rates may have increased at any time in the past few thousand years (there are no data points between approximately 2,500 years ago and 100 years ago), an increase accompanying the alteration of sedimentation patterns observed at approximately 100 years ago would be a reasonable interpretation.

LIST OF REFERENCES

Campbell, K.M., 1973, Geology of Hillsborough County: Tallahassee, Florida Bureau of Geology, 17pp.

Dean, W.E., 1974, Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: comparison with other methods: Jour. of Sed. Petrol., v. 44, p. 242-248.

Doyle, L.J., E.S. VanVleet, W.M. Sackett, N.J. Blake, and G.R. Brooks, 1985, Hydrocarbon levels in Tampa Bay: Final Report to Fla. Department of Natural Resources, 193p.

Esteban, M. and C.F. Klappa, 1983, Subaerial exposure, in P.A. Scholle, D.G. Bebout, and C.H. Moore, eds., Carbonate depositional environments: AAPG, Memoir 33, p. 1-92.

Fehring, W.K., 1985, History of the Port of Tampa, in S.F. Treat, J.L. Simon, R.R. Lewis, and R.L. Whitman, eds., Proceedings, Tampa Bay Area Scientific Information Symposium (BASIS), p. 512-524.

Folk, R.L., 1965, Petrology of sedimentary rocks: Austin, Hemphills, 159p.

George, S.M., 1989, Alarming changes in sedimentation rates in major bays along the Gulf coast: Transactions - GCAGS Trans., v. 39, p. 579.

Goodwin, C.R., 1984, Changes in tidal flow, circulation, and flushing caused by dredge and fill in Tampa Bay, Florida: USGS Open File Report, p. 84-447.

Isphording, W.D., F.D. Imsaud and G.C. Flowers, 1989, Physical characteristics and aging of Gulf coast estuaries: Transactions - GCAGS Trans., v. 39, p. 387-401.

Johansson, J.O.R. and A.P. Squires, 1988, Surface sediments and their relationship to water quality in Hillsborough Bay, a highly impacted subdivision of Tampa Bay, Florida, in E.D. Estevez, ed., Tampa and Sarasota Bays: issues, resources, status and management: Washington D.C., NOAA Estuary of the Month Seminar Series, #11, p. 129-143.

Milliman, J.D., 1974, Marine Carbonates: New York, Springer-Verlag, 375p.

Neumann, A.C., 1971, Quaternary sea-level data from Bermuda: Quaternaria, v. 14, p. 41-43.

Scholl, D.W. and M. Stuiver, 1967, Recent submergence of southern Florida: a comparison with adjacent coasts and other eustatic data: GSA Bull., v. 78, p. 437-454.

Stahl, L.E., 1970, The marine geology of Tampa Bay (M.S. Thesis): Tallahassee, Florida State University, 69p.

Taylor, J.L., J.R. Hall and C.H. Saloman, 1970, Molluscs and benthic environments in Hillsborough Bay, Florida: Fishery Bulletin, v. 68, p. 191-202.

Willis, J.W., 1984, The shallow structure of Tampa Bay (M.S. Thesis): St. Petersburg, University of South Florida, 84p.

FIGURE CAPTIONS

Figure 1. Location map showing Tampa Bay and core locations in the upper Bay.

Figure 2. Vertical distributions of grain size, %CO_3 and %TOC for vibracore 3-7.

Figure 3. Vertical distributions of grain size, %CO_3 and %TOC for vibracore 3-13.

Figure 4. Vertical distributions of grain size, %CO_3 and %TOC for vibracore 13-6.

Figure 5. Vertical distributions of grain size, %CO_3 and %TOC for vibracore 3-30.

Figure 6. Vertical distributions of grain size, %CO_3 and %TOC for vibracore 3-22.

Figure 7. Vertical distributions of grain size, %CO_3 and %TOC for vibracore 5-15.

Figure 8. Vertical distributions of grain size, %CO_3 and %TOC for vibracore 10-20.

Figure 9. Seismic profile showing the irregular basal reflector interpreted to represent the blue-gray clay layer at the top of the Miocene Hawthorne Formation. Also shown in the site of vibracore 3-7, the base of which sampled the blue-gray clay.

Figure 10. Seismic profiles showing subbottom depressions in mud dominated zones at vibracore sites 3-22(A) and 3-13(B).

Figure 11. Vertical distribution of grain size for push cores 3-13, 3-30, 10-20 and OTB3.

Figure 12. Vertical distribution of carbonate content (%CO_3) for push cores 3-13, 3-30, 10-20 and OTB3.

Figure 13. Vertical distribution of %TOC for push cores 3-13, 3-30, 10-20 and OTB3.

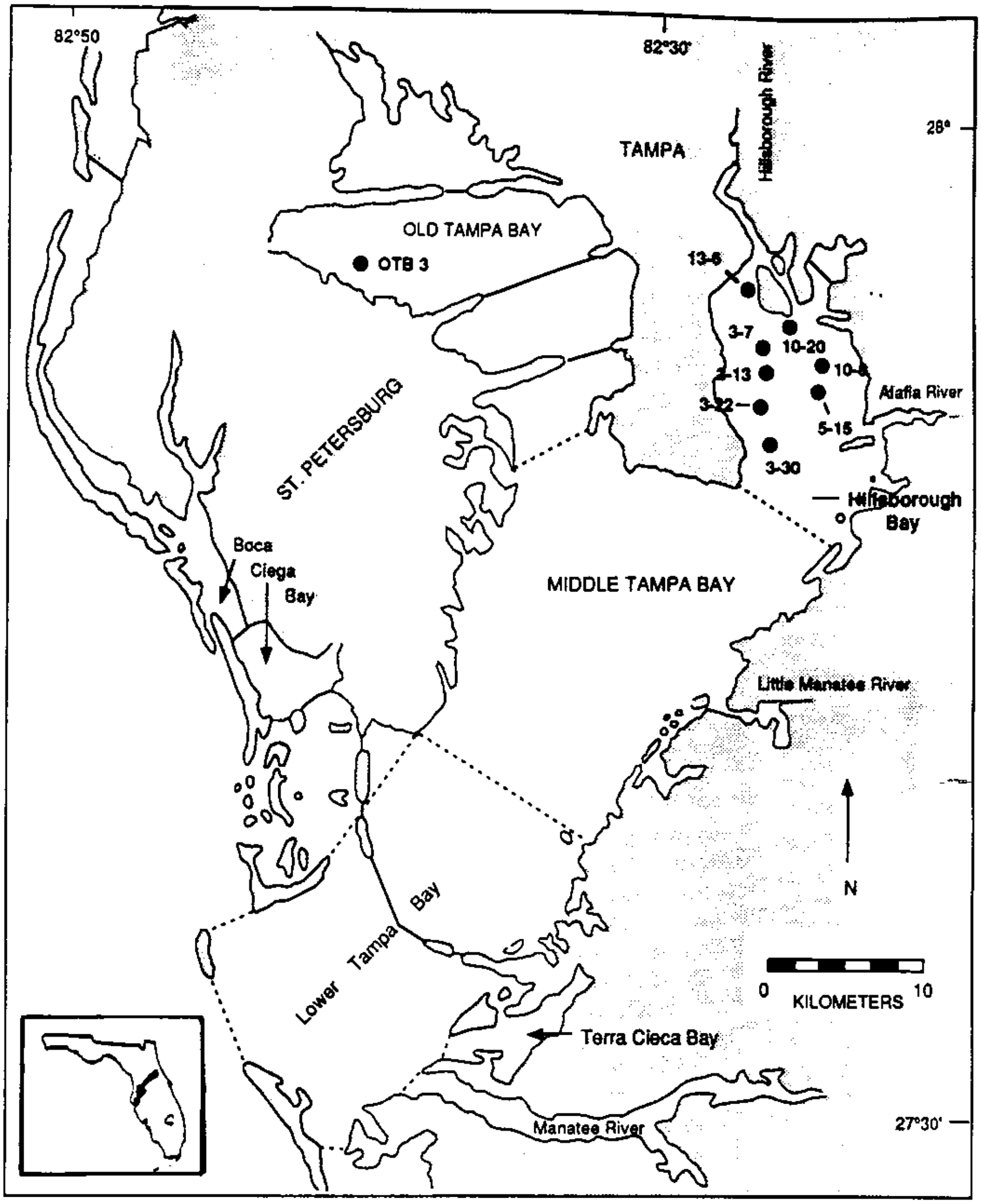

82°50
82°30'
Hillsborough River
28°
TAMPA
OLD TAMPA BAY
OTB 3
13-6
3-7
10-20
3-13
10-8
Alafia River
3-22
5-15
3-30
Hillsborough Bay
ST. PETERSBURG
Boca Ciega Bay
MIDDLE TAMPA BAY
Little Manatee River
N
0
KILOMETERS
10
Lower Tampa Bay
Terra Cieca Bay
Manatee River
27°30'

Figure 1.

Figure 2.

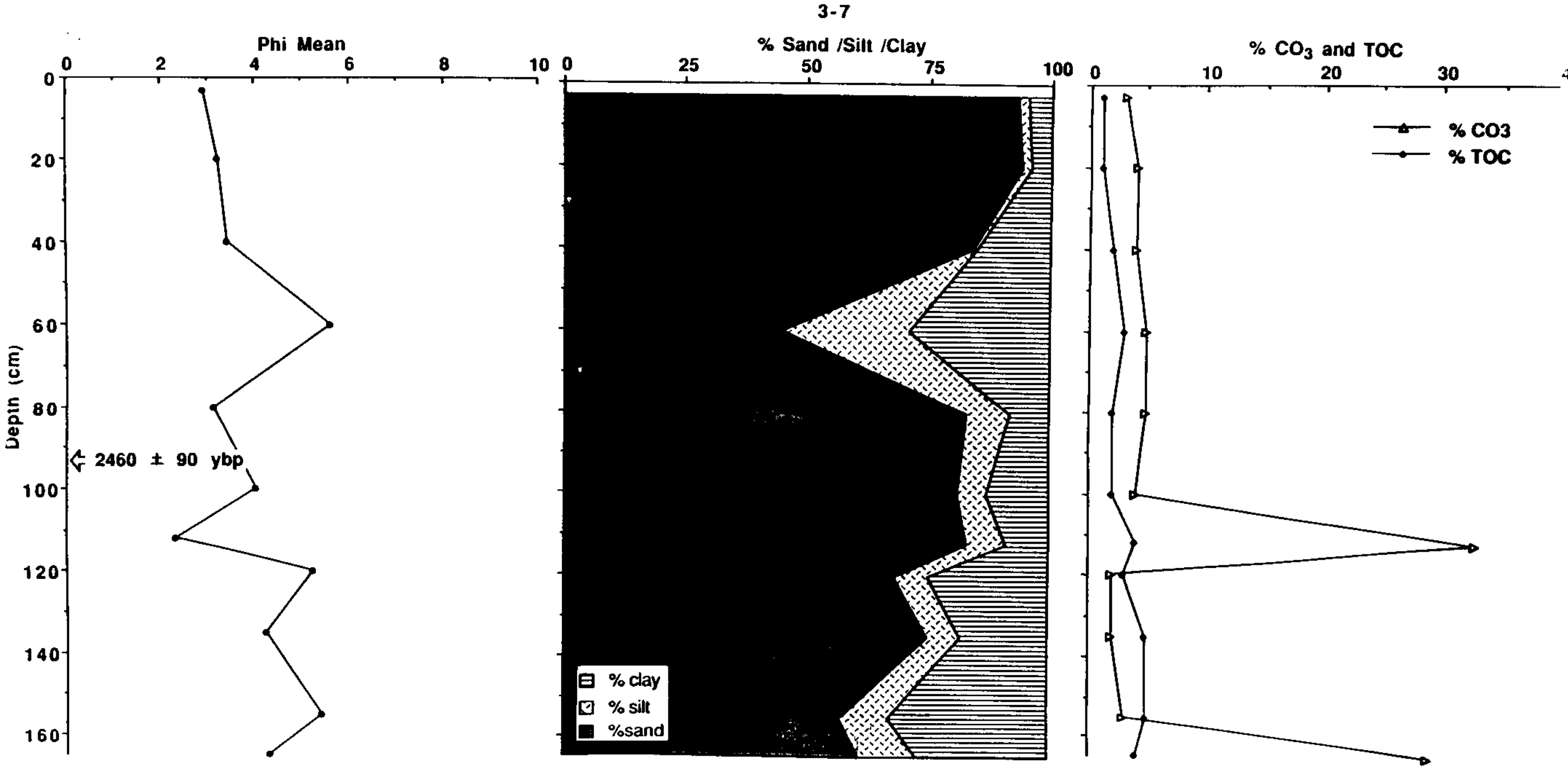
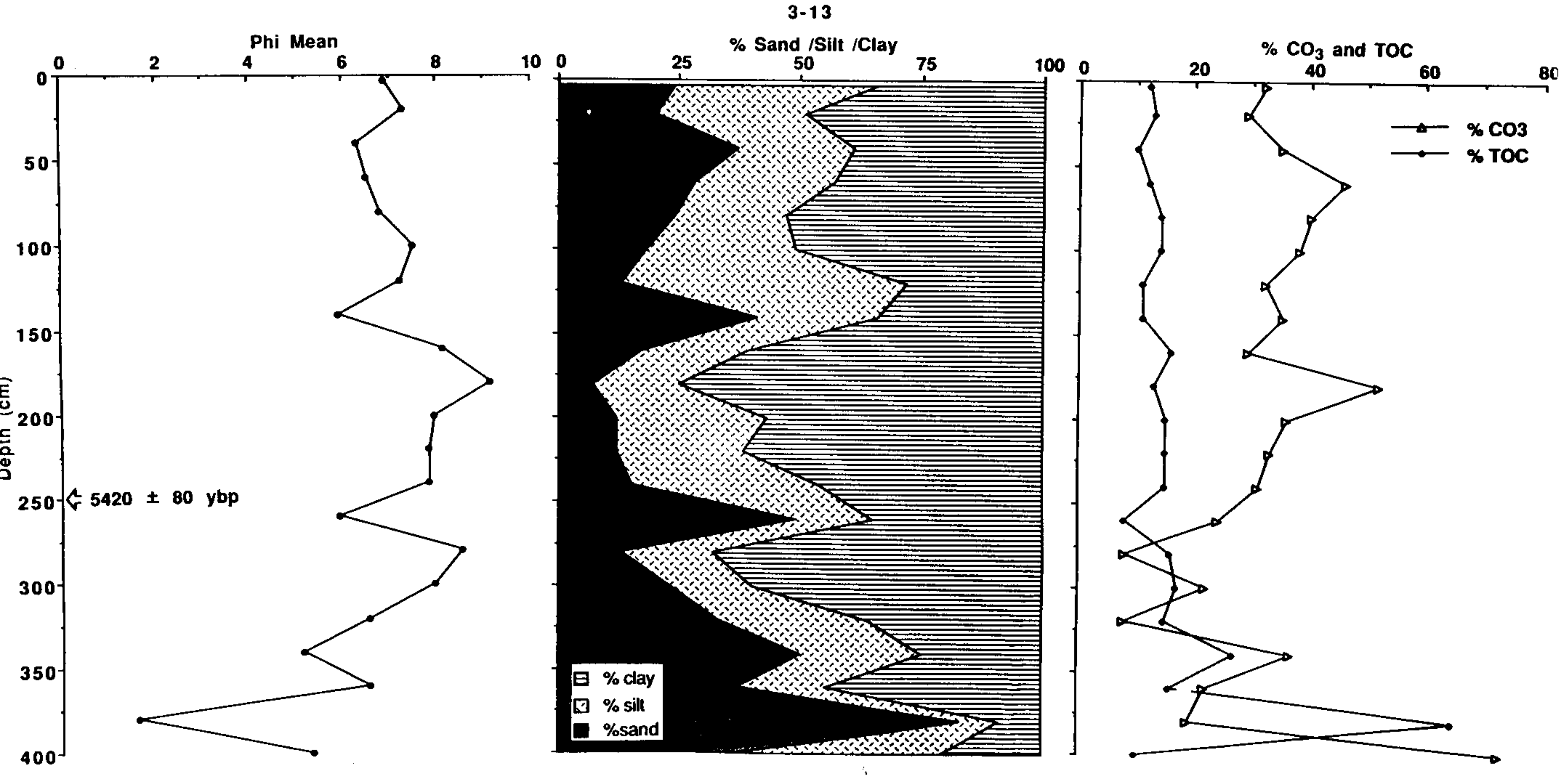

3-7
Phi Mean
0
2
4
6
8
10
Depth (cm)
0
20
40
60
80
100
120
140
160
2460 ± 90 ybp
% Sand /Silt /Clay
0
25
50
75
100
% clay
% silt
%sand
% CO3 and TOC
0
10
20
30
% CO3
% TOC

Figure 3.


3-13
Phi Mean
0
2
4
6
8
10
% Sand /Silt /Clay
0
25
50
75
100
% clay
% silt
%sand
% CO3 and TOC
0
20
40
60
80
% CO3
% TOC
Depth (cm)
0
50
100
150
200
250
300
350
400
5420 ± 80 ybp

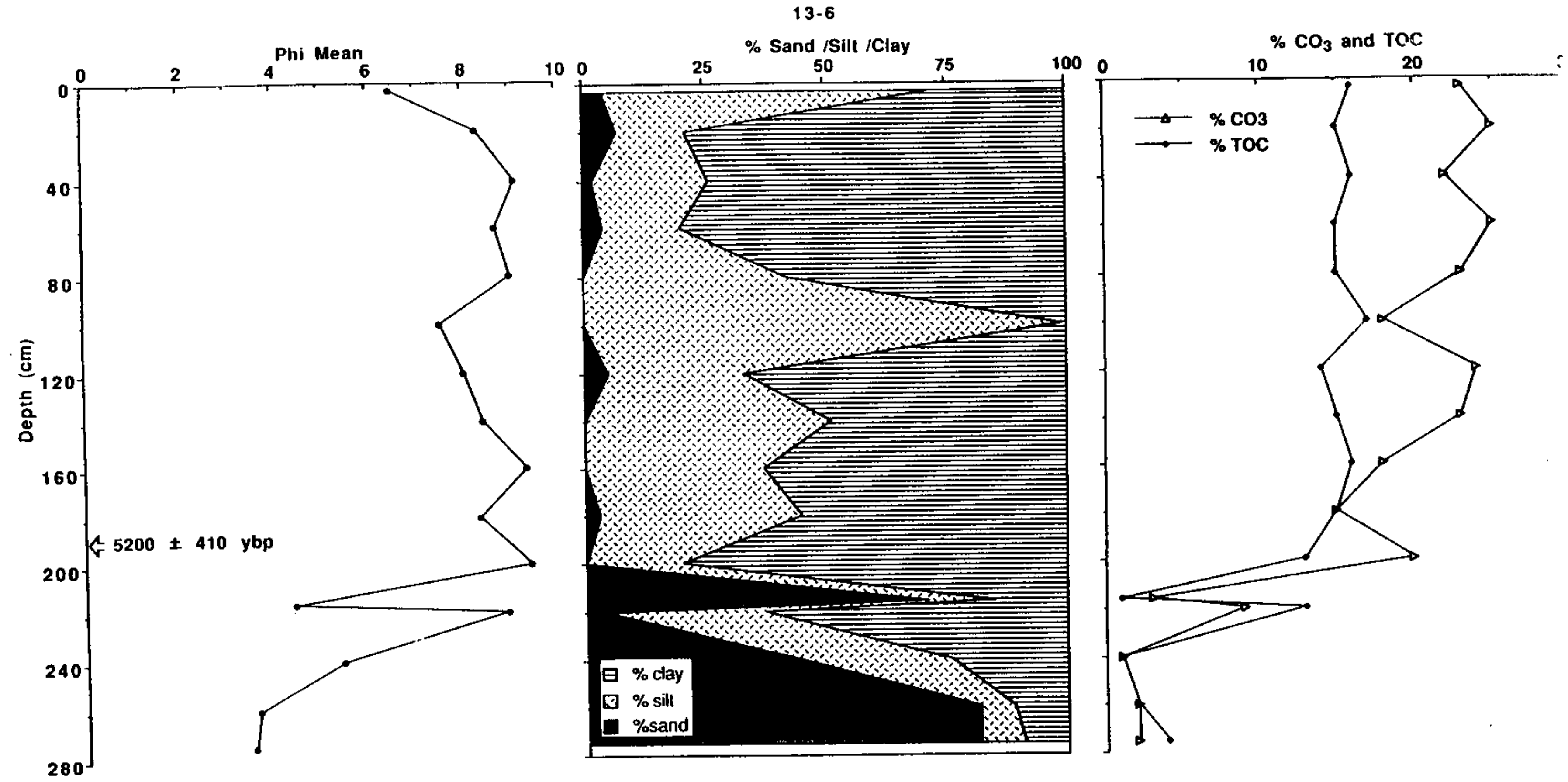
13-6
Phi Mean
0
2
4
6
8
10
Depth (cm)
0
40
80
120
160
200
240
280
5200 ± 410 ybp
% Sand /Silt /Clay
0
25
50
75
100
% clay
% silt
%sand
% CO$_3$ and TOC
0
10
20
% CO3
% TOC

Figure 1.

Figure 5.
6

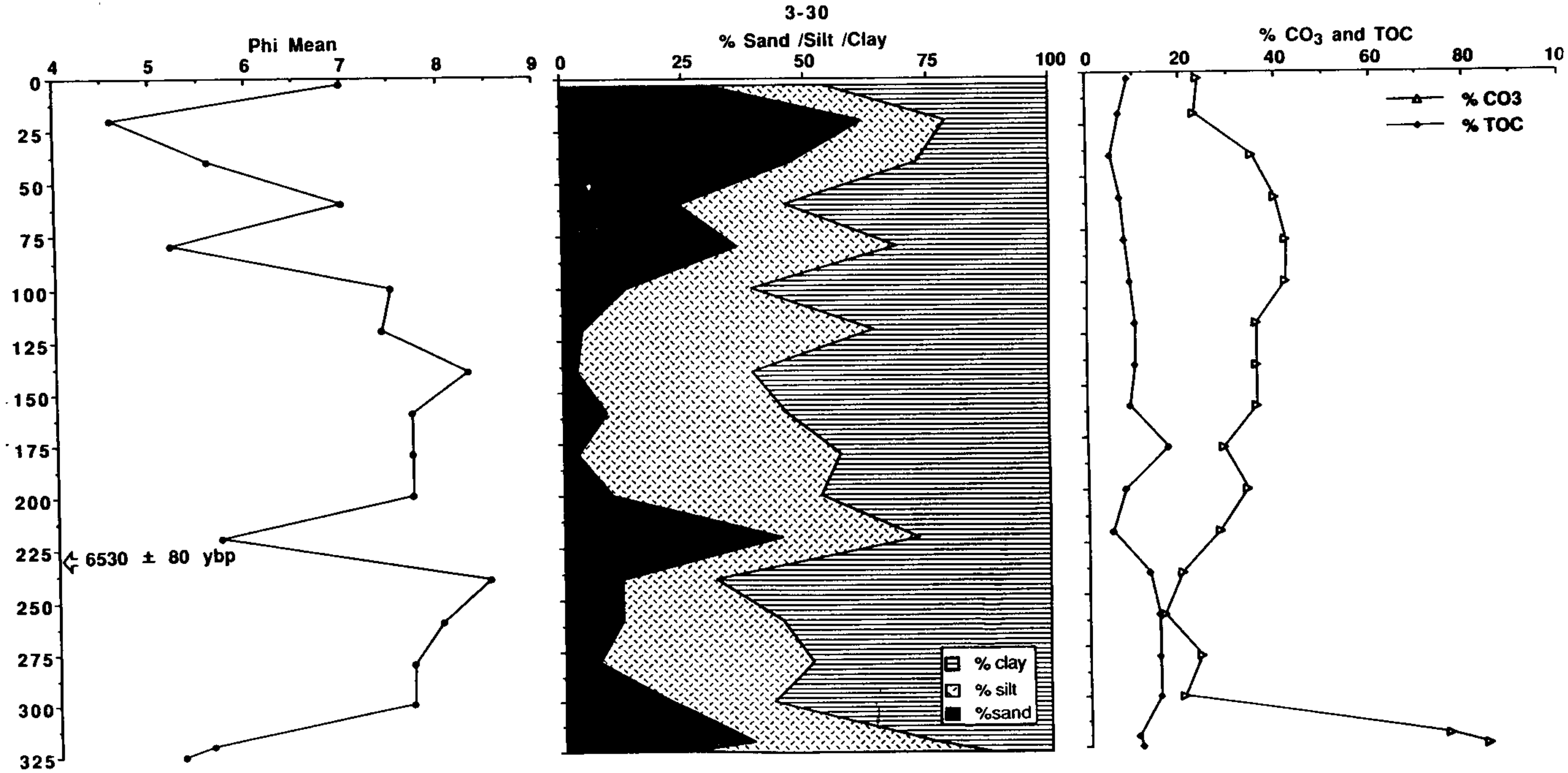
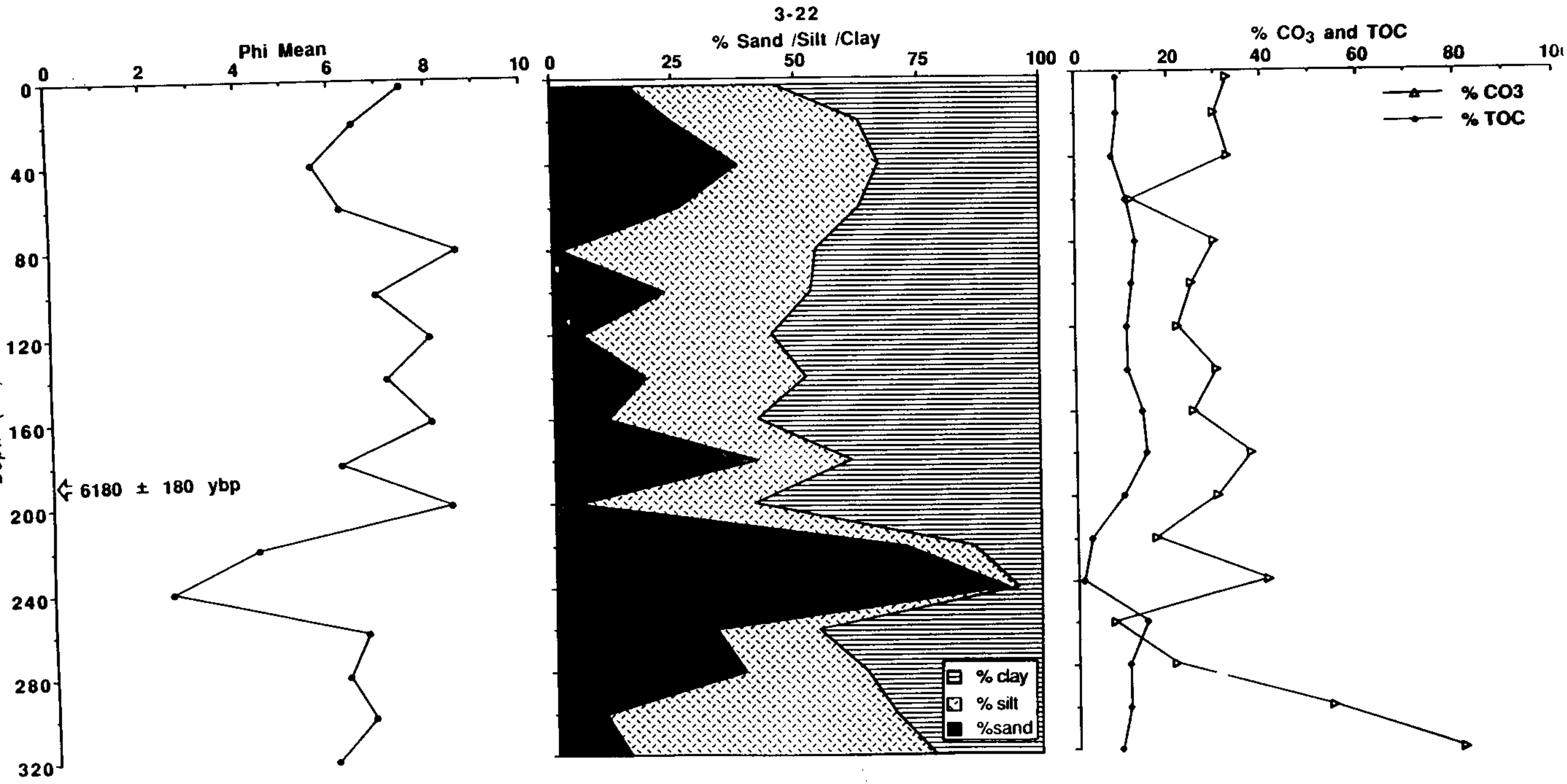

Phi Mean
4
5
6
7
8
9
0
25
50
75
100
125
150
175
200
225
250
275
300
325
6530 ± 80 ybp
3-30
% Sand /Silt /Clay
0
25
50
75
100
% clay
% silt
%sand
% CO₃ and TOC
0
20
40
60
80
10
% CO3
% TOC

Figure 6.


3-22
Phi Mean
0
2
4
6
8
10
0
40
80
120
160
200
240
280
320
6180 ± 180 ybp
% Sand /Silt /Clay
0
25
50
75
100
% clay
% silt
%sand
% CO$_3$ and TOC
0
20
40
60
80
% CO3
% TOC

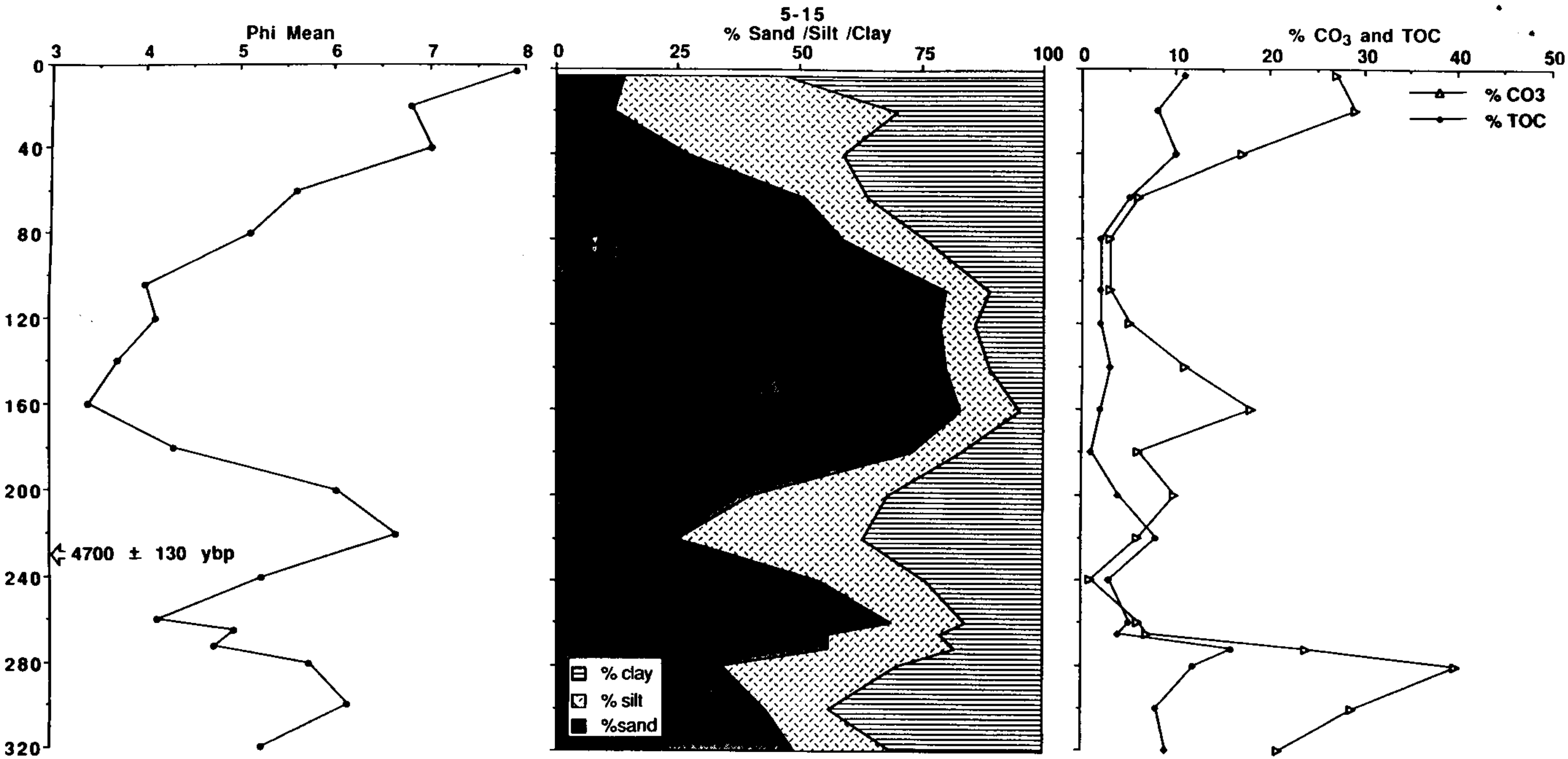
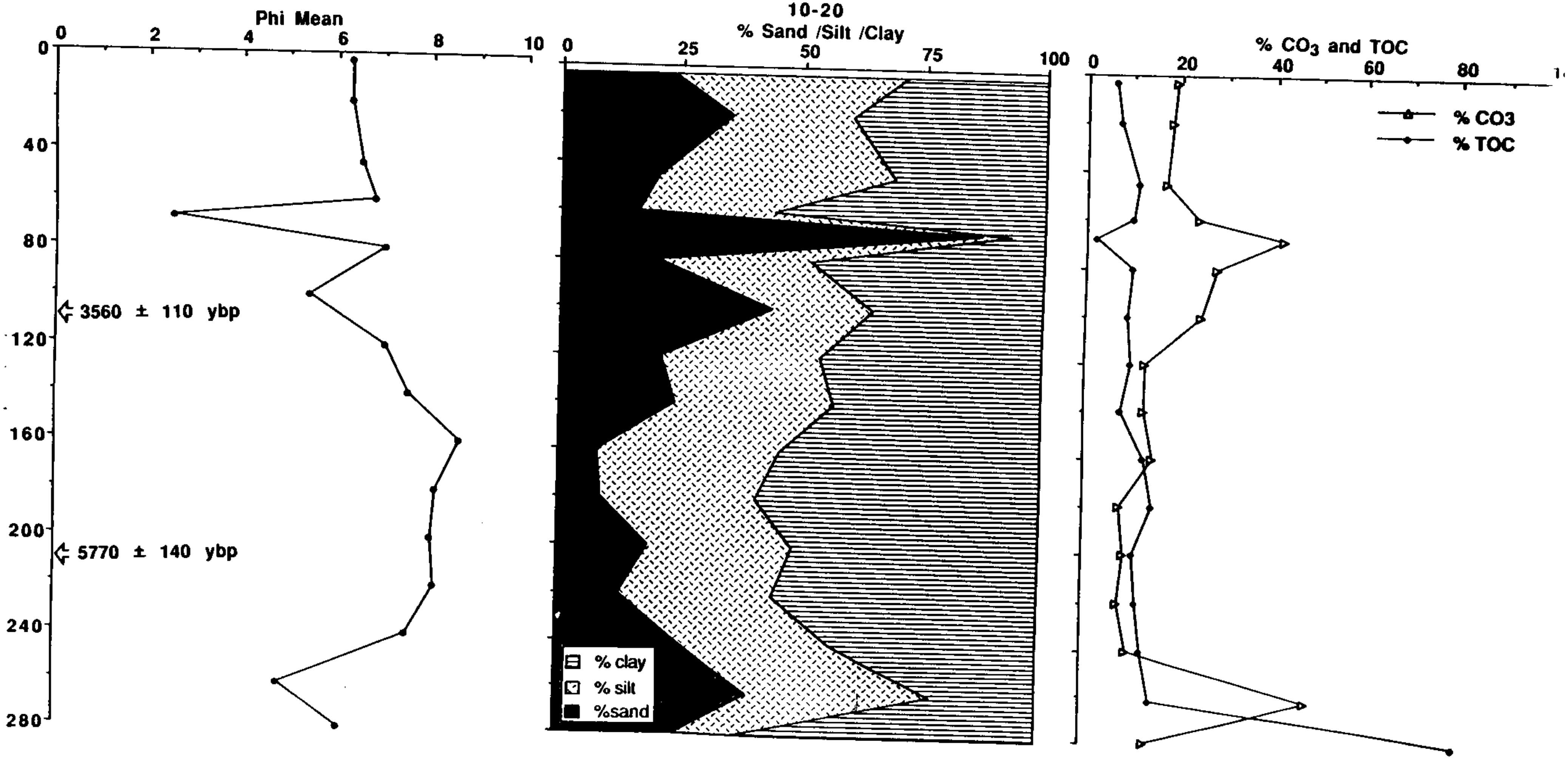

Phi Mean
3
4
5
6
7
8
0
40
80
120
160
200
240
280
320
4700 ± 130 ybp
5-15
% Sand /Silt /Clay
0
25
50
75
100
% clay
% silt
%sand
% CO$_3$ and TOC
0
10
20
30
40
50
% CO3
% TOC

Figure 1.

Figure 8.
C


Phi Mean
0
2
4
6
8
10
0
40
80
120
160
200
240
280
3560 ± 110 ybp
5770 ± 140 ybp
10-20
% Sand /Silt /Clay
0
25
50
75
100
% clay
% silt
%sand
% CO_3 and TOC
0
20
40
60
80
% CO3
% TOC

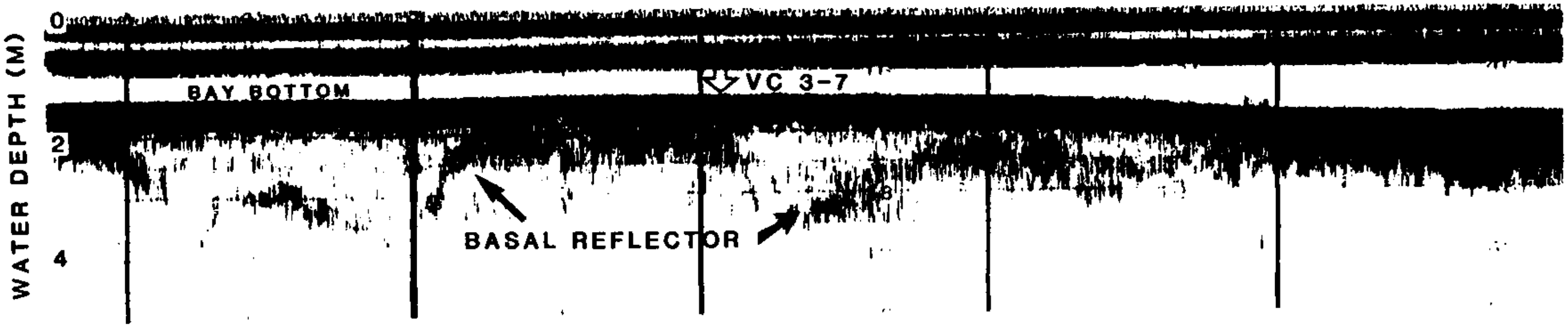


Figure 1.

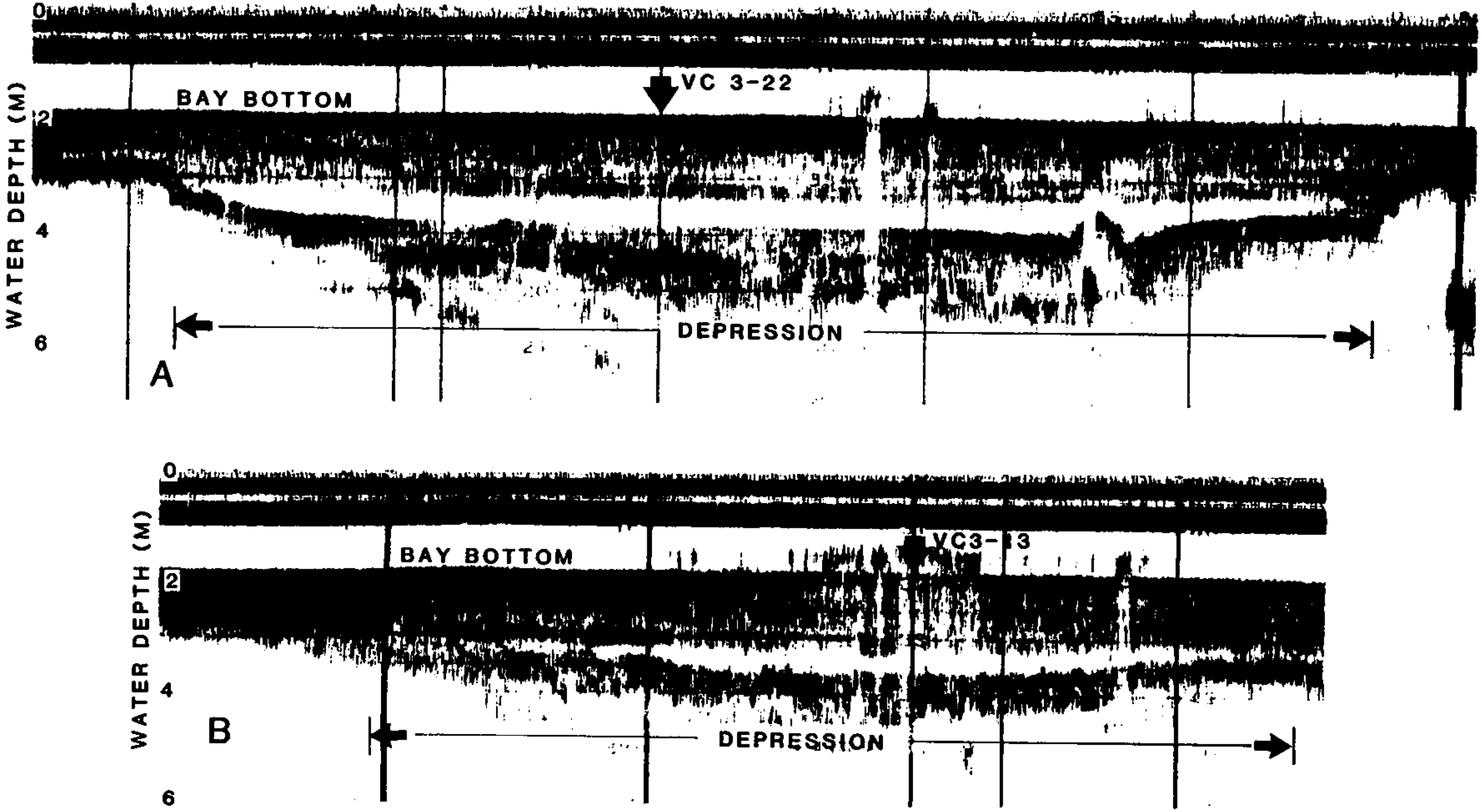

WATER DEPTH (M)
0
2
4
6
BAY BOTTOM
VC 3-22
DEPRESSION
A
WATER DEPTH (M)
0
2
4
6
BAY BOTTOM
VC3-13
DEPRESSION
B

Figure 12.

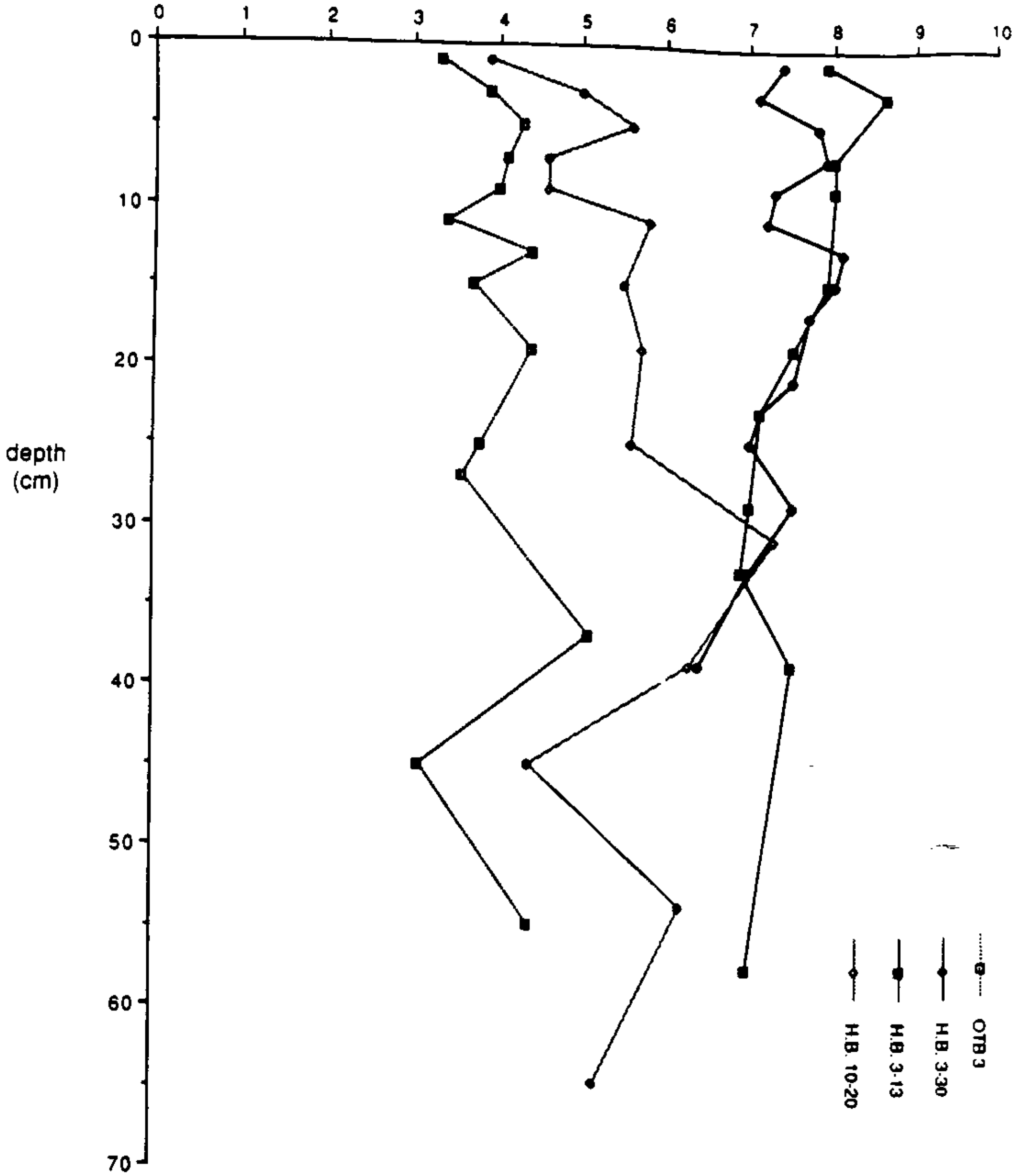

0
1
2
3
4
5
6
7
8
9
10
depth
(cm)
0
10
20
30
40
50
60
70
OTB3
H.B. 3-30
H.B. 3-13
H.B. 10-20

Figure 11.

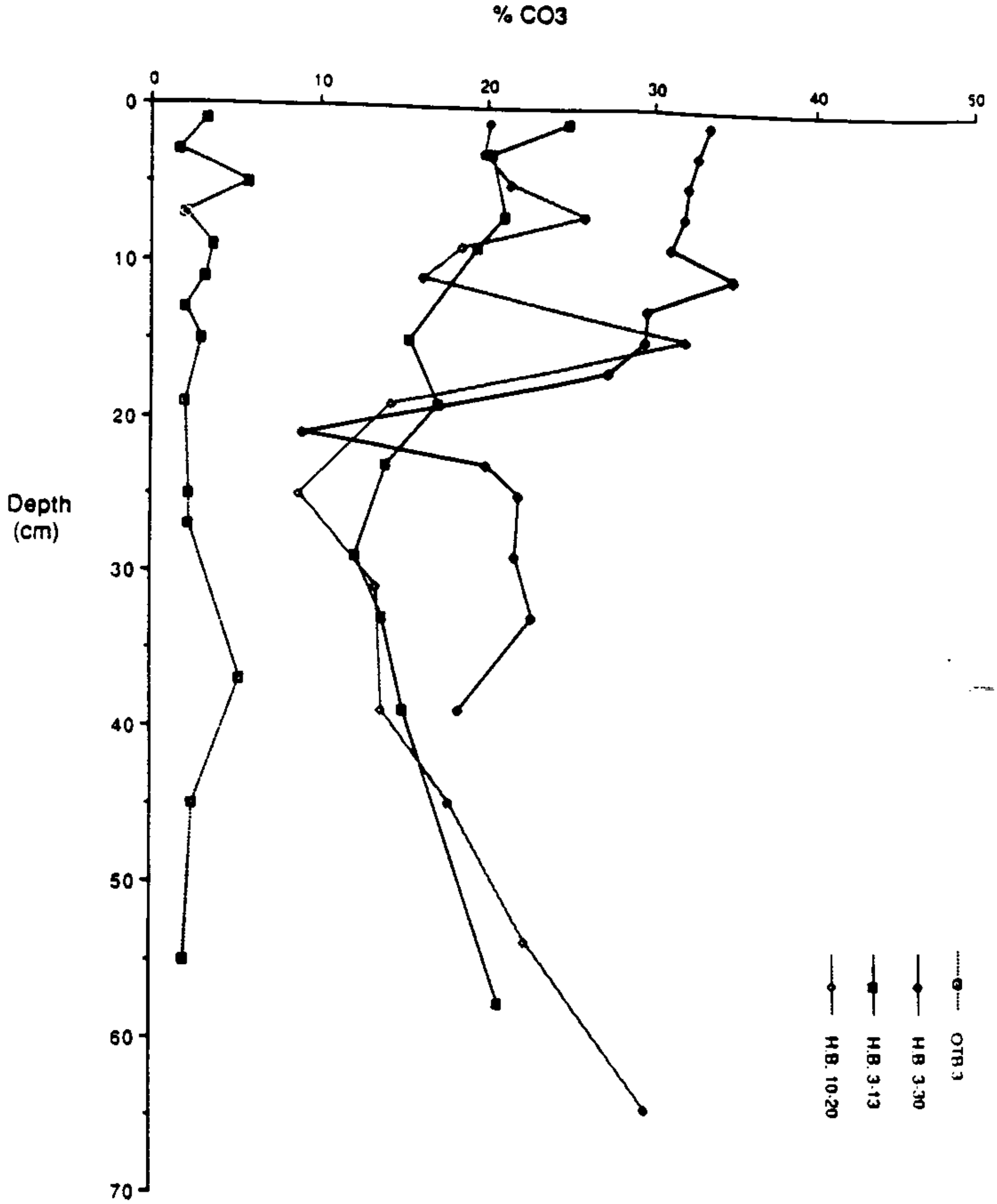

% CO3
0
10
20
30
40
50
Depth (cm)
0
10
20
30
40
50
60
70
OTB 3
H.B. 3:30
H.B. 3:13
H.B. 10:20

Figure 12.

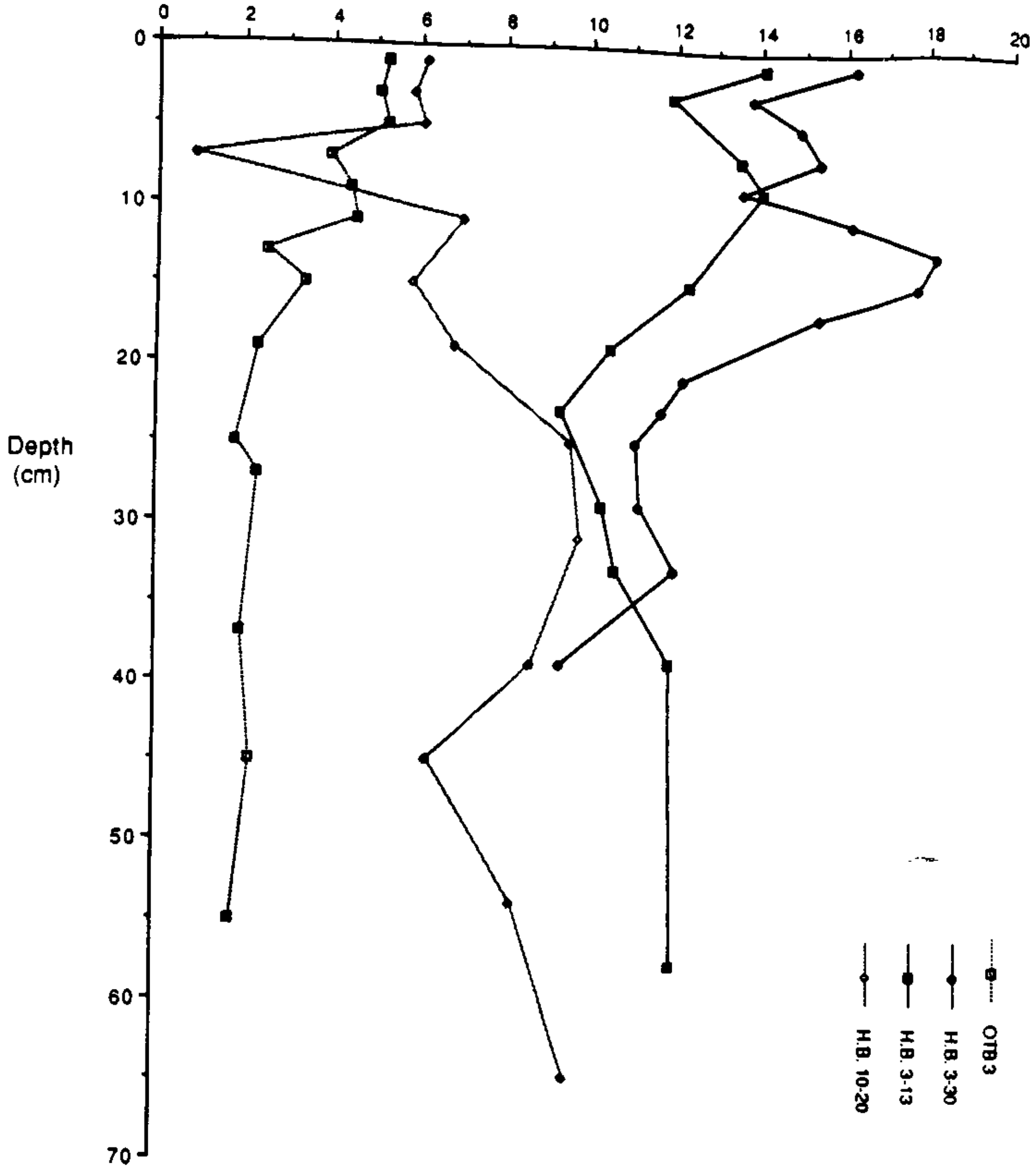

0
2
4
6
8
10
12
14
16
18
20
Depth (cm)
0
10
20
30
40
50
60
70
OTB3
H.B. 3-30
H.B. 3-13
H.B. 10-20

Figure 13.