ORGANIC GEOCHEMICAL COMPARISONS OF FORTUNE BAY AND BAY D'ESPOIR

KALIDAS PULCHAN

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ORGANIC GEOCHEMICAL COMPARISONS OF FORTUNE BAY AND BAY D'ESPOIR.

by

© Kalidas Pulchan BSc. (Hons.)

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graduate studies in partial fulfillment of the
requirements for the degree of Master of Science

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ABSTRACT

Fortune Bay and Bay D'Espoir are two fjords in close proximity, yet with contrasting internal properties and processes. Samples from six cores from Bay D'Espoir and five cores from Fortune Bay were analysed for organic carbon and nitrogen content, $\delta^{13}C$, $\delta^{15}N$, and total and individual amino acids. The $\delta^{13}C$ values for Bay D'Espoir samples were relatively lower than those for Fortune Bay, indicating a stronger influence of a terrigenous source in Bay D'Espoir. The $\delta^{15}N$ values were constant (7-8°/oo) for all cores except for cores BDE-1643 and BDE-1657, which were strongly depleted in ^{13}C and ^{15}N. The $\delta^{15}N$ and the amino acid signatures delineate a predominantly macrophytic source of organics within both bays. Productivity levels were reflected in the percent organic carbon and total amino acid abundances which were higher in Fortune Bay samples than those in Bay D'Espoir samples. There is a general decrease in percent organic carbon and total amino acids with depth. The magnitude of this trend varies with each core. In cores FO-840404 and FO-840405 the trend may be related to a change from modern marine sedimentation to glaciomarine sedimentation. The change in sedimentation pattern is also reflected in the fraction greater than 63μ, foraminiferal count and ^{18}O abundances of the foraminiferal carbonate tests. Finally, the D_{ALE}/L_{ILE} indicated higher sedimentation rates in Bay D'Espoir than in Fortune Bay.

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INTRODUCTION

1.1. Prologue

Fjords are deep, glacially excavated estuaries that have several unique characteristics when compared to more shallow embayments. They are commonly found along high latitude western coastlines and may be considered as miniature ocean systems wherein reaction rates and environmental gradients may be an order of magnitude higher than similar oceanic rates and gradients. Thus fjords can be natural laboratories where various environmental, geochemical, sedimentological and biological problems can be investigated at an accelerated time scale.

1.2. The study area

Both Fortune Bay and Bay D'Espoir are located along the southern shore of Newfoundland adjacent to one another (Fig. 1-1). They are both regarded as fjords with respect to location, morphology and restricted circulation. Fortune Bay is a shallow fjord. The maximum depth is 526 meters in Belle Bay, separated from the rest of Fortune Bay by a sill 195 meters deep (Fig. 1-2) (DeYoung, 1983). The mean depth of Fortune Bay is 120 meters and the maximum depth of the main part of the bay is 420 meters (DeYoung, 1983). In the center of the bay is a bank 15 kilometers long and about 180 meters deep.

The bay has three sills - St. Pierre, Miquelon and Sagona sills - with limiting sill depths of 125, 115, and 100 meters respectively (DeYoung, 1983). The Miquelon and Sagona sills connect to the Hermitage channel, whereas the St. Pierre sill

Figure 1-1: The study area showing core locations of Fortune Bay.

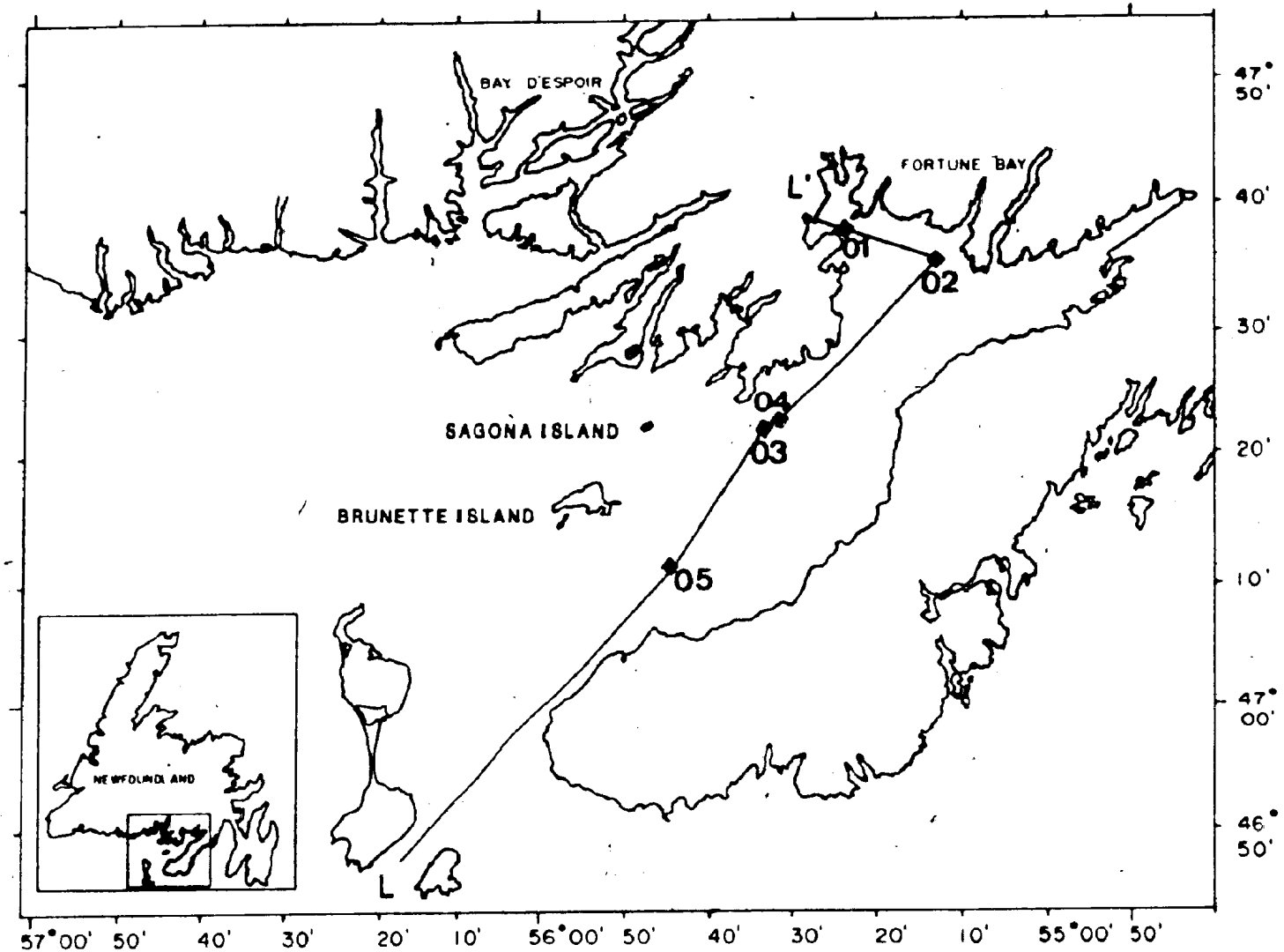
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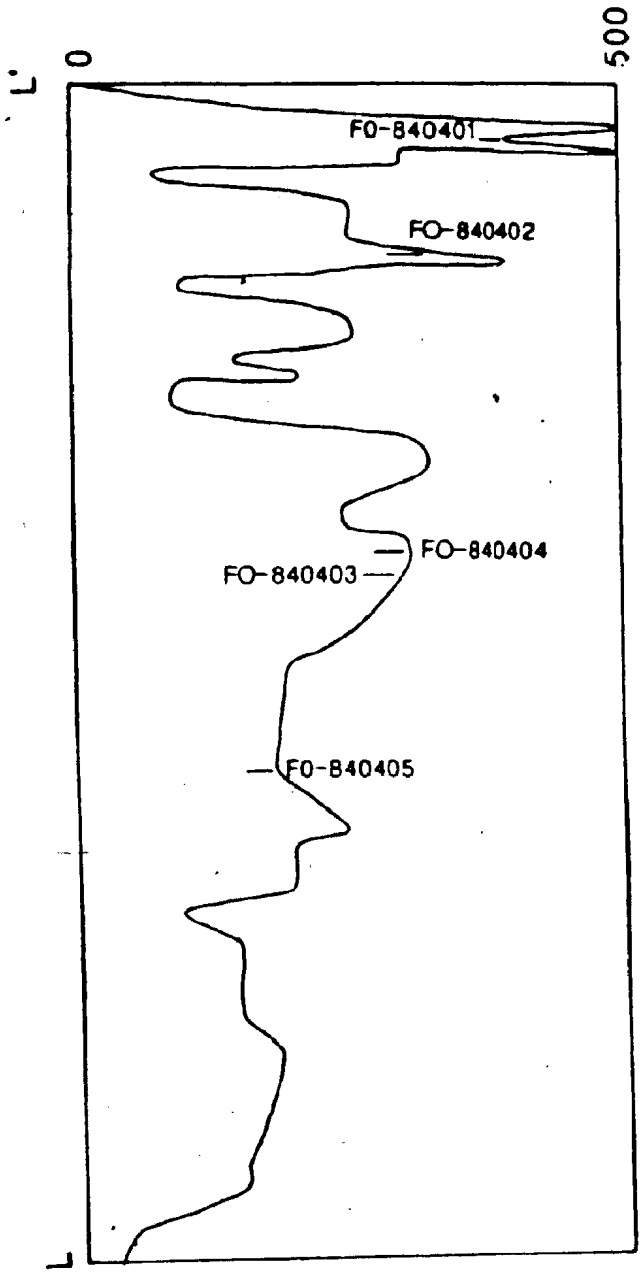
Figure 1-2: Cross section of Fortune Bay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gives access to the St. Pierre Channel (DeYoung, 1983). The St. Pierre channel transports cold Labrador Current Water (-0.5 to -1.0 °C) which is relatively fresh with a salinity of 33.0 °/oo (DeYoung, 1983; Richard and Hay, 1984).The Hermitage channel is a two layered system with respect to water type - Modified Slope Water from the bottom to intermediate depths near 150 meters and an upper layer of cold Labrador Current Water (DeYoung, 1983; Richard and Hay, 1984). The Modified Slope Water is warm and saline with temperatures of 4 to 6 °C and a salinity of 34.5 °/oo (Richard and Hay, 1984).

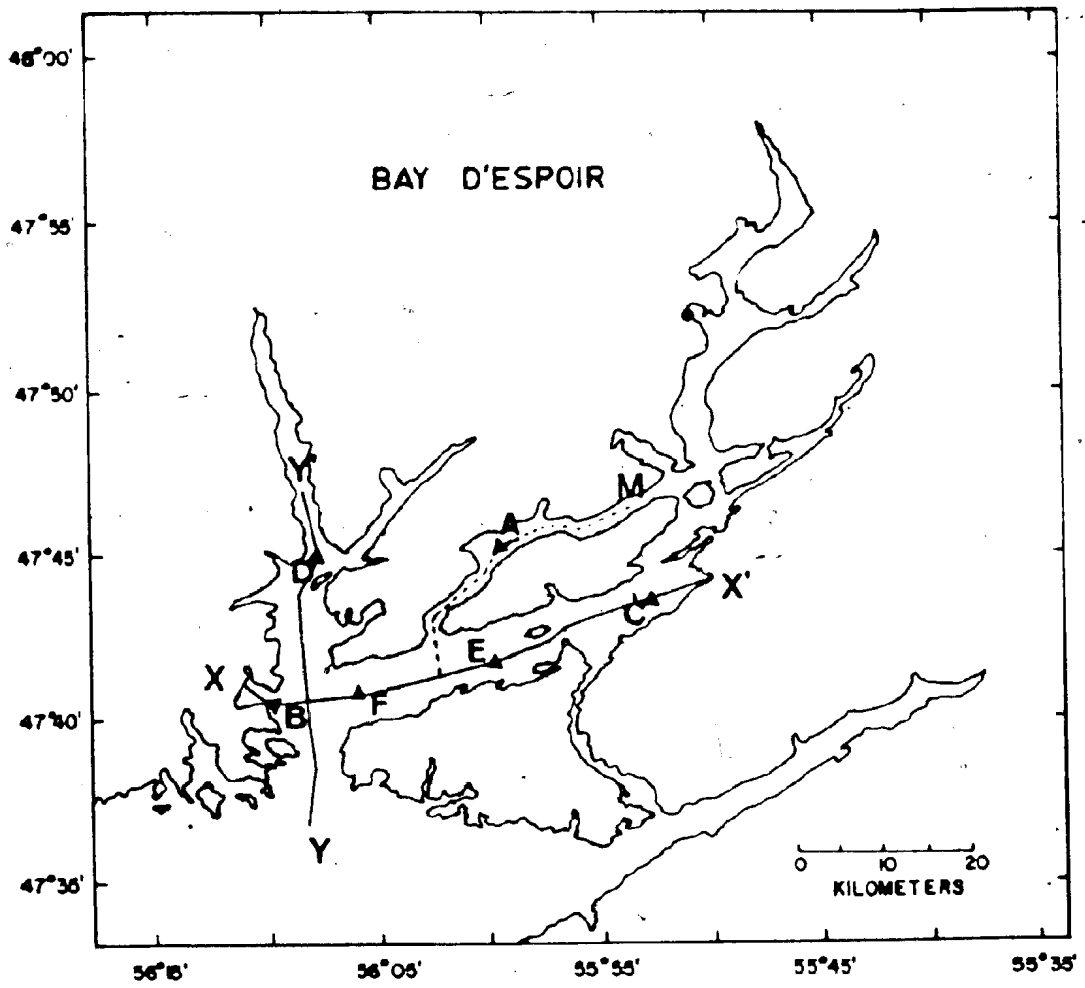
The main source of freshwater into Fortune Bay is from the Bay du Nord River which runs into Belle Bay. This total yearly contribution of freshwater into the bay , expressed as a percentage of the bay, is about 0.6% (DeYoung, 1984).

Bay D'Espoir is a deeper fjord consisting of a deep outer basin connected to two shallow principal arms (Fig. 1-3). The maximum depth of the outer basin is 773 meters as compared to 289 meters (in Lampidos Passage) in the inner basin. A total of 10 sills, 1 outer and 9 inner ones occur between the mouth and the head (Fig. 1-4) (Richard and Hay, 1984). The outer sill, about 280 meters deep, at the seaward entrance of Hermitage Bay, limits the exchange of deep water between the main basin and Hermitage channel (Richard and Hay, 1984). The inner sills, especially those at Copper Head and Riches Island, which are respectively 40 and 27 meters deep, restrict the exchange of water between the outer and inner basin to the extent that the water properties of the inner basin are not influenced by the Modified Slope Water (Richard and Hay, 1984).

The upper Bay D'Espoir region has three major sources of freshwater input: the Bay D'Espoir power plant, the Conne River and Southeast Brook (Richard and Hay, 1984).Additional inflow is derived from the Bay D'Espoir Brook and Salmon River.

The contrasting properties of the two fjords in terms of morphology and the resultant internal circulation make this study particularly interesting. Fortune

Figure 1-3: Core locations of Bay D'espoir



A = BDE-11

B = BDE-1657

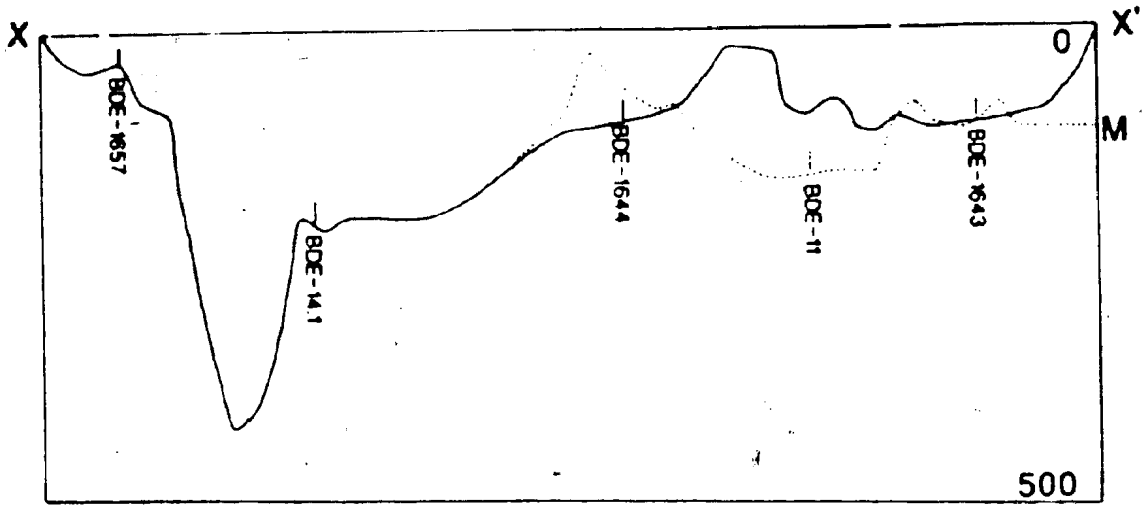
C = BDE-1643

D = BDE-NB4

E = BDE-1644

F = BDE-14.1

Figure 1-4: Sections of Bay D'espoir.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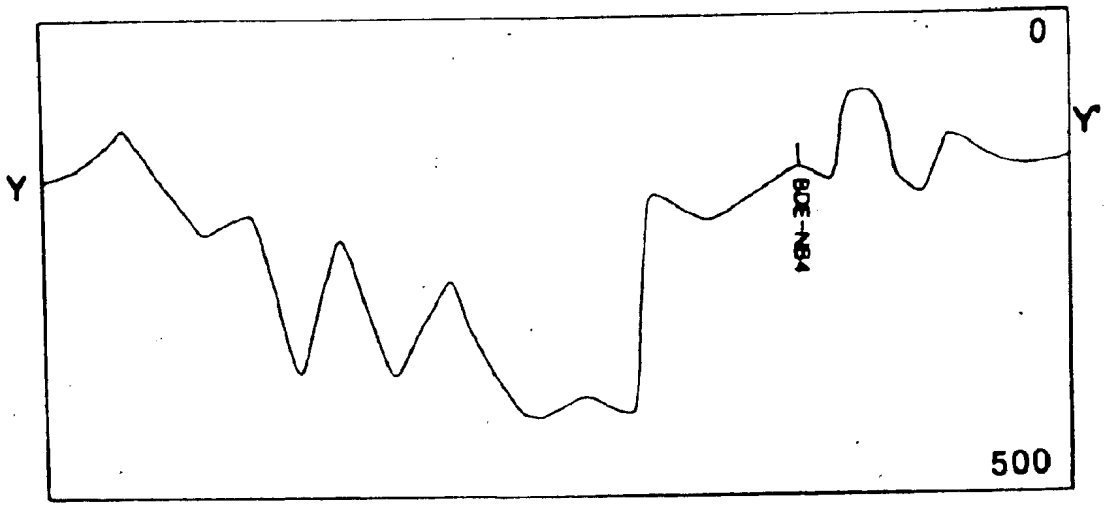
0
Y
Y'
BDE-NB4
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Bay is a large fjord with unrestricted internal circulation. It recieves seawater from two different major channels, and the influx of freshwater is insignificant. On the other hand Bay D'Espoir recieves seawater from one major channel. It has several sills landward of the main mouth thereby breaking the fjord into partially separated basins and restricting intra-fjordic circulation. Thus the productivity of the Modified Slope Water and a mixture of the Modified Slope Water and Labrador Current can be compared. Finally, the freshwater influx into Bay D'Espoir appears to be significant, causing Bay D'Espoir to be less saline than Fortune Bay. Bay D'Espoir may therefore have significant terrestrial organic inputs.

Thus it was expected that, although productivity in Fortune Bay is higher, restricted circulation of Bay D'Espoir create a better environment for preservation of organics. This thesis describes the organic geochemistry of both bays. It relates primary productivity to the water types and temperatures and compares the relative inputs of organic matter at various localities in Fortune Bay and Bay D'Espoir. Environmental conditions relating to preservation of organic matter and the biochemical reactions involved in the destruction of organic matter are also investigated. These results are then utilized to interpret the glacial history of the area.

1.3. Late Quaternary glacial history of study area

There are two basic hypotheses concerning the local timing of events and glacial ice distribution during the Wisconsin glaciation. King and Fader,(1986) suggest an encompassing ice cover from Early to Late Wisconsin and by late Wisconsin the ice cover was in a recessional stage reaching the present day coast by $\sim$ 16 Ka ago. Tucker and McCann (1980) report evidence that there were two ice sheets and the glacial maximum was from Early to Mid Wisconsin. The southern Hermitage area was influenced by a small ice cap centered north and east of the Hermitage area which moved southward during the Late Wisconsin ($\sim$ 18 Ka) (Leckie and McCann, 1982; Tucker and McCann, 1980).

In either case the sequence of events remains the same - glaciomarine sedimentation in a deep sub-basin during the glacial maximum followed by proximal and distal glacial deposits and finally a return to normal marine conditions (as sea level rises).

1.4. Sedimentation of organic matter

Organic matter represents a small fraction of the total sedimentary material. It consists primarily of naturally occurring biopolymers (polysaccharides, lipids, proteins, sporopollenins, lignin cuticles), geopolymers such as humic material and residual organic matter and biomonomers which includes decomposition products, mainly from microbial activity of the biopolymers (Brooks, 1978; Morris and Culkin, 1975).

The organic matter incorporated into the sediments of the fjords may be from terrestrial and marine sources. Terrestrial detritus may enter fjords by a number of processes. River transport is the major input mechanism for terrigenous organic matter to nearshore marine environments (Simoneit, 1978; Romankevich, 1984). This organic matter is in the form of dissolved organic compounds and suspended particulate organics. Aeolian transport carries fine grained particles into the marine environment. Other forms of transport include glacial runoffs, ice rafting and slumping. Once material is deposited in the fjordic environment, it may be redistributed by turbidity currents. The allochthonous organic matter is derived mainly from terrestrial biosyntheses (and industrial activities) (Eglinton and Barnes, 1978). In route to the marine environment, this organic matter may be subjected to considerable microbial degradation and could be enriched in more resistant molecules (Eglinton and Barnes, 1978).

Marine organic matter is principally autochthonous material derived from marine flora and fauna (Bordovskiy, 1965; Romankevich, 1984). Phytoplankton, zooplankton, bacteria and algae and macrophytes populations produce autochthonous organic matter in the fjord environment (Nienhius, 1981).

Photosynthesis by phytoplankton is the main source of organic matter and may account for more than 90% of the marine primary productivity (Nienhius, 1981). The distribution and abundance of plankton is dependent on the supply of nutrients (Bordovskiy, 1965; Ward, 1985). Fjords are known to contain highly diverse, seasonally changing populations of plankton that vary both in number and estuarine location (Lewis and Syvitski, 1983). Plankton populations may be concentrated in near stagnant waters, sheltered behind sills, upwelling areas and near river mouths.

Sedimentation of organic matter is effected mainly by active transportation as it passes through food chains, extracted by filter feeding organisms and by absorption of dissolved organic matter on to mineral particles or coagulation of organic colloids (Bordovskiy, 1965).

1.5. Early diagenesis

The physico-chemico-microbiological changes that operate during deposition and within the first meter of burial are termed early diagenesis (Brooks, 1978). Biological agents are the principal factors in the degradation of organics during early diagenesis, the most important are the benthic fauna and abundant microorganisms (Bordovskiy, 1965). The marine benthos generally recycles the upper 2 to 10 cm of sediment thereby exposing materials several times to oxic conditions. Eventually the sediment is buried below the zone of reworking and remains in an anoxic environment.

The most significant agents of degradation of organic matter in the sedimentary column are bacteria, which vary in number and type and with increasing depth of sediment and physico-chemical conditions within the sediment (Bordovskiy, 1965; Moore, 1969; Morris and Culkin, 1975; Brooks, 1978). Bacteria and bacterial degradation are most abundant at the surface of the sediment layer, in the zone of active reworking (Bordovskiy, 1965; Moore, 1969; Morris and Culkin, 1975 Brooks, 1978). This is accomplished by many enzymatic reactions which cleave

large molecules (biopolymers) into smaller and simpler molecules (monomers) (Brooks, 1978; Morris and Culkin, 1975). These microbiological degradation products can be identified in recent and ancient environments as "bio-markers" (Eglinton, 1969). Below the zone of reworking, the sediment contains no free oxygen and living aerobic bacteria decrease at a logarithmic rate. Consequently it is usually observed that the amount of organic matter decreases with depth.

Bacterial degradation is accompanied by the incorporation of metabolic by-products and dead bacterial cells entering the sediment. This biological activity presents an analytical problem in that it is difficult, if not impossible to distinguish between the organic compounds extracted from living organisms inhabiting the sediment and those extracted from the non-living content of the sediment (Eglinton, 1969).

Early diagenesis also involves several chemical reactions occurring in the upper meter of the sedimentary column (Brooks, 1978). These reactions may include cleavage of carbon - carbon bonds, reduction of unsaturated carbon - carbon bonds, disproportionation reactions, aromatisation and loss of NH_3, H_2S, CO_2 and CH_4 from organic molecules (Brooks, 1978).

The quality and quantity of organic matter found in a sediment are a function of many environmental parameters and the source of the organic matter. In this thesis, multiple tracer analysis is employed to determine the sources of organic matter and reconstruct the depositional environment. Stable isotopes of carbon and nitrogen and abundances of amino acids in sediments are used to determine the source of organics and some depositional conditions. The oxygen isotopic determinations of the carbonate of foraminiferal tests are used to estimate paleosalinities which may indicate sea level changes resulting from the Wisconsin glaciation. Finally, use is made of the epimerization of L-ILE to D-AILE in foraminiferal tests as a chronological tool to better establish any events in a time frame.

1.6. Stable carbon and nitrogen isotopes

Carbon and nitrogen both have two stable isotopes. The relative abundances are:

$^{12}C = 98.89\%$ $^{13}C = 1.11\%$
$^{14}N = 99.64\%$ $^{15}N = 0.36\%$

The carbon and nitrogen isotopic signature of marine and terrestrial organisms is usually preserved in the organic component of the sediment.

Fractionation of organic carbon during photosynthesis is controlled by environmental and metabolic effects (Degens et al., 1969). Maximum fractionation is achieved when pH and water temperature are low, the dissolved carbon dioxide concentration is high and the growth rate of the plant population is moderate (Degens et al., 1969). Of these variables, temperature effects on fractionation is the most pronounced. Plankton in lower temperature waters produce isotopically light carbon (Parker et al., 1972; Newman et al., 1973; Sackett et al., 1973; Fontugne and Duplessy, 1978; Sackett, 1986). A systematic relationship is observed between ^{13}C values of oceanic plankton and surface water temperature: ^{13}C values range from about -30.0°/oo at 2°C to about -20.0°/oo at 15°C (Sackett et al., 1973). Furthermore, analysis of phytoplankton from several different locations indicate different mineral carbon fixation pathways on either side of a 25 °C isotherm (Fontugne and Duplessy, 1981). The $\delta^{13}C$ values increase linearly from low temperatures (-1 °C) to 25 °C, above which the $\delta^{13}C$ values decreased slightly. This was attributed to different metabolic pathways operative on either side of the 25 °C isotherm.

Metabolic effects become important in the photosynthetic pathway of the plant. There are three pathways (Black, 1976; Hoefs, 1980; Fry and Sherr, 1984; Sternberg et al., 1984):

(1) The Calvin or C3 pathway, where CO_2 is incorporated from the atmosphere by carboxylation of ribulose diphosphate (RUDP).

(2) The Hatch Slack or C4 pathway, where CO_2 is fixed by carboxylation of phosphoenolpyruvate (PEP) followed by transportation of the carboxylation product to the outer layer of the photosynthetic cell where decarboxylation and refixation by RUDP occurs.

(3) Crassulacean Acid Metabolism or CAM pathway, which can utilise either RUDP or PEP Carboxylase for CO_2 fixation, depending on environmental conditions.

The different enzymatic reactions during photosynthesis by C3 and C4 plants produce the most ^{13}C-depleted plants (-26.0 to -31.0°/oo) and the most ^{13}C-enriched plants (-12.0 to -15.0°/oo), respectively (Fig. 1-5) (Hoefs, 1980). The $\delta^{13}C$ values for CAM plants reflect both C3 and C4 pathways and span the entire range of ^{13}C values for land plants (Fig. 1-5) (Black, 1976). However, CAM plants are rare and not consequential for the estimation of terriginous inputs to marine environments.

Stable isotopes of carbon can be used to investigate the following:

(1) The amounts and location of terrestrial and marine inputs in nearshore environments. The $\delta^{13}C$ values of recent marine sediments (about -20.00°/oo) are approximately the same as that of the organisms in that environment, except in areas which recieve large allochthonous influxes (Parker, 1964; Simoneit, 1976). Significant positive correlation exists between $\delta^{13}C$, distance from river mouth and grain size (Gearing et al., 1977). Grain size may be a function of source because terrigenous detritus tends to be larger than marine (Newman et al., 1973; Gearing et al., 1977; Parker, 1977).

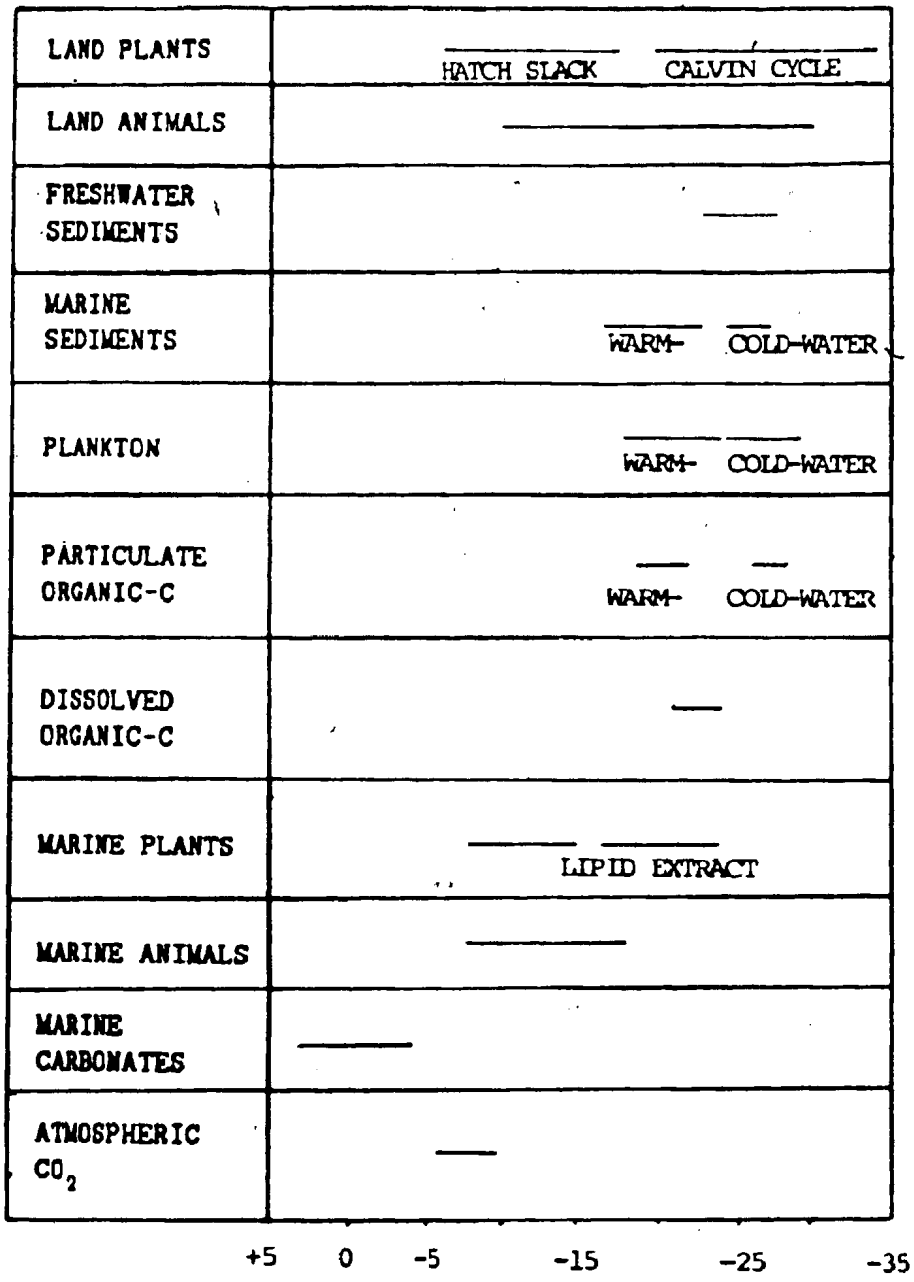
(2) Early diagenesis of organic matter. The isotopic composition of an organic compound depends on its source and fate. Parker (1964) has shown that the $\delta^{13}C$ values of sediments in a marine estuary are a function of the $\delta^{13}C$ values of the biological community of that environment. However, the $\delta^{13}C$ values can be

Figure 1-5: Isotopic variations of carbon in naturally occurring substances.

Source: Macko, 1981.

SELECTED VALUES OF CARBON ISOTOPIC ($\delta^{13}C$) RESERVOIRS

(PEEDEE BELEMNITE STANDARD = 0 0)



severely altered by microbial activity (Macko and Estep,1984: Blair et al.,1985). Any synthetic or degradative process has the potential to create an isotopic fingerprint for the newly formed compounds (Blair et al., 1985). Thus the isotopic composition of the final product depends also on the metabolic pathway of the microbes.

The $\delta^{13}C$ values of sedimentary organic matter is a function of the contributions of the various metabolic fractions (for example, starch vs lipids). The isotopic composition of various metabolic fractions and also individual compounds (glutamate vs aspartate etc.) are different (Abelson and Hoering, 1968; O'Leary, 1980; Macko and Estep, 1984; Blair et al., 1985). Any changes in $\delta^{13}C$ values of the organics of the sedimentary column may be related to changes in the relative amounts of organic compounds and/or organic components.

The lipid fraction of plants, animals and sediments are significantly more depleted in ^{13}C than the total plants, animals and sediments, respectively (Fig. 1-5)(Parker, 1964; DeNiro, 1977: O'Leary, 1980). This is a consequence of the isotopic fractionation associated with the decarboxylation of pyruvic acid in a step transformation, culminating in the incorporation of ^{13}C-depleted acetyl groups in the lipid fraction (DeNiro, 1977). Because lipid synthesis is similar in all organisms, ^{13}C-depleted lipid components are usually observed (DeNiro and Epstein, 1977). The depletion of ^{13}C during lipid synthesis (or any other synthesis) is accompanied by an enrichment of ^{13}C in the substrate in order to achieve isotopic mass balance. In addition, many decomposition reactions tend to be decarboxylation, during which isotopically heavy carboxyl groups are preferentially removed leaving the residual organic matter depleted in $\delta^{13}C$ (Tan and Strain, 1982).

Finally, in diagenesis and other chemical reactions, preferential rupture of ^{12}C-^{12}C bonds over ^{13}C-^{12}C bonds may also occur (Smith, 1975).

There is an overlap beween the $\delta^{13}C$ values of organics of different origins. This

makes it difficult to distinguish unambiguously between the sources of organics in nearshore sediments. Consequently, this necessitates the use of other stable isotopes, one of which can be ^{15}N.

The variation of $^{15}N/^{14}N$ observed in the biosphere can be explained by isotopic fractionations in biochemical reactions of the nitrogen cycle, such as inorganic nitrogen assimilation, nitrogen fixation, nitrification, denitrification and ammonification (Smith, 1975; Wada and Hattori, 1976; Peters et al., 1978; Hoefs, 1980; Macko, 1981; Macko et al., 1982a). Generally biologically combined nitrogen is enriched in ^{15}N relative to the atmosphere (Fig. 1-6).

Stable nitrogen isotopic analysis may be used to investigate the following:

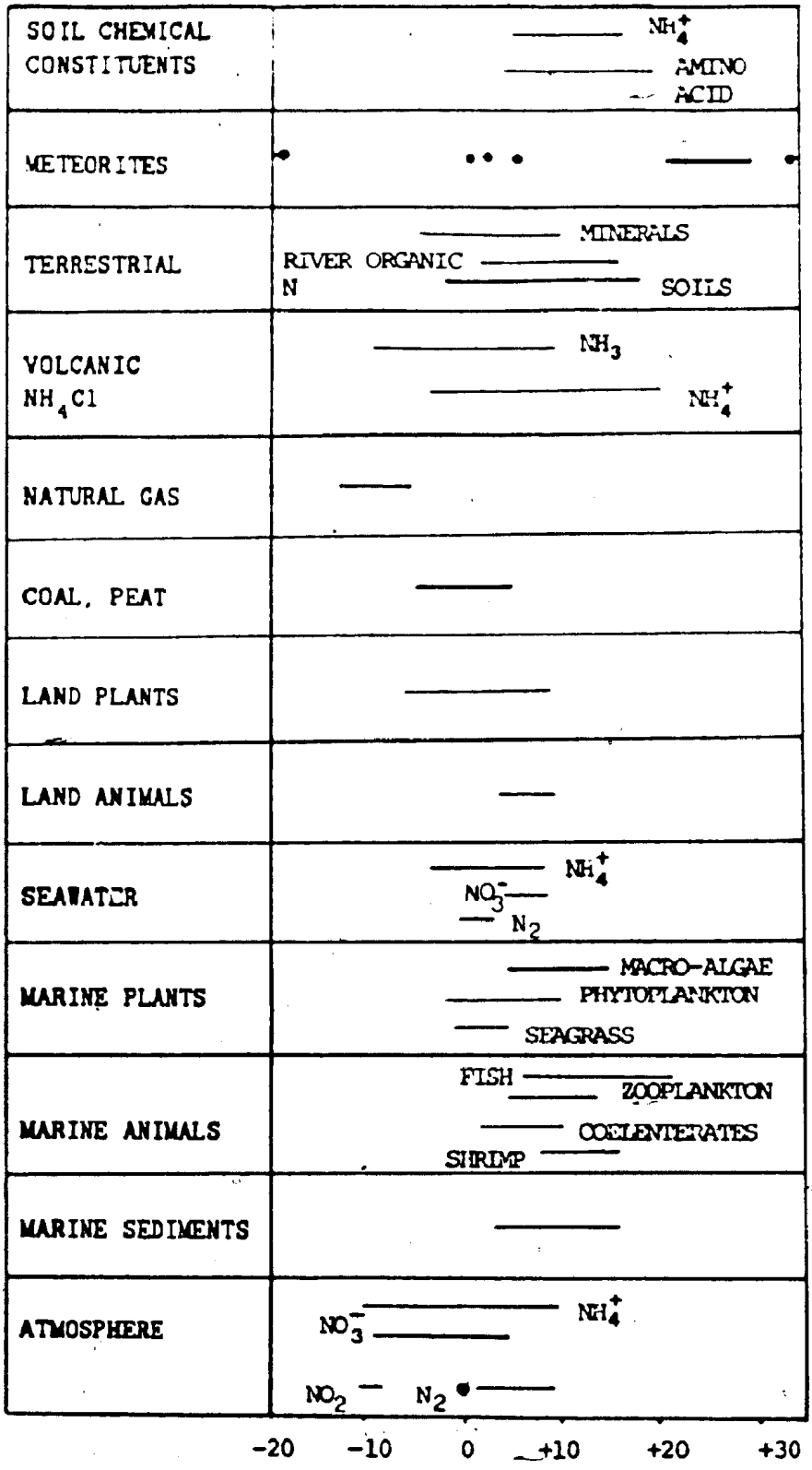
(1) The origin of organic nitrogen in sediments. Marine sediments have higher ^{15}N values (about $+7.0^{o}/oo$) than terrestrial sediments (about $0.0^{o}/oo$) as a result of nitrogen source differences. Delwiche and Steyn (1970) compared $\delta^{15}N$ values for clover and grass from the same site. The $\delta^{15}N$ values for grass and soil were significantly higher than those for clover. They concluded that the nitrogen of the clover was from atmospheric nitrogen, whereas that of the grass came from the soil. However, this use may be restricted to environments where the nitrogen fraction is not readily biodegradable (Sweeney et al., 1978).

(2) Diagenesis. The difference in isotopic composition of nitrogen in the atmosphere, biosphere and soil can be explained by isotopic discrimination of the reactions involved in the cycling of nitrogen. Bacteria preferentially utilize ^{14}N in the process of nitrification, fixation, denitrification and assimilation. The remaining nitrogen, which is available for biological utilization, is therefore enriched in ^{15}N (Smith, 1975). Fractionation factors, β, for these processes (fixation, nitrification, denitrification and assimilation) were about 1.004 with *Aztobacter vinelandii*, 1.026 *Nitrosomonas europaea*, 1.026 *Pseudomonas denitrificans* and 1.015 *Aztobacter vinelandii*, respectively. Similar fractionation results were obtained by Macko et al., (1982b) using blue-green algae, *Anabaena*.

Figure 1-6: Isotopic variations of nitrogen in naturally occurring substances.

Source: Macko, 1981.

GLOBAL NITROGEN ISOTOPE ABUNDANCE $\delta^{15}N$ SCALE



A small fractionation of -2.35°/oo was observed between algal organic matter and the inorganic nitrogen source during fixation of molecular nitrogen compared to a large fractionation of up to -13.3°/oo during assimilation and reduction of an unlimited nitrate or ammonium supply.

The primary organic nitrogen compounds in the biosphere are combined amino acids, which occur as peptides and proteins in cells and extracellular products (Sigleo and Macko, 1985). The fractionation of nitrogen isotopes during bacterial utilization of these organic nitrogen substrates appears to occur during the processes of deamination, during which amino acids entering the cell are broken down to produce ammonia and organic acids (Macko and Estep, 1984; Macko et al.,1982b). Most of this nitrogen is incorporated into protein amino acids via GLU transamination, while other organic acids enter the Krebs cycle.

Nitrogen isotope fractionation, like carbon isotope fractionation, depends on the substrate and the biosynthetic pathway of microbes (Macko and Estep, 1984). In laboratory cultures utilising ALA, SER and THR as substrates, large negative isotopic fractionations were observed i.e. a depletion of up to 12.9°/oo relative to the initial composition of the substrate. The ASP and GLU may enter the metabolic pathway directly, without deamination. Bacteria grown on ASP and GLU were enriched in ^{15}N relative to the substrate.

The C/N of the substrate also affected the amount of fractionation - more aspartate (C/N = 4) must be deaminated by the bacteria than glutamate (C/N = 5) for a similar amount of cellular energy.Smaller nitrogen isotopic fractionations were observed in cultures grown on TYR, ARG, GLY, PRO and N-acetylglucoseamine.

Although other organic substrates are in the sedimentary column, correlations between the $\delta^{15}N$ values with the abundance of the various amino acids were hypothesized.

Generally, the organic or inorganic compounds containing ^{14}N will react faster than the same compounds containing the heavier isotope ^{15}N (Macko and Estep, 1984b). There may be an enrichment in ^{15}N with increasing depth. This may be due to kinetic fractionation processes resulting in the removal of lighter and more easily hydrolysable nitrogeneous compounds from the sedimentary organic substrate, which becomes enriched in ^{15}N (Ivany, 1985).

Linear regression lines were obtained through correlation of carbon and nitrogen isotopic data sets in nearshore environments (Peters et al., 1978; Macko, 1982c; Ivany, 1985). The correlations appear to represent the mixing of marine and terrestrial "end members" of the residual refractory organic matter. This type of analysis also serves to characterize environments of unusual organic productivity (Ivany, 1985).

Finally, significant correlations between organic carbon and organic nitrogen content may reflect compositional changes. This type of analysis on organics of sediments from the Baffin Island fjords also defined terrestrial and marine "end members". In addition, C/N has been used as an approximation of the state of organic matter - organics with a low C/N are considered to be relatively undecomposed and richer in protein than organics in a similar environment with a higher C/N (Carter and Mitterer, 1978). Thus, a preferential loss of nitrogen during decomposition results in an increase in the C/N with increasing depth of the sedimentary column . Data published by Degens (1967) showed that the C/N of marine organics ranged from 7.4 to 8.0 with a mean of 7.8. Sediments in Funka Bay, Hokkaido (Japan) were found to have C/N that gradually increased from 8 at the surface to about 13 in the lower layers (Montani et al., 1980).

1.7. Amino acid analysis

Amino acids are present in sediments as bound proteins, humic acids, proteinaceous matter and also as free amino acids from microbial activity (Hare, 1969). The sediment-water interface contains the highest concentrations of amino acid material, which decreases rapidly with depth in the sediment (Hare, 1969; Whelan, 1977; Montani et al., 1980). The identification and quantification of amino acids can be used in several aspects of environmental studies:

(1) Environmental indicators. Amino acids play a very important role in a number of chemical and biochemical processes which take place in the water column and sediments (Starikova and Korzhikova, 1969; Bada and Mann, 1980). Thus the presence or absence of amino acids may be due to certain reactions taking place. For instance, an increase in GLY concentration and a corresponding decrease in SER and THR concentrations may be related to specific reaction pathways (Bada and Mann, 1980). Alternatively the differences in amino acid compositions can be explained in terms of depositional environments and different stabilities through microbial or geochemical reactions (Degens, 1970; Morris, 1975; Degens and Mopper, 1976; Dungworth et al., 1977; Whelan, 1977; Carter and Mitterer, 1978; Gonzalez, 1983). Analysis of two cores from the Ebro delta (Spain) showed that the branched-chain amino acids (VAL, LEU and ILEU) are the least stable geochemically (Gonzalez, 1983). Black Sea sediments, deposited under varying conditions, reflect variations of amino acid compositions (Degens and Mopper, 1976). Also, THR and SER are not expected in older sediments due to their thermal instabilities (Wehmiller and Hare, 1972).

(2)Indicators of sediment source. The amino acid composition may also reflect the source (terrestrial or marine) of the sedimentary organic matter which may then be related to the processes of sedimentation). Relatively large amounts of acidic amino acids are present in the organics of terriginous sediments (Akiyama and Johns, 1972). Within the acidic fraction, ASP seems to be more abundant than GLU in marine derived organics than terrestrial organics (Pulchan, 1985).

Similarly, aromatic amino acids seem to be more abundant in offshore sediments. In the neutral fraction, a predominance of THR over SER could indicate a marine planktonic source (Gonzalez, 1983). Related to the source of amino acid is the correlation of certain amino acid ratios (Pulchan, 1985). Significant correlations were between ASP/GLU and GLY/ALA and ASP/GLU and PHE/TYR. These correlations yielded linear regression lines which defined marine and terrestrial "end members" (Pulchan, 1985). GLY/ALA and ASP/GLU have also been observed to decrease with depth of the sedimentary column (Wehmiller and Hare, 1972).

(3) Index of the amount of organic preservation. The amount of amino acids present may also serve to indicate the amount of organic matter present within the sediment and the degree of preservation. Both amino acid and total organic matter generally decrease with depth.

1.7.1. Epimerisation of Isoleucine

Amino acids in sediments are of biological origin and should exist as the L-configuration (Hare and Abelson, 1968; Bada et al., 1970; Bada and Schroeder, 1975; Bada and Schroeder, 1976; Bada and Mann, 1980). After death of the organisms, the D-amino acid/L-amino acid increases with geologic age until an equilibrium ratio is reached.

The mechanics of epimerisation involves the extraction of an α proton (by a base) resulting in the formation of a planar carbanion (Bada and Schroeder, 1975; Morrison and Boyd, 1978). The reaction may be represented as:

L-ILE	D-AILE .....(1)

where k_{ILE} and k_{AILE} are the first order, temperature dependent rate constants for the interconversion of L-ILE and D-AILE respectively. The rate constants are governed by the Arrhenius equation :

$$k_{ILE} = Ae^{E_a/RT} \quad \ldots\ldots (2)$$

where A is the species-dependent frequency factor, E_a the genus-dependent activation energy, R the gas constant and T the temperature (K) (Bada and Schroeder, 1975; Dungworth, 1976; Williams and Smith, 1977; Miller and Hare, 1980). The differential kinetic expression for the reaction is

$$-d[L\text{-ILE}]/dt = k_{ILE}[L\text{-ILE}] - k_{AILE}[D\text{-AILE}] \quad \ldots\ldots (3)$$

Solving equation (3) as a function of time yields

$$\ln\{(1+[D/L])/(1-K'[D/L]\} - \ln\{(1+[D/L])/(1-K'[D/L]\}_{t=0} = (1+k').k_{ILE}.t \quad \ldots\ldots (4)$$

where D and L are the amounts of D-AILE and L-ILE respectively

$1/K' = k_{ILE}/k_{AILE} = K_{eq}$ and

K_{eq} is the equilibrium ratio of D-AILE to L-ILE.

Since very little, if any, L-ILE epimerisation occurs during acid hydrolysis of foraminiferal tests or exists naturally, the term $t = 0$ in equation (4) is negligible (Bada and Schroeder, 1975; Bada and Mann, 1980). Equation (4) then becomes

$$\ln\{(1+[D/L])/1-0.72[D/L]\} = 1.72k_{ILE}t \quad \ldots\ldots (5)$$

The epimerisation of L-ILE has many geologic applications:

(1) Geochronology. Use is made of this reaction as a geochronological tool in dating marine sediments. It appears to follow a first order kinetics rate expression in carbonate tests. This dating method is a relative one and it needs to be calibrated against absolute dates.For instance, if there is a stratigraphic horizon of known age, then k_{ILE} can be calculated from equation (5):

$$k_{ILE} = \ln\{(1+[D/L])/1-0.72[D/L]\} / 1.72t \quad \ldots\ldots (6)$$

A racemization curve can be obtained by plotting $\ln\{(1+[D/L])/(1-0.72[D/L]\}$

verses depth (Bada and Mann, 1980; Macko and Aksu, 1985). Two regions of linearity were observed. The first linear region generally occurs in the interval from 0 to about 145,000 years (or from [D/L] = 0.229) (Macko and Aksu, 1985). The second region begins at 145,00 years and appears to continue to equilibrium. To make age estimates, $k_{ILE'}$ $[D/L]_{equilibrium}$ and [D/L] must be known. Using $[D/L]_{equilibrium} = 1.3$, and measuring [D/L] in foraminiferal tests, an age estimate can be obtained.

(2) Aminostratigraphy. The ILE epimerisation ratios in benthonic foraminifera can also be used to correlate sedimentary units that contain *in situ* faunas and have similar thermal histories (Sejrup et al., 1984). This type of analysis is termed aminostratigraphy (Nelson, 1982; Miller et al., 1983; Funder and Simonarson, 1984). This technique may be particularly applicable to this study, considering the close proximity of the two bays and their similar glacial history.

It should be noted that other epimerization (and racemization reactions) can be used for the above mentioned studies. However, the epimerisation of L-ILE was chosen because analytically it is the easiest to study. The L-ILE has two chiral carbon atoms and it exists as diastereomeric molecules, and thus epimerisation produces an amino acid, D-AILE, with slightly different chemical properties (Bada and Mann, 1980). Hence L-ILE and D-AILE behave differently for example, on cation-ion-exchange columns - D-AILE is less hydrophobic and is eluted more readily than L-ILE (Hare and Abelson, 1968; Bada and Mann, 1980). Another advantage of the ILE epimerisation is the fact that the $[D/L]_{equilibrium}$ is greater than unity.

Limitations to this approach include the large number of factors controlling amino acid diagenesis, the most important being the thermal history and contamination and leaching of amino acids. Analysis is also restricted to monospecific samples in order to avoid a "species effect". Finally, use of the amino acid epimerisation reaction is restricted to mostly marine sediments where temperature fluctuations are less frequent and smaller than in terrestrial sediments.

1.8. The greater than 63μ fraction

This sedimentary fraction consists of sands and larger clastic particles and biogenic debris, the most important in this study being benthic foraminifera. The abundance of individual components is related by sediment texture which in turn is related to depositional environment (Slatt and Sasseville, 1976). The size of the greater than 63 micron fraction depends on 3 factors:

(1) Mechanical - this describes the energy of the environment and is related to physical processes such as waves and currents and the effect of bottom feeders (Kukal, 1971; Elhers and Blatt, 1980; El-Ella and Coleman, 1985). Larger particle sizes are indicative of higher physical energy and vice versa. The effect of bottom feeders act in the opposite direction i.e. reduction of particle size.

(2) Physico-chemical conditions, deal mainly with the Eh-pH conditions, salinity, temperature, and the degree of calcium carbonate saturation. These conditions can reflect the foraminiferal abundance:

1. Eh-pH conditions will determine whether foraminiferal tests will be preserved or corroded.

2. Salinity variations will be reflected in the foraminiferal assemblage. Most foraminifera are adapted to normal marine salinities ($\sim 35°/oo$) under which the most diverse assemblages are found(Brasier, 1980).

3. Temperature is very important, since each species is adapted to a certain range of temperature conditions, the most critical being the range over which successful reproduction can take place (Brasier, 1980).

4. Calcium carbonate solution is directly related to Eh-pH conditions and also temperature. The solubility of calcium carbonate is less in warm than cool waters, resulting in thicker tests in warm waters. Solubility also increases with depth (Brasier, 1980).

(3) Biogenic describes the qualitative and quantitative differences in the productivity of organisms and organic matter. Foraminifera are micro-omnivores

in the marine environment feeding on bacteria, algae protists and other invertebrates whose populations are dependent on the amount of organics in the environment and the substrate. Silty and muddy substrates are often rich in organic debris and the small pore spaces contain abundant bacterial blooms (Brasier, 1980). Large pore spaces of sands and gravels contain fewer nutrients and therefore, support sparser bacterial populations (Brasier,1980). Hence foraminifera are excellent environmental and paleoclimatic indicators (Aksu and Mudie, 1985; Mudie and Aksu, 1984).

1.9. Oxygen isotopic analysis

Oxygen has three stable isotopes with the following abundances (Garlick, 1969; Hoefs, 1980):

$^{16}O = 99.730\%$
$^{17}O = 0.0375\%$
$^{18}O = 0.1995\%$

Because of the higher abundance and greater mass difference, the $^{18}O/^{16}O$ is normally determined. In this study ^{18}O values from the carbonate of foraminiferal tests are determined and applied to paleosalinity fluctuations.

During glacial periods great volumes of water were stored on the continents in the form of ice, which increased the salinity of the oceans (Herman and O'Neil, 1975; Erez, 1979). Glacial ice is enriched in ^{16}O,whereas the more saline ocean became enriched in ^{18}O (Kenneth and Shackleton, 1975).This is a consequence of the preferential concentration of ^{16}O in the water molecules in the vapour phase during evaporation (Hoefs, 1980). The ^{18}O analysis of the Arctic Ocean water indicates that the $^{18}O/^{16}O$ closely follows the salinity profile, with ^{18}O values decreasing by $0.8^{o}/oo$ with a $1.0^{o}/oo$ decrease in salinity in the upper 350 meter (Herman and O'Neil, 1975).

In conclusion multiple tracer analysis is performed on the sediments of Bay D'Espoir and Fortune Bay. Carbon and nitrogen isotopes and total amino acid

abundances will indicate inputs. Amino acid distributions can also be used as environmental indicators. The epimérisation of L-ILE will yield approximate ages of the sediments which can be used to correlate sedimentary units in both bays. Finally, oxygen isotopic data will indicate glacial fluctuations.

Chapter 2
METHODS

2.1. Materials

Quartz distilled water and quartz distilled 6N HCl were used in the preparation of all buffers for amino acid analysis (Table 1). Other materials for amino acid analysis included a HCl buffer of approximately pH 2, citrate buffers, #1 and #2, of pH 3.25 and 4.25 (Sigma Chemical Co. ,St. Louis,U.S.A.) and a borate buffer, #3, of pH 9.8 which was prepared in the laboratory. A concentrated solution of common hydrolysate amino acids (Sigma Chemical Co., St. Louis,U.S.A.) was diluted and used for standard separation and calibration. *Ortho*-phthaldialdehyde (OPA) (Sigma Chemical Co.,St. Louis, U.S.A) was the post column derivatization reagent.

Precombusted copper oxide (BDH Chemical, Toronto, Montreal, Vancouver) and pure granular copper (Alpha Resources Inc., Stevensville, Wisconsin) were oxidant and reductant respectively, for the conversion of organic matter to carbon dioxide and molecular nitrogen for isotopic analysis.

One hundred percent orthophosphoric acid (H_3PO_4)was used to release carbon dioxide (CO_2) from the carbonate of the foraminiferal tests for oxygen isotopic analysis.

Table 1: Preparation of buffers.

SOLUTION	REAGENT AND AMOUNT USED	FINAL VOLUME AFTER DILUTION USING QUARTZ-DISTILLED WATER
BUFFER #1	100 mls of pH 3.25 Citrate Buffer + 400 ul of 6N HCl + 20 mls of methanol	1 Liter
BUFFER #2	50 mls of pH 3.25 Citrate Buffer + 50 mls of pH 4.25 Citrate Buffer	1 Liter
BUFFER #3	2 g of Boric Acid + 10 g of Sodium Chloride + 1 g of Sodium EDTA	1 Liter, pH adjusted to 10.9 using NaOH solution
OPA BUFFER	30 g of Boric Acid + 1 g of Brij •35 + 2.5 g of EDTA	1 Liter, pH adjusted to between 9.8 and 10.0 using KOH solution
OPA SOLUTION	0.5 g of OPA + 2.5 mls of Methanol + 0.5 mls of Mercaptoethanol + 500 mls of OPA Buffer	503 mls
APPROXIMATE pH 2 BUFFER	2 mls of 6N HCl	202 mls, pH ~ 2
AMINO ACID STANDARD	60 µl Amino Acid Concentrate + 14.94 mls of ph 2 Buffer	15 mls

2.2. Apparatus

Separation, identification and quantification of amino acids was done on a commercial automatic amino acid analyser consisting of four components (Hare, et. al., 1985) - a column, a pre-programmed buffer unit, fluorescence detector and an integrater with a chart recorder. High performance liquid chromatography was accomplished using a column (length = 6.95cm) containing 3μ, 9% crosslinked synthetic resin (polystyrene/divinylbenzene). Detection of the fluorescent derivatives was achieved with an HTV Instrumentation Fluoroflow detector 10. The output was displayed on a Soltec S-4202 chart recorder and a Hewlett Packard Integrator (Model 3390A).

Separation and collection of carbon dioxide and nitrogen from the sedimentary organic matter were done cryogenically on a high vacuum separation line (Fig. 2-1). Carbon dioxide from the carbonate of foraminiferal tests was isolated and collected on another high vacuum line (Fig. 2-2). High vacuum was achieved by a mercury diffusion pump backed by a rotary pump. Each separation line has a U trap where separation of gases was achieved. The first line (Fig. 2-1) also has a cold finger where carbon dioxide was trapped and measured on a calibrated manometer. Isotopic analysis of the gases and measurement of the organic nitrogen content were done on the mass spectrometer (V.G. Micromass 903E).

2.3. Methods

The cores were collected during the 1984 expedition of the C.S.S. Dawson to Fortune Bay and the 1985 expedition to Bay D'Espoir. The cores were subsampled and samples frozen until analysis. The sediment samples were first dried at 40^{0}C. A portion of this dried sediment was then saturated with 30% HCl to remove carbonates according to the equation below.

$$CaCO_3 + 2HCl\ (excess) \longrightarrow CaCl_2 + H_2O + CO_2\uparrow$$

calcium carbonate	hydrochloric acid	calcium carbonate	water	carbon dioxide

Figure 2-1: Gas separation line used to purify and collect N_2 and CO_2 gases.

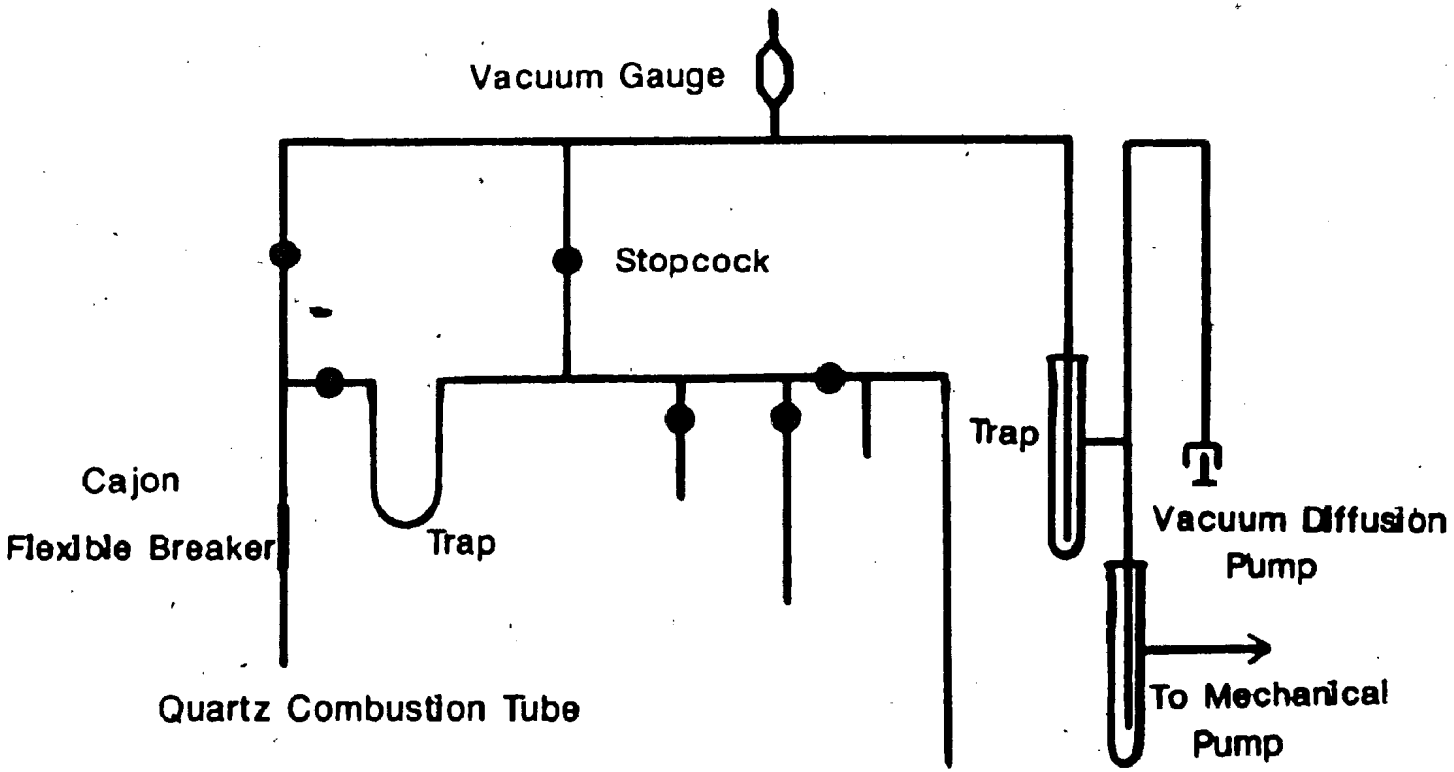
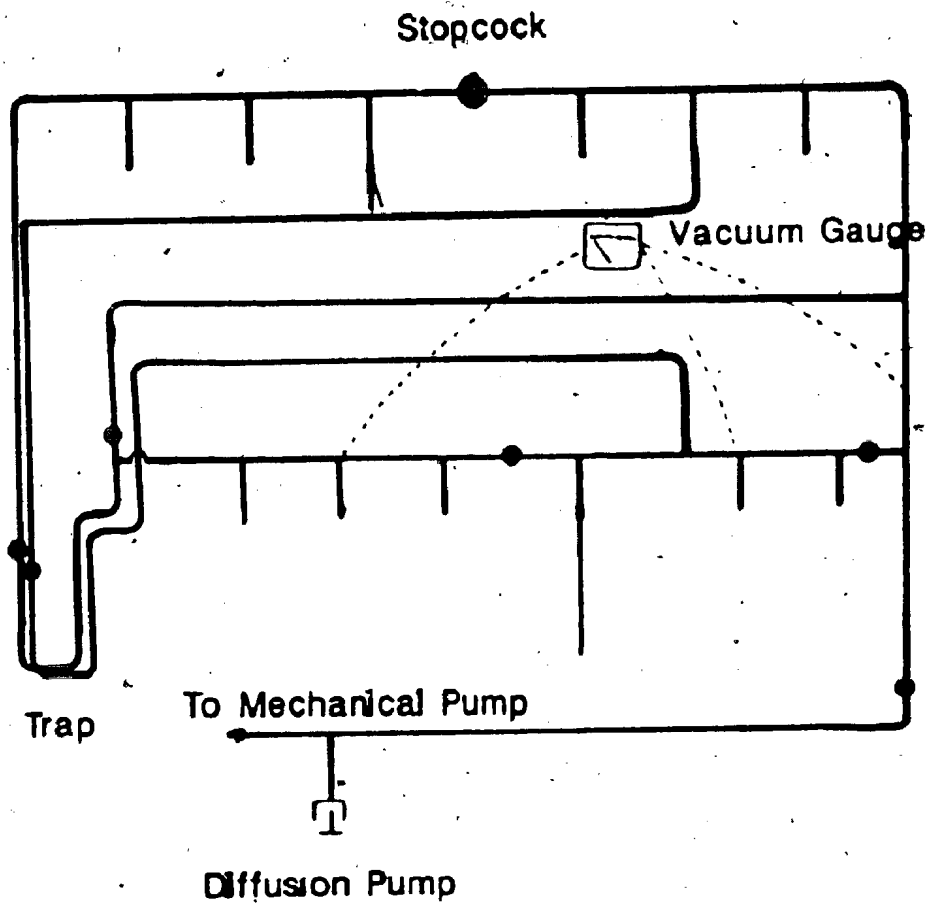
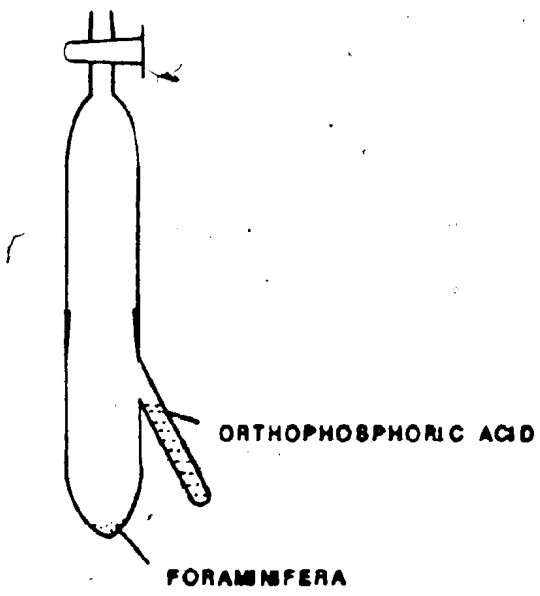

Vacuum Gauge
Stopcock
Trap
Cajon
Flexible Breaker
Trap
Vacuum Diffusion
Pump
Quartz Combustion Tube
To Mechanical
Pump

Figure 2-2: Gas separation line used to purify and collect CO_2 gas.


Stopcock
Vacuum Gauge
Trap
To Mechanical Pump
Diffusion Pump


ORTHOPHOSPHORIC ACID
FORAMINIFERA

The carbonate free sediment was then used for carbon and nitrogen isotopic analysis.

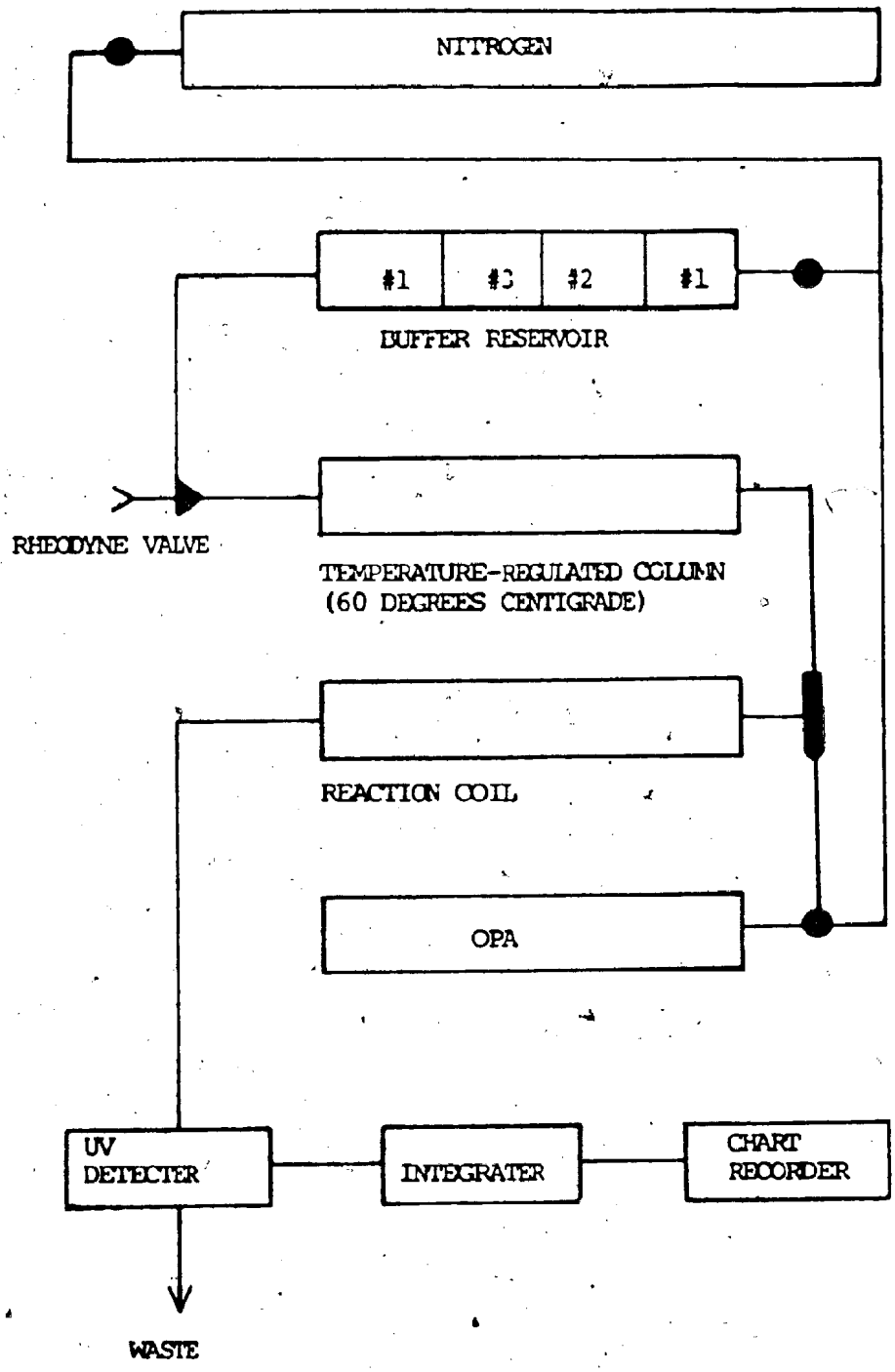
The cores were also subsampled for foraminifera for D_{AILE}/L_{ILE} and oxygen isotopic analyses. A suspension of about .5 to 10 grams of sediment in approximately 240 mls of water and 10 mls of calgon (dispersing agent) was sieved through a 63μ mesh and the fraction greater than 63μ was collected and gravimetrically estimated. The relative foraminiferal abundance was determined from the fraction greater than 120μ, following which the species *Globobulimina auriculata* (Bailey) were carefully picked for D-AILE/L-ILE analysis. These samples were ultrasonically washed three times in pure water for 4 seconds and then weighed. About 4 mgs of foraminifera were acidified with 0.5 mls of clean 6N HCl and excess 7N HCl to yield a final concentration of 6N acid, which was sealed under nitrogen and digested for 24 hours at 100 ^{0}C.

A portion (typically 50 μl) of the digestion liquor was transferred to another clean tube, warmed and evaporated to dryness under a stream of filtered air. The residue was then dissolved in 400 μl of pH2 buffer and injected into the amino acid analyser.

For analysis of total bound amino acid content, approximately 200 mgs of the unacidified dried sediment was transferred into a clean digestion tube, to which exactly 1 ml of high purity 6N HCl was added. The tube was then sealed under nitrogen and the contents were digested at 100^{0}C for exactly 24 hours. Each tube was then opened and 50 μl of the acid liquor was transferred to another clean tube, warmed and evaporated to dryness under a stream of filtered air. The residue was then dissolved in 2 μl of pH2 buffer. This solution was injected into the amino acid analyser (Fig. 2-3).

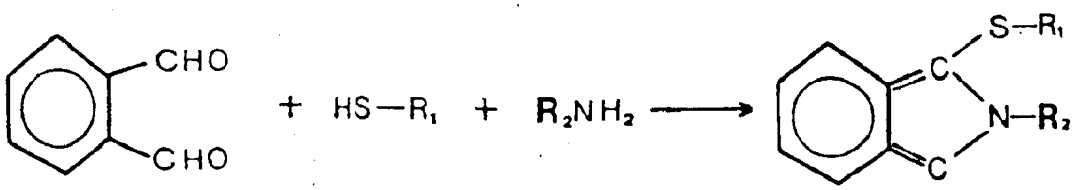
The samples were drawn into a loop with a syringe through a Rheodyne 7125 injection valve. On rotation of the valve, the amino acid solution was placed in stream with the column. The separation was then accomplished by stepwise

Figure 2-3: Schematic of the amino acid analyzer


NITROGEN
#1
#3
#2
#1
BUFFER RESERVOIR
RHEODYNE VALVE
TEMPERATURE-REGULATED COLUMN
(60 DEGREES CENTIGRADE)
REACTION COIL
OPA
UV
DETECTER
INTEGRATER
CHART
RECORDER
WASTE

isocratic elution using three buffers #1, #2 and #3 (of constant ionic strength), respectively. At low pH, the basic amino acids (HIS, LYS and ARG) were strongly bound to the resin whereas the acidic ones (GLU and ASP) were easily released. The amino acids were released from the column at characteristic rates as indicated by specific retention timesfor each amino acid. Following separation the column was re-equilibrated with buffer #1.

The post-column derivitization reagent, OPA, was pumped to the column effluent stream by means of nitrogen back pressure applied to the vessel containing the OPA solution. The amino compounds were then allowed to react with the reagent in a teflon reaction coil (length = 51cm, width = .5mm). The reaction (shown below) produces amino fluorescent derivatives, the intensity of the fluorescence is proportional to the concentration of the amino acids.



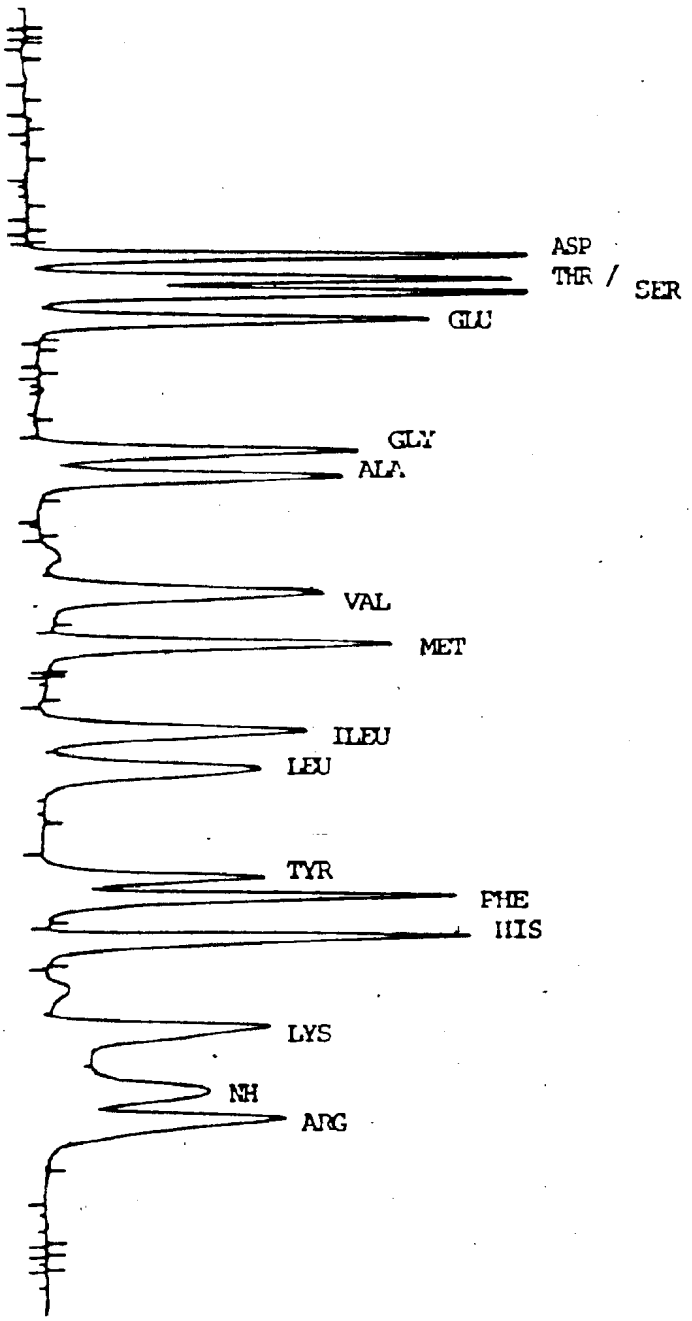
OPA | MERCAPTO-ETHANOL | PRIMARY AMINE | FLUORESCENT DERIVATIVE

Fluorescent derivatives absorb at one wavelength and re-emit light at a longer wavelength (Hare et. al., 1985). The fluorescent derivative was excited at a wavelength of 340 nm; emission was measured at 455 nm. The response of the fluorimeter to the derivatives was then plotted and areas integrated on the HP3390A. The responses were also plotted on a separate chart recorder. A typical separation is shown in Fig. 2-4.

The carbonate content estimation involved saturating a sediment portion with 30% HCl, followed by drying at 40°C. The acidified sediment samples were then washed (to get rid of $CaCl_2$), dried and weighed.

The procedure used in the preparation of sediments for nitrogen and carbon isotopic analysis is essentially a modified Dumas method (Macko, 1981). Carbon

Figure 2-4: Chromatogram showing the separation of amino acids


ASP
THR / SER
GLU
GLY
ALA
VAL
MET
ILEU
LEU
TYR
PHE
HIS
LYS
NH
ARG

and nitrogen isotopic analyses were carried out on acidified sediments, whereas oxygen isotopic analysis was carried out on foraminiferal tests.

About 200 mgs of sediment was accurately weighed and carefully transferred to a clean quartz tube, approximately 30 cm long and 1 cm in diameter. Ground copper oxide followed by granular copper metal were then added to the sediment. The volume ratio of the sediment to copper oxide to copper metal was approximately 1: 5 : 1. This ensures combustion in the presence of excess oxidant and reductant, during which the organic carbon is oxidized to carbon dioxide and the nitrogen content of ammonia is oxidized to nitrogen, as shown below.

$$C_{org} + 4CuO \longrightarrow 2Cu_2O + CO_2\uparrow$$

organic carbon	cupric oxide	cuprous oxide	carbon dioxide

$$2NH_3 + 3CuO \longrightarrow 3Cu_2O + 3H_2O + N_2\uparrow$$

ammonia	cupric oxide	cuprous oxide	water	nitrogen

The quartz tubes containing the sample, copper and copper oxide were then evacuated on the high vacuum line and sealed. Following homogenization of the contents, the tubes were combusted for 1 hour at 850 ^{0}C and allowed to cool overnight prior to removal from the furnace.

Each tube was then etched about 1.5 inches from one end and secured to the separation line by a Cajon flexible breaker, so that the etched mark was in the middle of the breaker (Fig. 2-1). The entire line was then evacuated and the sample tube broken after being cooled for 10 seconds in liquid nitrogen to decrease internal pressure.

A liquid nitrogen trap around the U trap held the carbon dioxide and water vapor, following which nitrogen was collected on the liquid nitrogen cooled 5 Angstrom molecular sieve for five minutes. Ion intensity of the N_2 was measured in a calibrated volume on the mass spectrometer prior to isotopic analysis. Next,

carbon dioxide was separated from water vapor, measured and collected. The liquid nitrogen trap on the U tube was replaced by a dry ice-methanol slurry. This released the carbon dioxide, but trapped any water vapor. A liquid nitrogen cooled cold finger acted as a cryogenic pump to collect carbon dioxide. After the manometric measurement of carbon dioxide, it was transferred in a liquid nitrogen cooled pyrex tube for storage until analysis on the mass spectrometer.

For ^{18}O analysis, at least .4 mgs of washed monospecific foraminifera picked from the greater than 120 μ fraction were placed in a reaction vessel and 2 mls of 100% phosphoric acid carefully transferred into the arm of the reaction vessel. Following evacuation of the reaction vessel on a high vacuum separation line and temperature equilibration at 50^0C in a water bath for one hour, the reaction between the acid and carbonate of the foraminiferal tests was initiated by tilting the reaction vessel to mix the acid and the foraminifera. The reaction was allowed to reach completion at 50^0C in the water bath and then the reaction vessel was placed on the high vacuum separation line carbon dioxide. A dry ice-methanol slurry released carbon dioxide which was transferred by cryogenic pumping of liquid nitrogen cooled transfer tube, U tube and finally the pyrex tube where it was collected (Fig. 2-2).

By making comparative measurements of ratios of isotopes instead of absolute measurements, the variations of isotopic ratios in natural samples can be more accurately estimated than through use of absolute abundance determinations. The stable carbon, nitrogen and oxygen isotopic ratios (i.e. $^{13}C/^{12}C$, $^{15}N/^{14}N$, $^{18}O/^{16}O$) were measured relative to laboratory sub-standards in the isotopic ratio mass spectrometer. Tanks of carbon dioxide and nitrogen substandards (^{13}C = 45.95°/oo, ^{18}O = 10.1°/oo and ^{15}N = -1.11°/oo) were used in this study. $\delta^{13}C$, $\delta^{18}O$ and $\delta^{15}N$ values were then recalculated to values relative to international standards. The carbonate of the *Belemnitella americana* of the Pee Dee formation is the standard for $\delta^{13}C$ and $\delta^{18}O$ values. $\delta^{15}N$ values were reported relative to atmospheric nitrogen.

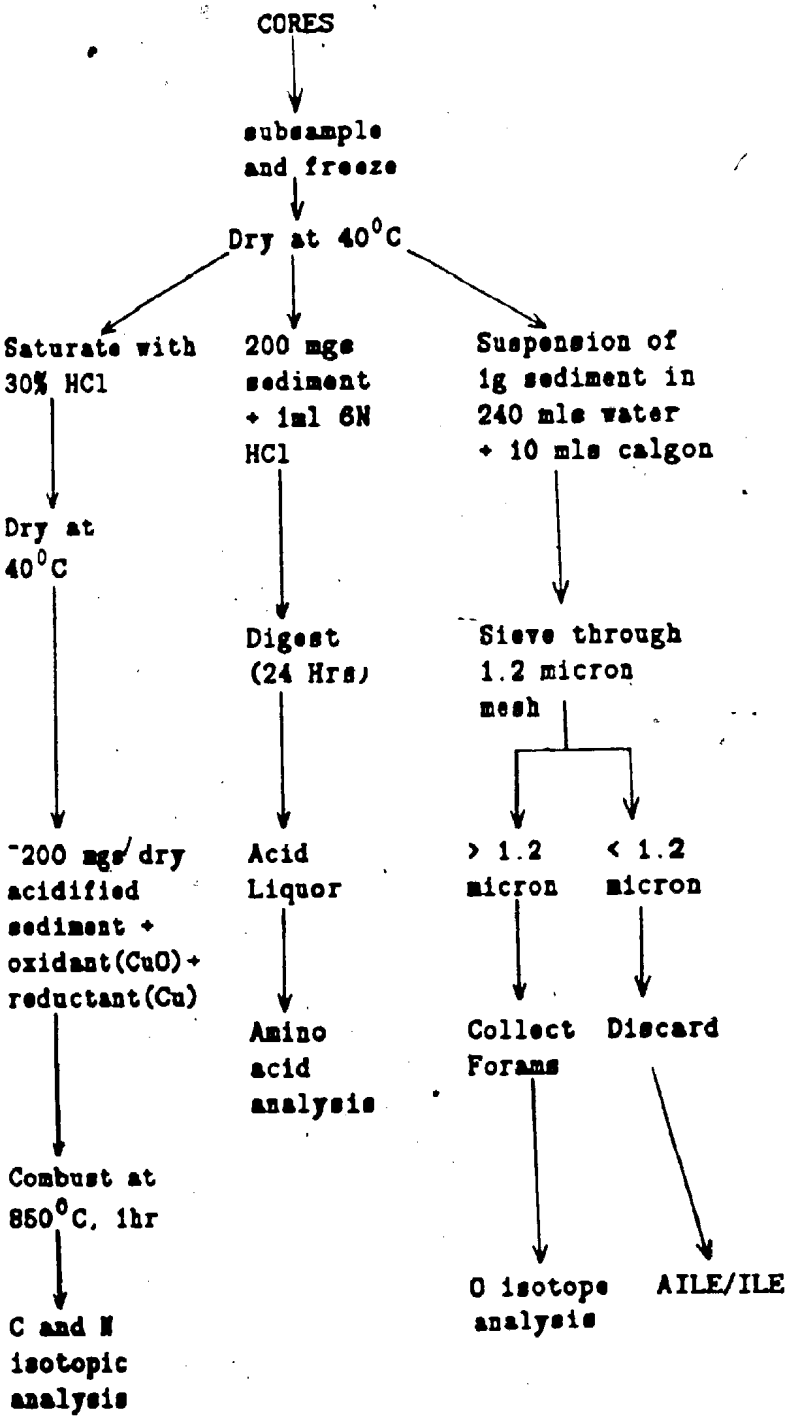
For the best precision, measurements are made by comparing the abundance ratio of the heavy to the light isotope in the sample to the same ratio in a standard. All measurements with precision greater than .1 °/oo were repeated. Results are expressed in terms of $\delta^{13}C$, $\delta^{18}O$. $\delta^{15}N$ values per mil defined as follows:

$$\delta \text{ value } (°/oo) = (R_{Sample}/R_{Standard} - 1) * 10^3) \quad ---(7)$$

where R = abundance ratio of the heavy to light isotope.

A summary of the different steps towards amino and isotopic analyses is shown in Fig. 2-5.

Figure 2-5: Schematic of study plan


CORES
subsample and freeze
Dry at 40°C
Saturate with 30% HCl
Dry at 40°C
200 mgs dry acidified sediment + oxidant(CuO) + reductant(Cu)
Combust at 850°C, 1hr
C and N isotopic analysis
200 mgs sediment + 1ml 6N HCl
Digest (24 Hrs)
Acid Liquor
Amino acid analysis
Suspension of 1g sediment in 240 mls water + 10 mls calgon
Sieve through 1.2 micron mesh
> 1.2 micron
< 1.2 micron
Collect Forams
Discard
O isotope analysis
AILE/ILE

Chapter 3
RESULTS

FORTUNE BAY CORES

3.1. CORE FO-840401

3.1.1. Core Description

This core is olive grey at the top and becomes progressively darker with depth. The total length of this core is 96 cm. The sand fraction values are fairly low varying between 3.9% at the surface to 1.0% at 70 cm. A general decrease in sand fraction with depth is observed (Appendix 1).

3.1.2. Geochemical analyses

The $\delta^{13}C$ isotopic signature is relatively constant downcore, at about -22.2°/oo, except at 30 and 40 cm, where values increase to -21.5 and -21.3°/oo respectively, (Table 2 and Fig. 3-1). The $\delta^{15}N$ values are also fairly constant with minor fluctuations between 7.1 and 7.9°/oo (Table 2 and Fig. 3-1).

Total and individual amino acid concentration values are high throughout this core, the former ranging between 126.9 μM/g (at the surface) and 88.0 μM/g at 90 cm (Appendix 2a and Fig. 3-2). Glycine concentrations are highest, with values ranging from 28.2 μM/g at the surface to 18.1 μM/g at 90 cm (Appendix 2a and Fig. 3-2). The second most abundant amino acid is ASP showing the same trend as GLY, with concentrations ranging from 19.1 μM/g at the surface to 13.2 at 90cm. Glutamic acid (11.1 to 7.2 μM/g), ALA (13.5 to 7.6 μM/g), THR and SER

Table 2: Fortune Bay cores data.

CORE 7	FO-840401
CORE 8	FO-840402
CORE 9	FO-840403
CORE 10	FO-840404
CORE 11	FO-840405

CORE	DEPTH	TOC	TN	C/N	TAA	$\delta^{13}C$	$\delta^{15}N$
7	0	6.2	0.7	9.9	126.9	-22.2	7.3
7	5	5.6	0.7	9.9	113.5	-22.0	7.9
7	10	4.3	0.5	9.5	125.6	-22.3	7.3
7	20	5.9	0.6	11.4	97.5	-22.1	7.6
7	30	4.9	0.4	14.1	98.1	-21.5	7.4
7	40	3.8	0.4	10.9	95.5	-21.3	7.4
7	50	3.6	0.5	7.6	107.5	-22.1	7.9
7	60	4.7	0.7	8.2	101.3	-22.0	7.1
7	70	3.8	0.8	5.7	108.4	-22.3	7.7
7	80	3.8	0.5	8.3	115.0	-22.3	7.7
7	90	3.9	0.6	7.8	88.0	-22.3	7.6
8	0	3.2	0.5	7.2	108.8	-21.6	7.7
8	5	3.3	0.5	8.1	97.5	-21.6	7.5
8	10	2.9	0.5	7.4	118.0	-21.1	7.7
8	20	3.2	0.5	7.4	94.6	-20.5	7.7
8	30	4.1	0.5	8.9	89.1	-21.3	7.3
8	40	3.9	0.5	9.1	57.2	-21.5	7.7
8	50	3.2	0.5	7.3	52.9	-21.8	7.9
8	60	3.6	0.5	8.4	55.8	-21.9	7.1
8	70	3.8	0.5	9.6	89.1	-21.5	7.3
8	80	4.0	0.4	10.3	82.1	-21.5	7.7
9	0	3.5	0.4	10.4	93.4	-21.5	7.5
9	5	3.2	0.5	7.4	83.5	-21.5	7.4
9	10	2.8	0.4	7.3	67.0	-21.2	8.0
9	20	3.2	0.4	8.6	82.5	-21.9	7.4
9	30	2.8	0.5	6.9	80.6	-21.9	7.5
9	40	2.7	0.3	11.9	68.6	-21.3	7.6
9	50	3.2	0.4	8.9	72.1	-22.1	7.4
9	60	3.2	0.4	9.9	68.1	-21.5	7.1
9	70	2.9	0.3	10.1	88.7	-21.2	7.3
9	80	2.9	0.3	12.5	66.7	-21.6	7.7
9	90	2.3	0.5	5.0	83.8	-21.2	7.6

CORE	DEPTH	TOC	TN	C/N	TAA	$\delta^{13}C$	$\delta^{15}N$
10	0	3.9	0.4	12.1	68.4	-21.9	7.6
10	5	2.3	0.3	7.7	71.0	-21.1	7.4
10	10	2.4	0.3	11.1	57.1	-21.7	7.4
10	20	1.7	0.3	6.8	81.3	-21.7	7.6
10	30	0.8	0.1	8.8	25.1	-21.6	7.3
10	40	0.8	0.1	9.2	14.9	-21.5	7.6
10	50	0.7	0.1	9.7	8.9	-21.6	7.6
10	60	0.6	0.1	8.8	11.8	-21.2	6.8
10	70	0.7	0.1	8.5	12.0	-20.9	6.6
10	80	0.8	0.1	10.4	19.6	-21.9	7.6
10	90	0.6	0.1	7.7	11.3	-21.1	7.2
10	100	0.7	0.1	8.1	10.7	-22.2	7.5
10	110	0.8	0.1	10.9	11.2	-21.2	6.7
10	120	0.7	0.1	8.9	7.2	-21.9	7.3
11	0	1.5	0.2	11.4	36.6	-22.0	7.4
11	5	1.5	0.1	11.7	38.2	-21.9	7.6
11	10	0.6	0.1	5.5	32.1	-21.3	7.4
11	20	0.8	0.1	9.8	20.0	-21.2	7.5
11	30	1.0	0.1	12.3	15.4	-21.7	7.4
11	40	0.8	0.1	8.9	17.8	-20.5	8.0
11	50	0.6	0.1	8.7	14.0	-21.1	6.9
11	60	0.5	0.1	10.0	10.8	-21.8	6.6
11	70	0.6	0.1	9.3	8.8	-21.5	6.9
11	80	0.7	0.1	9.0	10.5	-20.8	8.0
11	90	0.7	0.1	9.7	10.3	-20.5	8.0
11	100	0.7	0.1	9.9	8.2	-21.3	7.2

Figure 3-1: FO-840401 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.

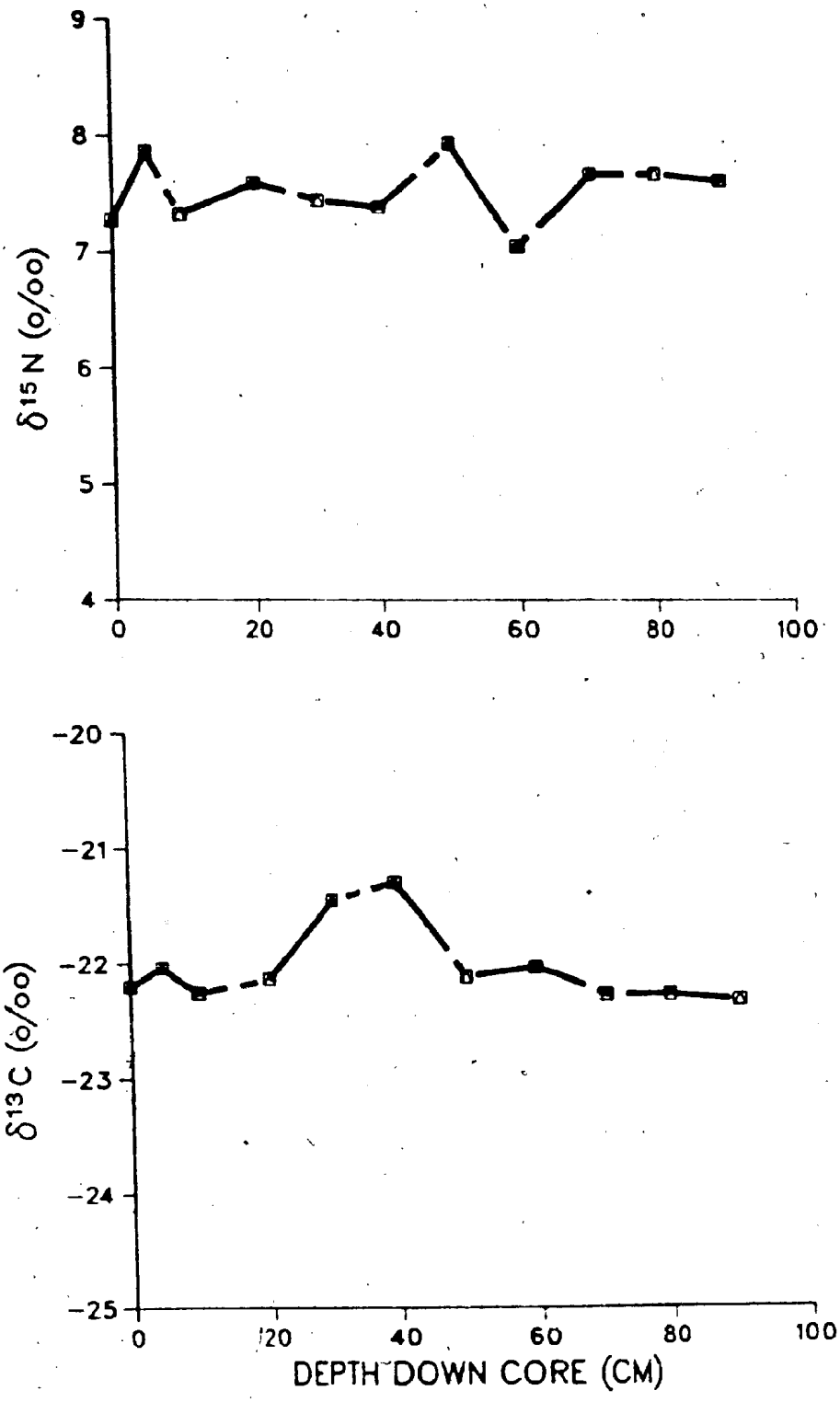
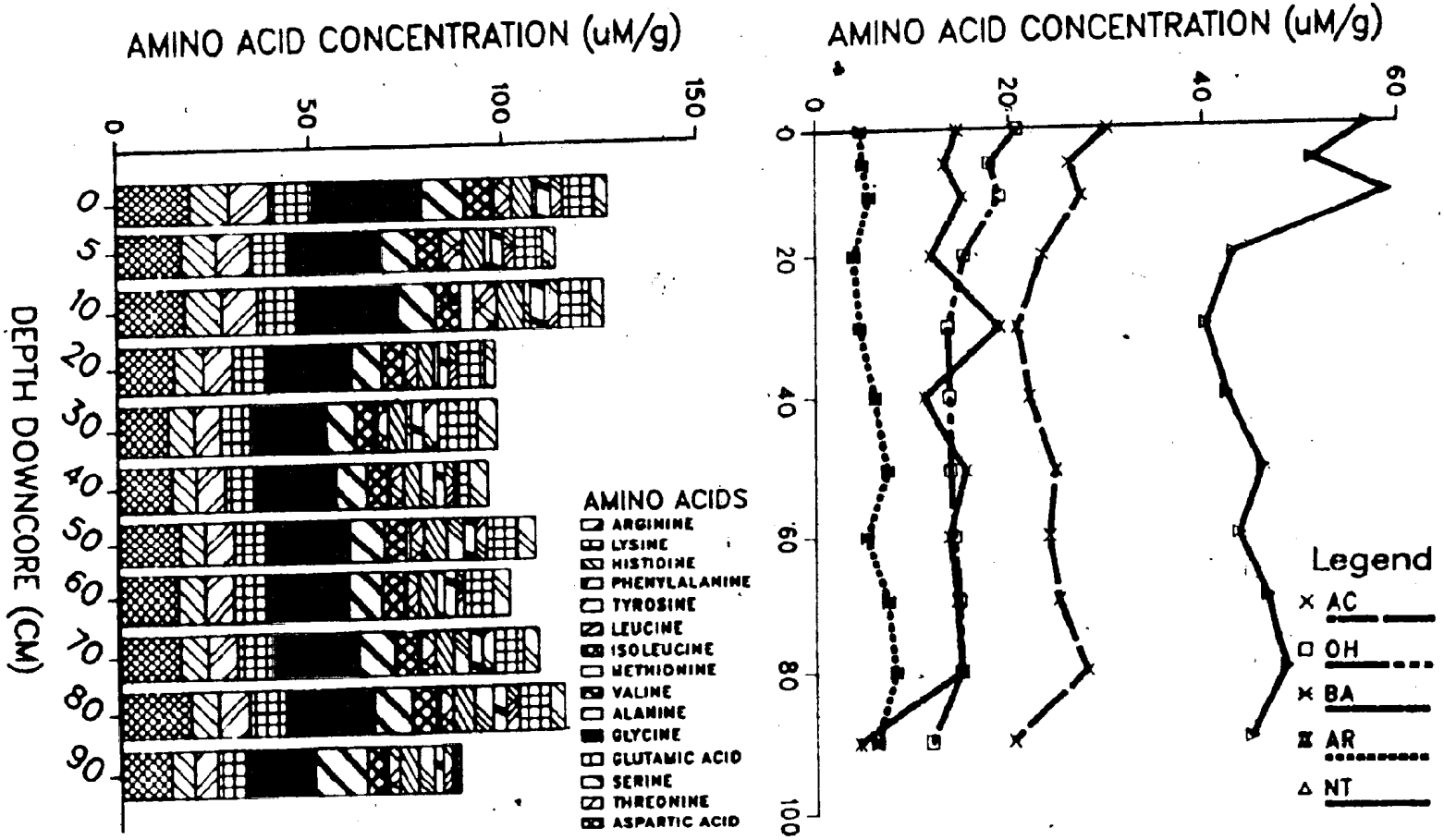

9
8
7
6
5
4
δ^{15}N (o/oo)
0
20
40
60
80
100
−20
−21
−22
−23
−24
−25
δ^{13}C (o/oo)
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

Figure 3-2: FO-840401 sediment profile:
Individual and amino acid fractions.

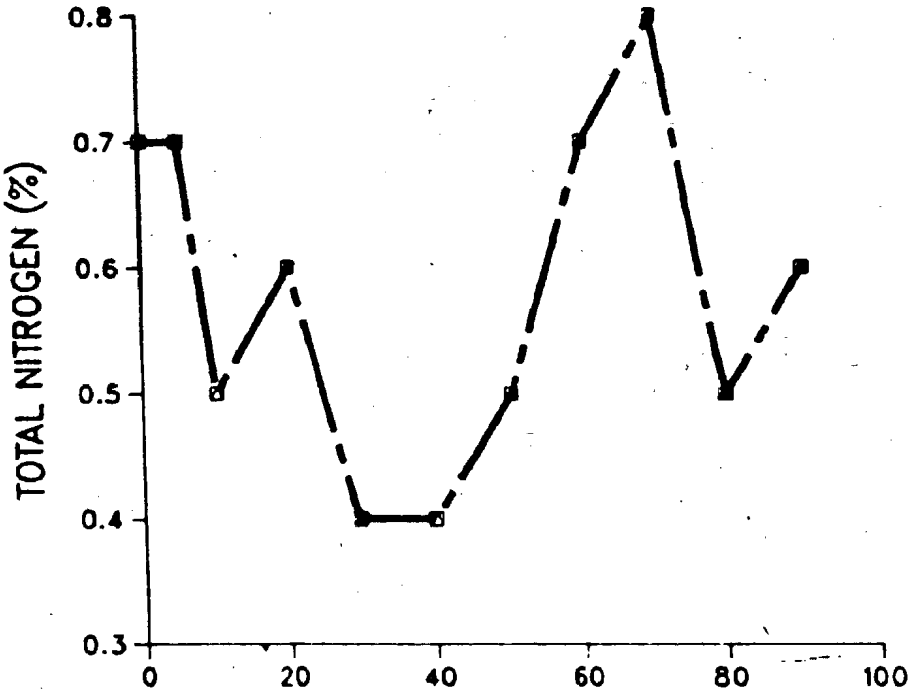

AMINO ACID CONCENTRATION (uM/g)
0
50
100
150
DEPTH DOWNCORE (CM)
0
5
10
20
30
40
50
60
70
80
90
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID
AMINO ACID CONCENTRATION (uM/g)
0
20
40
60
0
20
40
60
80
100
Legend
AC
OH
BA
AR
NT

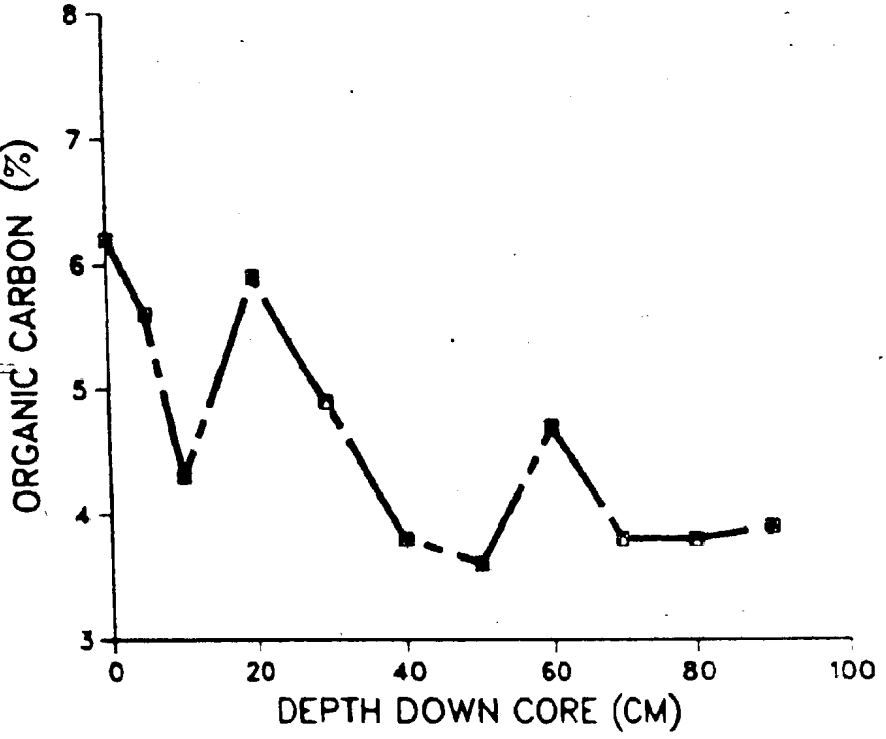
(10.6 to 5.9μM/g), VAL (7.1 to 4.4 μM/g) and LYS (10.0 to 7.0 μM/g) are also relatively high in concentration in comparison with GLY and ASP (Appendix 2a and Fig. 3-2). Methionine and TYR are the least abundant amino acids in this core, with concentrations ranging from 4.0 to 0.3 μM/g (Appendix 2a and Fig. 3-2). The total amino acid concentration is divided into five fractions: acidic (ASP and GLU), basic (HIS, LYS and ARG), hydroxy (SER and THR), aromatic (TYR and PHE) and neutral fractions (GLY, ALA, VAL, MET, ILEU and LEU). Within the amino acid fractions, the most abundant is the neutral fraction, with concentration values that are relatively constant downcore (between 56.9 and 40.2 μM/g) (Appendix 3a and Fig. 3-2). The acidic fraction has the second highest concentration, varying between 30.2 and 20.4 μM/g (Appendix 3a and Fig. 3-18), which is also relatively constant downcore. The aromatic fraction is the smallest with concentrations between 8.2 to 4.6 μM/g (Appendix 3a and Fig. 3-2). Moderate concentrations are seen within the hydroxy and basic fractions, 20.8 to 11.9 μM/g and 19.0 to 4.4μM/g respectively (Appendix 3a and Fig. 3-18). However, the concentrations within the basic fraction have an anomalous high of 19.0 μM/g at 30 cm and an anomalous low of 4.4 μM/g at 90 cm, the other values varying from 15.1 to 11.9 μM/g.

Organic carbon content is high throughout this core, ranging from 6.2% to 3.6%, and exhibits a decrease downcore (Table 2 and Fig. 3-3). Total nitrogen content is also high and varies between 0.7% and 0.4% (Table 2 and Fig. 3-3). No simple trends are observed. The C/N values range from 14.1 to 5.7, and are relatively constant downcore, with average values about 9.0 (Table 2).

The carbonate content within the sediment of this core has the highest values in the study area, and ranges between 32.0 to 22.5% (Appendix 1).

Figure 3-3: FO-840401 sediment profile:
– Organic carbon and total nitrogen contents.


TOTAL NITROGEN (%)
0.8
0.7
0.6
0.5
0.4
0.3
0
20
40
60
80
100


ORGANIC CARBON (%)
8
7
6
5
4
3
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

3.2. CORE FO-840402

3.2.1. Core Description

This core is 83.5 cm long and appears to consist of a very homogeneous olive grey sand. The sand fraction data is very similar to that of Core FO-840401, values ranging from 2.7 to 1.1% of the total sediment(Appendix 1).

3.2.2. Geochemical analyses

The results for this core are very similar to those for Core FO-840401. The $\delta^{13}C$ values are fairly constant, ranging from -20.5 to -21.9°/oo (Table 2 and Fig. 3-4). The $\delta^{15}N$ values are also relatively constant and range from 7.1 to 7.9°/oo (Table 2 and Fig. 3-4).

The total and individual amino acid concentrations are high.The total amino acids range from 118.0 to 52.9 μM/g. There is a decrease in amino acid concentration downcore (Appendix 2b and Fig. 3-5). The relative concentrations of the individual amino acids are very similar to that of FO-840401, with values slightly smaller (Appendix 2b). The GLY concentrations range from 23.9 μM/g at the surface to 12.8 at 60 cm and ASP concentrations range from 18.8 at 5 cm to 7.7 μM/g at 60 cm (Appendix 2b). Other relatively high concentrations of amino acids are seen in values for ALA (10.5 to 4.2 μM/g), GLU (7.9 to 4.2 μM/g), SER (9.5 to 4.2 μM/g) and THR (8.1 to 3.6 μM/g) (Appendix 2b). The lowest concentrations of amino acids were observed in MET (2.6 to 0.3 μM/g), TYR (2.2 to 0.7 μM/g), PHE (3 to 0.6 mg) and HIS (4.6 to 1.4 μM/g) (Appendix 2b). The relative abundances of the different amino acid fractions are very similar to FO-840401 showing the same order: 26.1 to 12.0 μM/g, 16.6 to 7.8 μM/g, 15.6 to 6.1 μM/g, 5.2 to 1.4 μM/g and 56.9 to 24.9 μM/g for the acidic, hydroxy; basic, aromatic and neutral fractions respectively (Appendix 3b and Fig. 3-5).

The organic carbon content fluctuates little downcore, with values ranging from 4.1 to 2.9% (Table 2 and Fig. 3-6). Similarly, the total nitrogen content is

Figure 3-4: FO-840402 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.

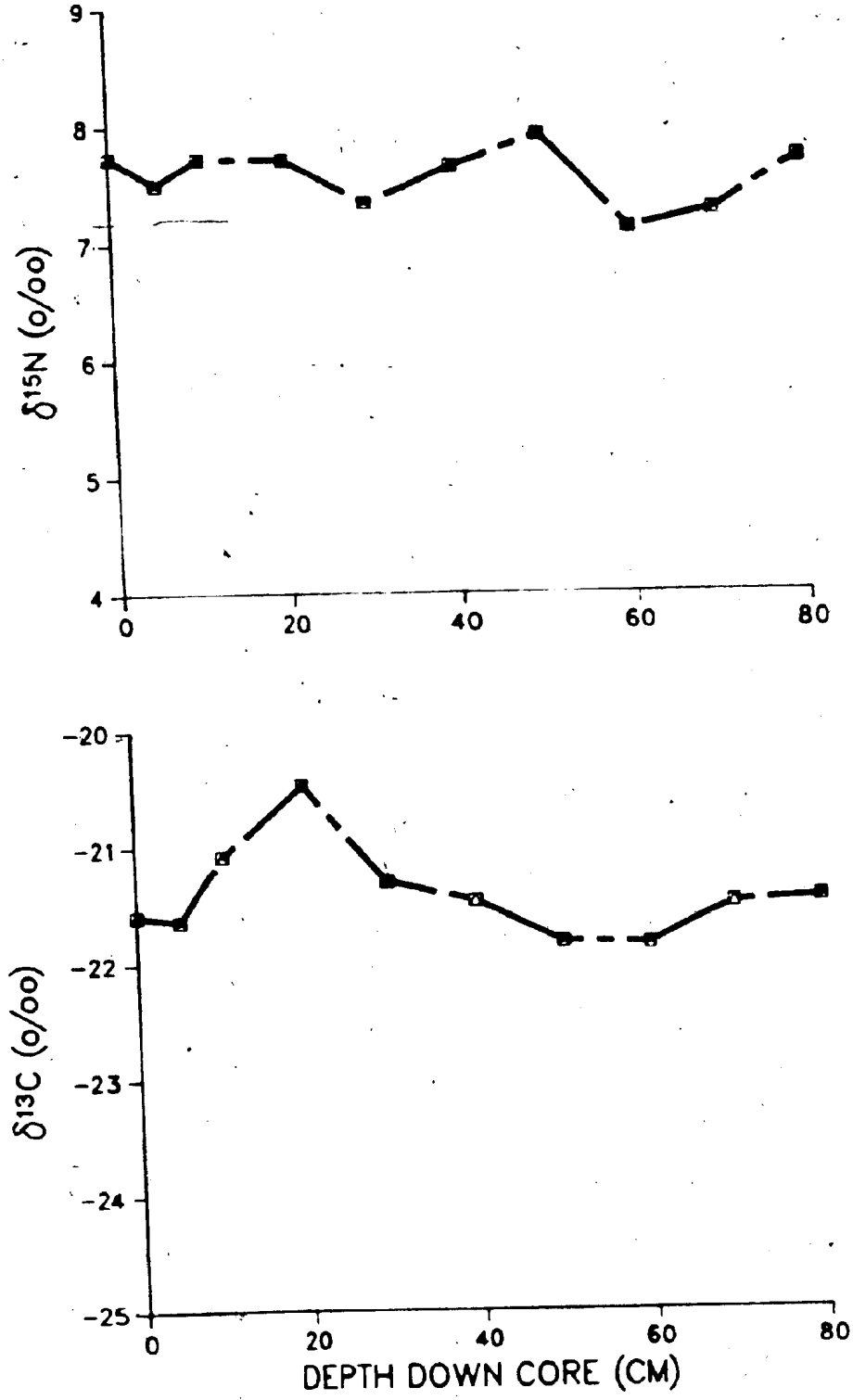
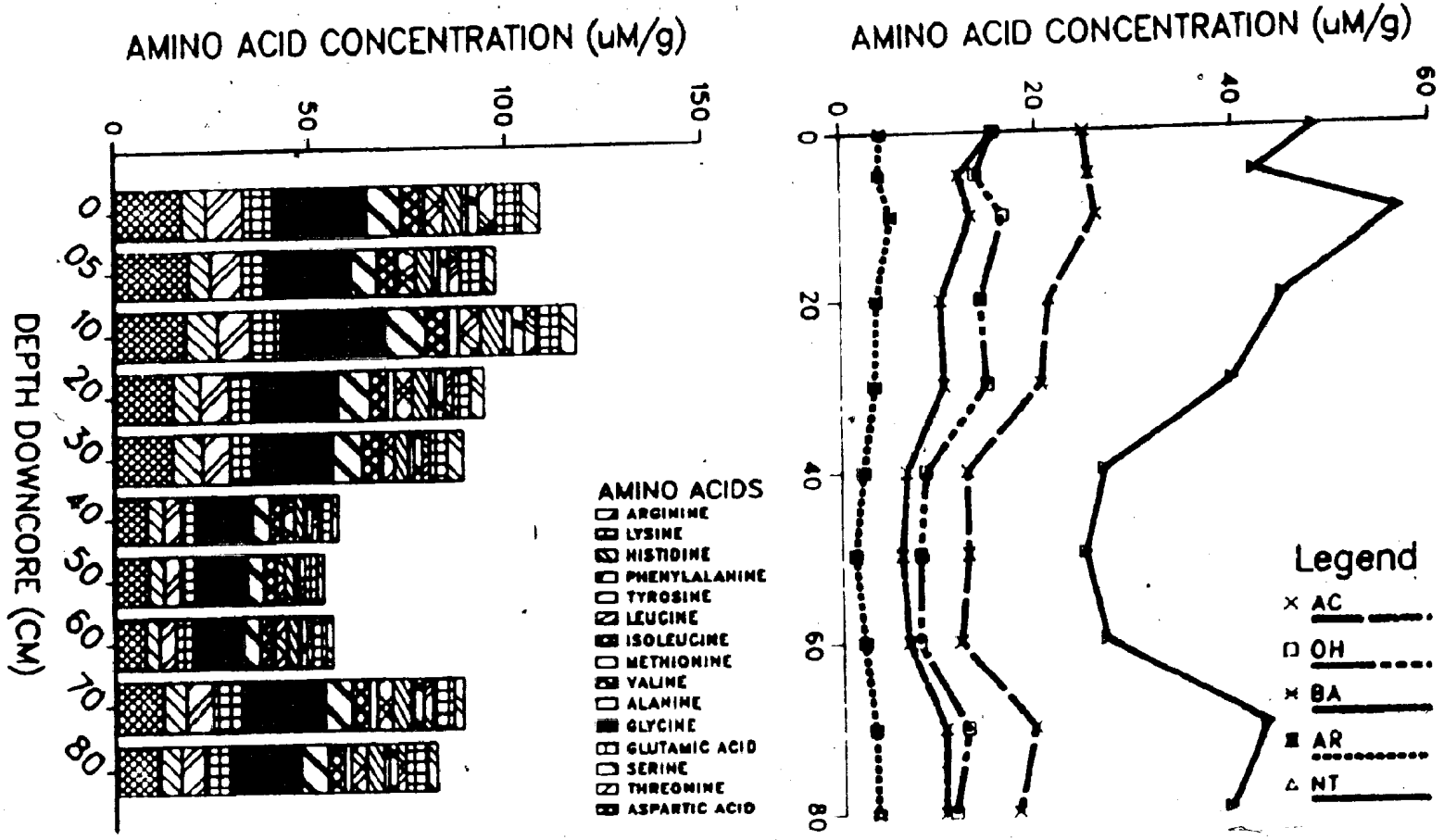

9
8
7
6
5
4
$\delta^{15}N$ (o/oo)
0
20
40
60
80
-20
-21
-22
-23
-24
-25
$\delta^{13}C$ (o/oo)
0
20
40
60
80
DEPTH DOWN CORE (CM)

Figure 3-5: FO-840402 sediment profile:
Individual and amino acid fractions.


AMINO ACID CONCENTRATION (uM/g)
0
50
100
150
DEPTH DOWNCORE (CM)
0
05
10
20
30
40
50
60
70
80
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID
AMINO ACID CONCENTRATION (uM/g)
0
20
40
60
0
20
40
60
80
Legend
AC
OH
BA
AR
NT

relatively constant downcore, at about 0.5%c (Table 2 and Fig. 3-6). As a result, C/N values are also constant and relatively low with values between 10.3 and 7.2, and an average value about 8. A slight increase in values downcore is also observed.

The carbonate content is also very high in the sediments of this core, with a slight decrease downcore. Values range from 24.6 to 16.7%c (Appendix 1). Within the foraminiferal assemblage, the species *Islandiella islandica* (Norvang) and *Globobulimina auriculata* are the most abundant. *Globobulimina auriculata* is most abundant in the upper 60 cm, ranging from 58.2 to 37.2%, and decreases to 13.4% at the bottom of the core (Appendix 1). The isotopic signal of the benthic foraminifera *Globobulimina auriculata* is relatively constant downcore with $\delta^{13}C$ composition ranging from 0.8 to 0.2°/oo and $\delta^{18}O$ composition between 2.3 and 1.8 °/oo (Appendix 1, Fig. 3-7). The D_{AlLE}/L_{ILE} for the species *Globobulimina auriculata* is 0.09 ± 0.025 at 80 cm (Appendix 1).

3.3. CORE FO-840403

3.3.1. Core Description

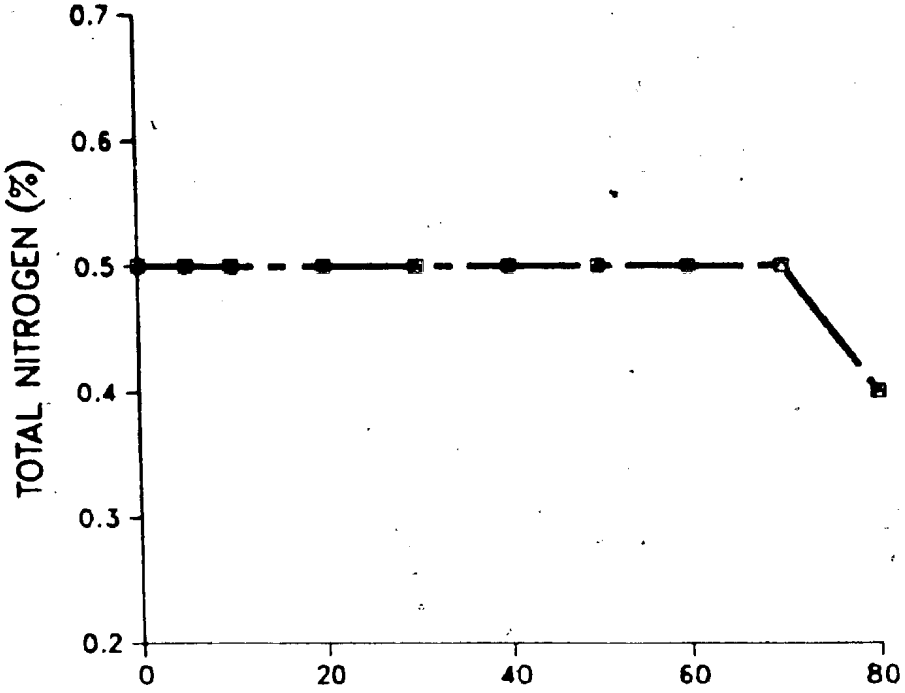
This core is 95 cm long and very similar to FO-840402. The sand fraction values range from 6.5 to 11.2%, and shows a slight increase with depth (Appendix 1).

3.3.2. Geochemical analyses

Minor fluctuations in the $\delta^{13}C$ values are seen throughout this core, with values remaining relatively constant between from -21.2 to -22.1°/oo (Table 2 and Fig. 3-8). The $\delta^{15}N$ values are also relatively constant, with values ranging from 7.3 to 8.0°/oo (Table 2 and Fig. 3-8).

The total and individual amino acid concentrations are very similar to that of FO-840401, with the exception of higher ARG content. Total amino acid

Figure 3-6: FO-840402 sediment profile:
Organic carbon and total nitrogen contents.


TOTAL NITROGEN (%)
0.7
0.6
0.5
0.4
0.3
0.2
0
20
40
60
80

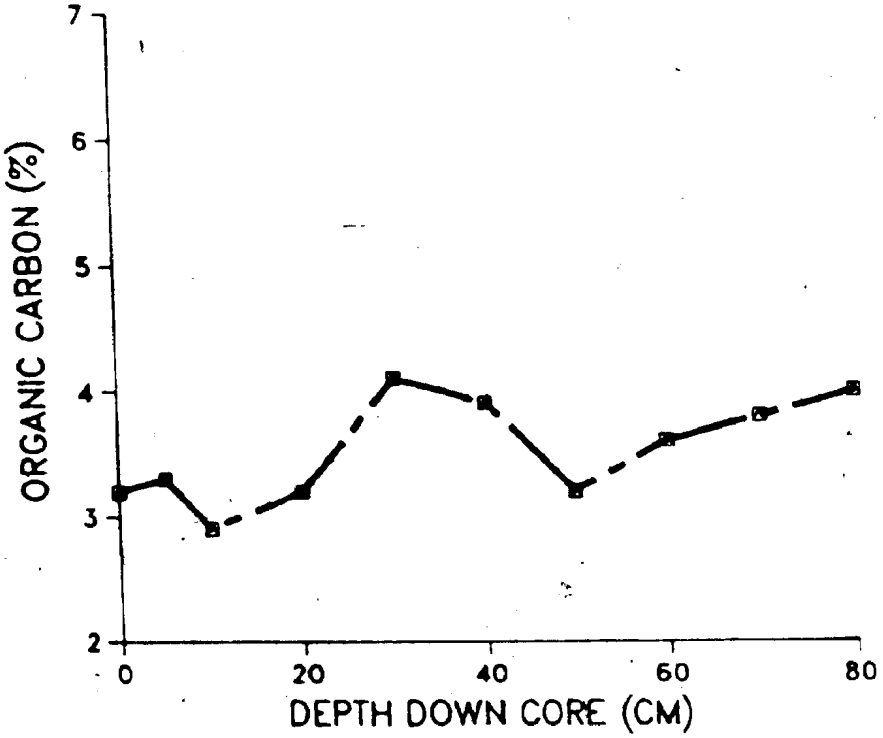

ORGANIC CARBON (%)
7
6
5
4
3
2
0
20
40
60
80
DEPTH DOWN CORE (CM)

Figure 3-7: Isotopic composition of foraminifera of cores FO-840403, FO-840404 and FO-840405.

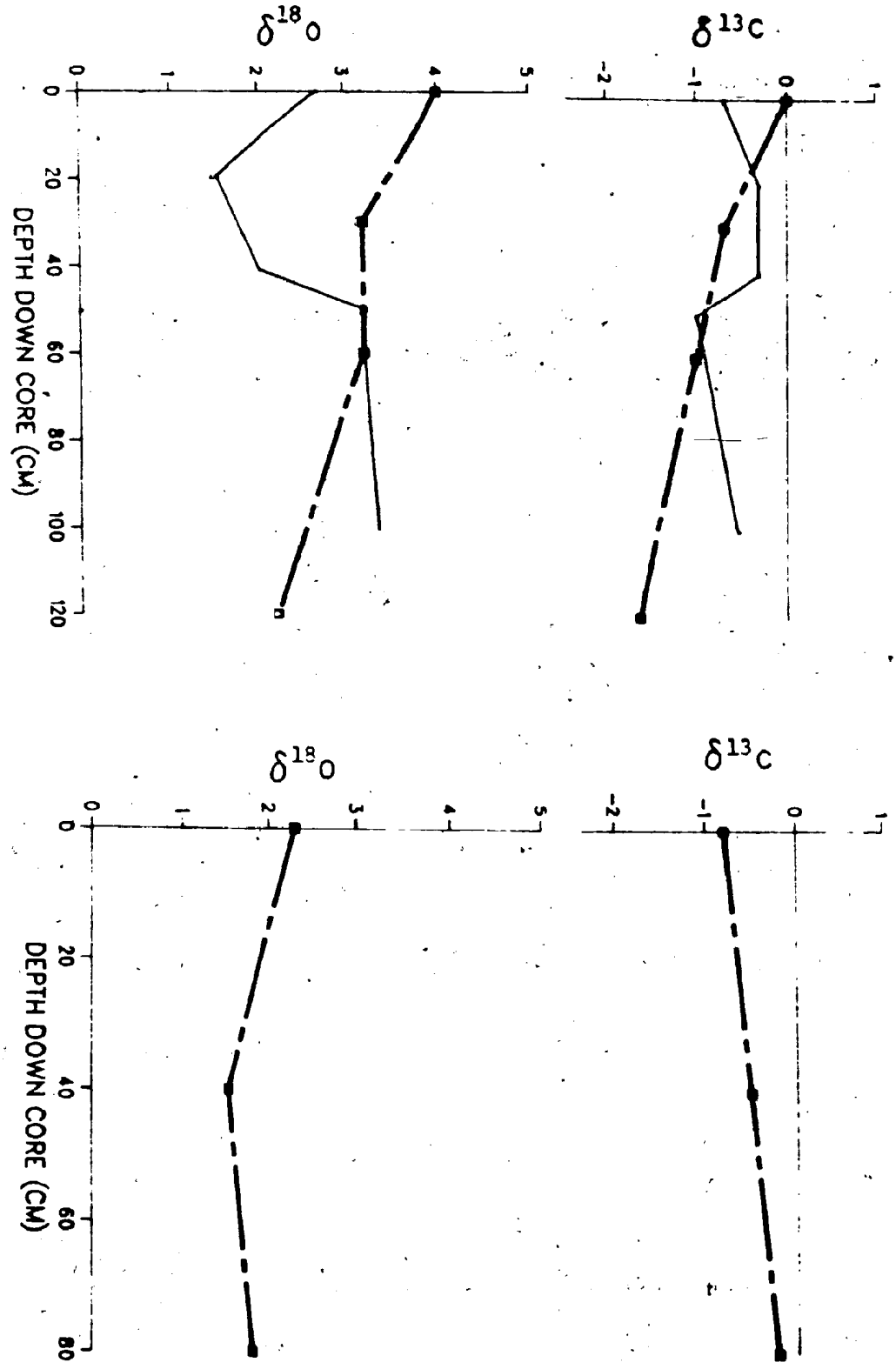
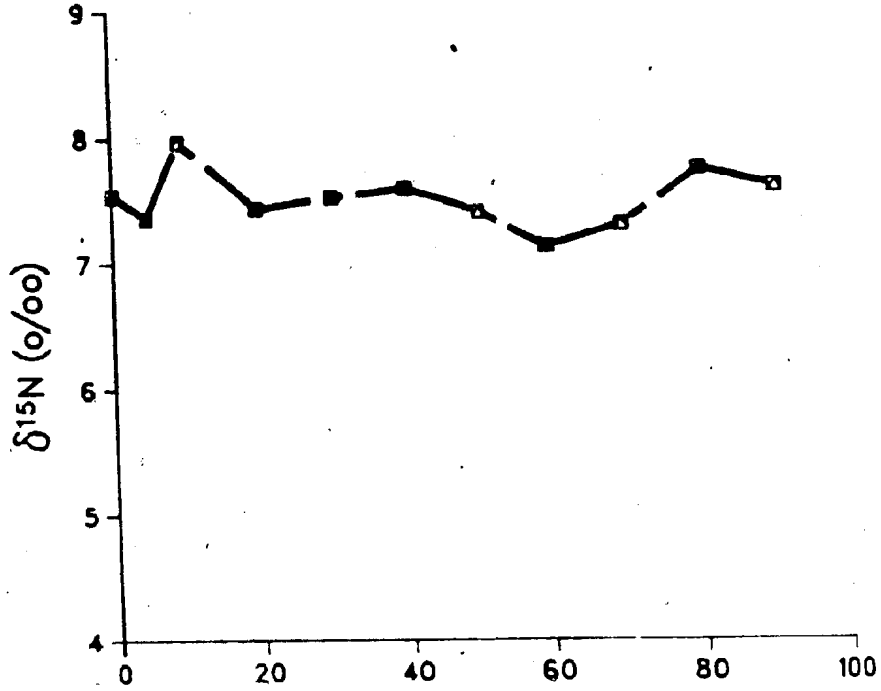
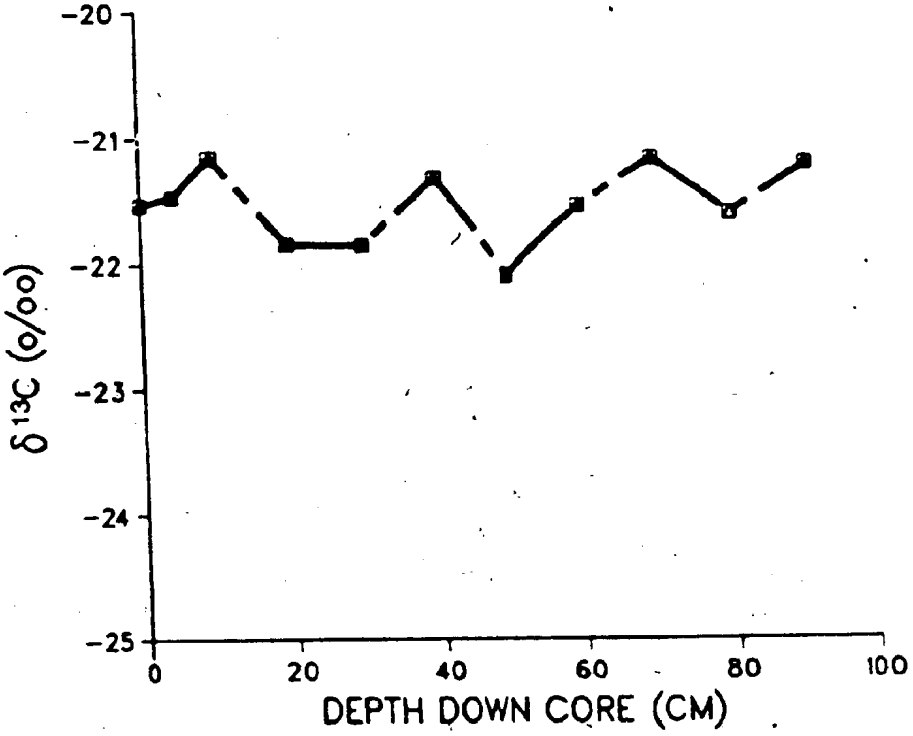

δ18O
δ13C
δ18O
δ13C
DEPTH DOWN CORE (CM)
DEPTH DOWN CORE (CM)

Figure 3-8: FO-840403 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.


9
8
7
6
5
4
δ15N (o/oo)
0
20
40
60
80
100


-20
-21
-22
-23
-24
-25
δ13C (o/oo)
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

concentrations range from 93.4 to 66.7 μM/g (Appendix 2c and Fig. 3-9). The GLY and ASP are the most abundant amino acids, with concentrations ranging from 23.9 to 14.8 μM/g and 16.3 to 9.9 μM/g (Appendix 2c). The next most abundant amino acids are GLU (8.3 to 5.3 μM/g), SER (7.2 to 5.1 μM/g), ALA (8.4 to 3.2 μM/g) and ARG (8.9 to 4.1 μM/g) (Appendix 2c). The amino acid fractions show a very slight decrease downcore, with values varying from 22.5 to 16.4 μM/g, 14.4 to 8.6 μM/g, 10.6 to 5.7 μM/g, 4.3 to 2.6 μM/g and 41.3 to 30.8 μM/g for the acidic, hydroxy, basic, aromatic and neutral fractions (Appendix 3c and Fig. 3-9).

The organic carbon content is highest at the surface (3.6%) and decreases downcore to a minimum value of about 2.3% at the bottom of the core (Table 2 and Fig. 3-10). Similarly, the total nitrogen content ranges from 0.5% (at the surface), to 0.3% (Table 2 and Fig. 3-10). The C/N values throughout the core range from 12.5 to 6.9, with no simple trend (Table 2).

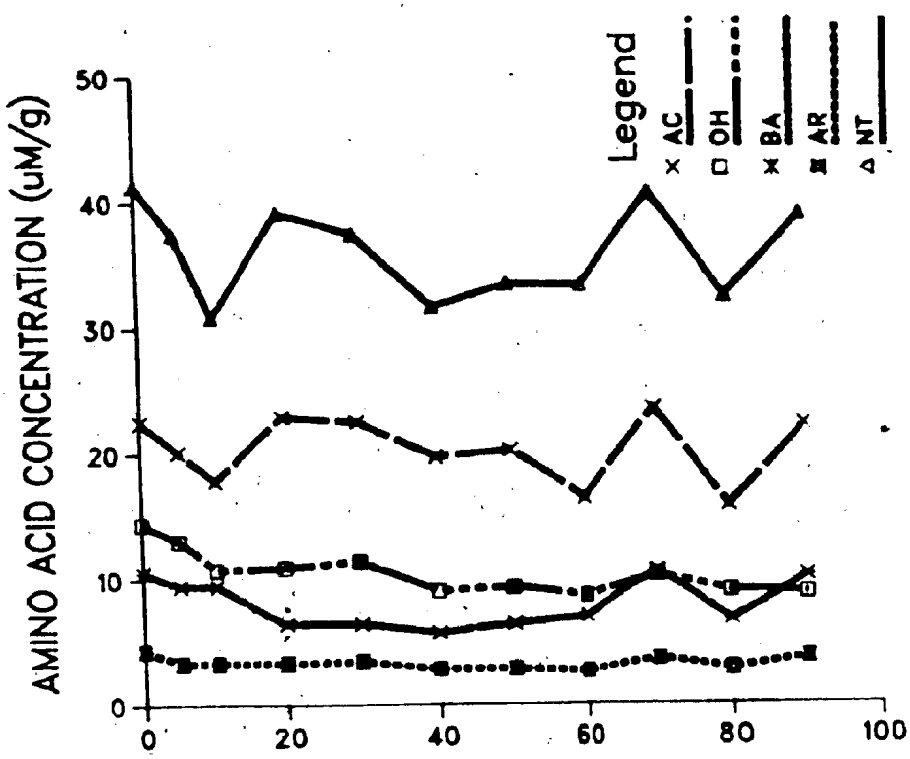
The carbonate content is very similar to that of FO-840402, ranging from 25.4% at the surface to 20.5% at 40 cm, to 17.0% at 90 cm (Appendix 1).

3.4. CORE FO-840404

3.4.1. Core Description

This core is 127 cm long and has visible color and textural variations. The upper 30 cm of this core consist of an olive grey and sandy mud. Below 30 cm the color and texture changes to a grey fine grained cohesive mud. The grain size data indicates a sharp discontinuity between 30 and 35 cm (Fig. 3-11). Above the discontinuity the sand fraction is high, ranging from 33.2% at the surface to 12.4% at 30 cm. At 35 cm depth, the sand fraction decreases sharply to 2.0% and remains near this value for the rest of the core (Appendix 1).

Figure 3-9: FO-840403 sediment profile: Individual and amino acid fractions.


Legend
AC
OH
BA
AR
NT
AMINO ACID CONCENTRATION (uM/g)
50
40
30
20
10
0
0
20
40
60
80
100

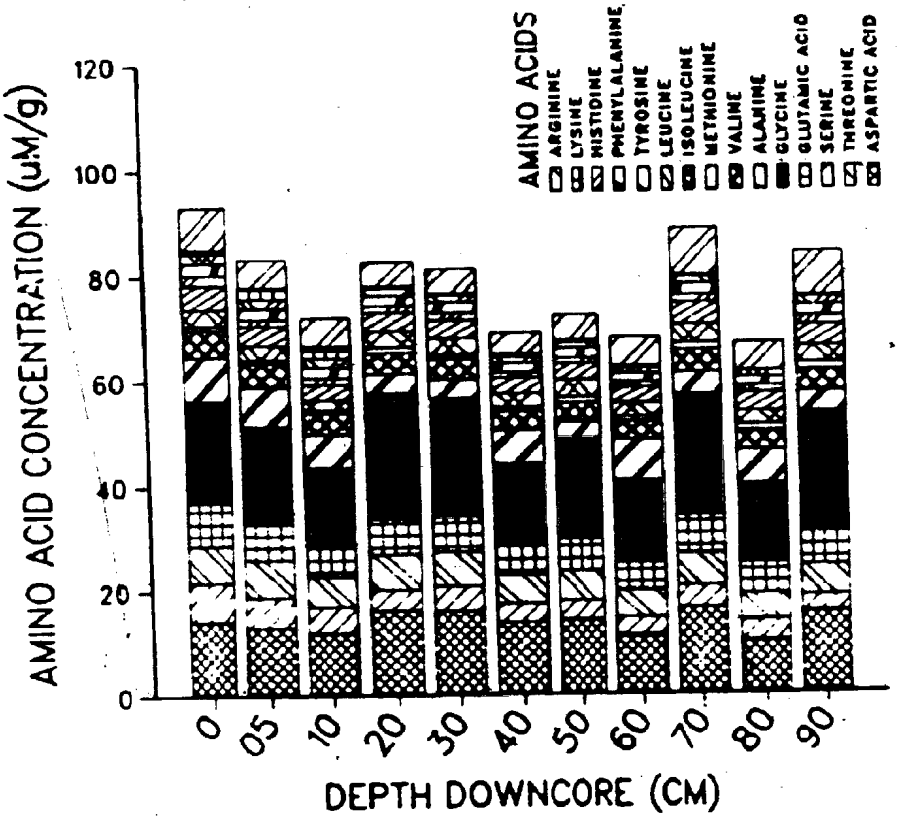

AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID
AMINO ACID CONCENTRATION (uM/g)
120
100
80
60
40
20
0
0
05
10
20
30
40
50
60
70
80
90
DEPTH DOWNCORE (CM)

Figure 3-10: FO-840403 sediment profile:
Organic carbon and total nitrogen contents.

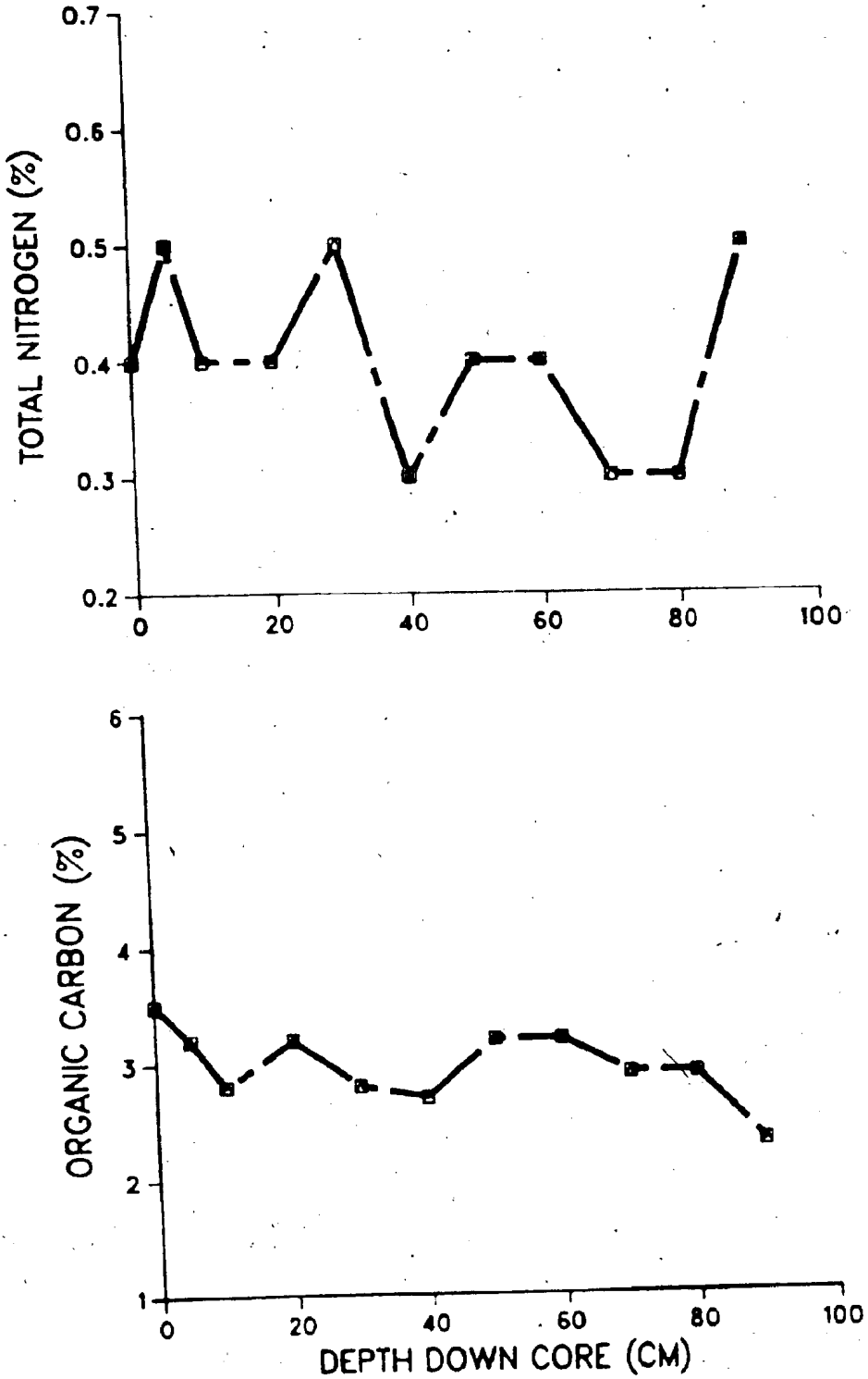
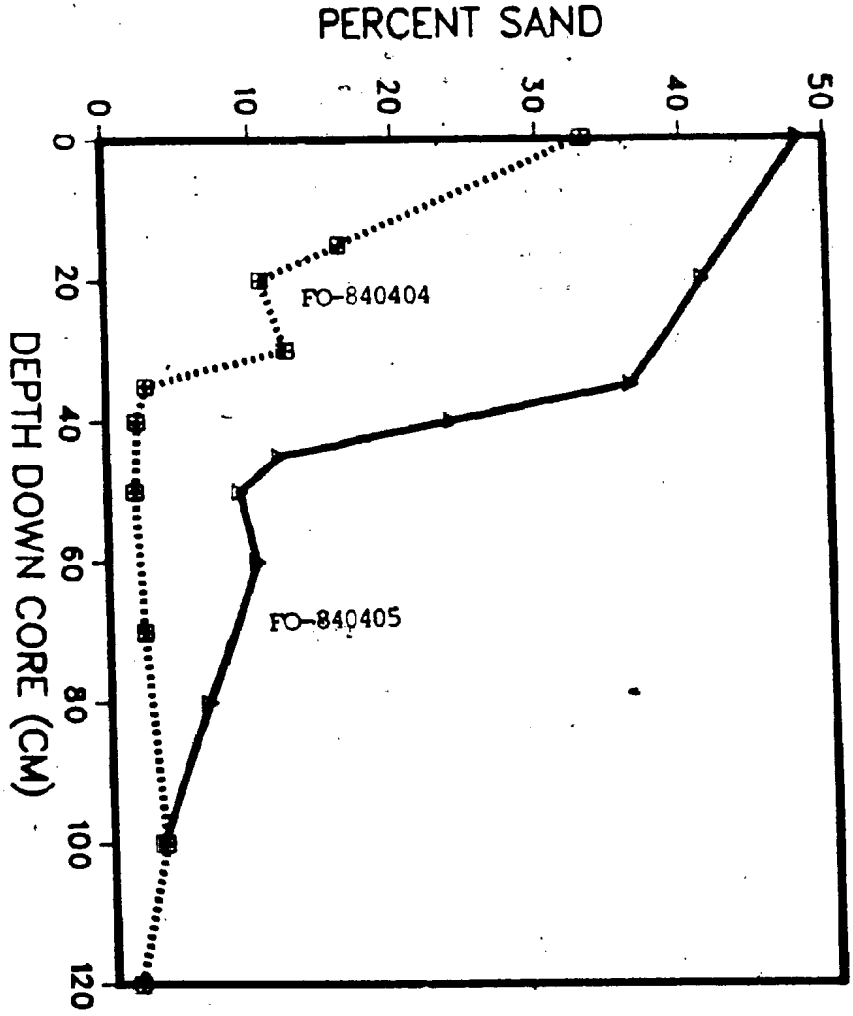

TOTAL NITROGEN (%)
0.7
0.6
0.5
0.4
0.3
0.2
0
20
40
60
80
100
ORGANIC CARBON (%)
6
5
4
3
2
1
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

Figure 3-11: FO-840404 and FO-840405 sediment profiles: Grain size.

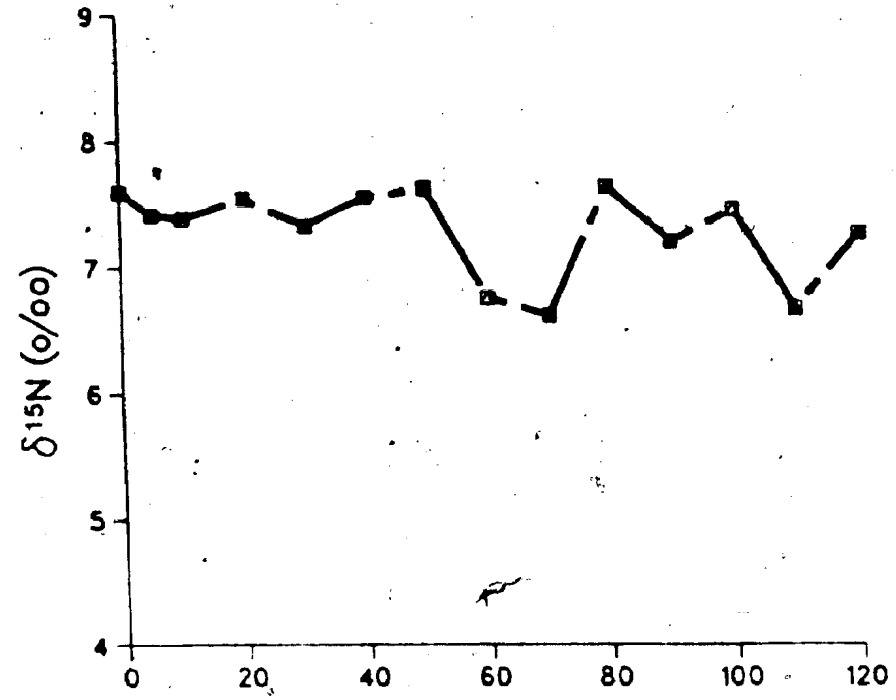

PERCENT SAND
0
10
20
30
40
50
DEPTH DOWN CORE (CM)
0
20
40
60
80
100
120
FO-840404
FO-840405

3.4.2. Geochemical analyses

The $\delta^{13}C$ isotopic signature is relatively constant from 0 to 50 cm at about -21.6°/oo and fluctuates between -20.9 to -22.2°/oo for the rest of the core (Table 2 and Fig. 3-12). The variations in $\delta^{15}N$ are similar to the $\delta^{13}C$ composition - fairly constant values from 0 to 50 cm (about 7.5°/oo), followed by fluctuations between 6.6 and 7.6°/oo with a slightly greater depletion in ^{15}N downcore (Table 2 and Fig. 3-12).

Individual amino acid concentrations are relatively high from the surface to 20 cm, below which the concentrations decrease sharply and remain constant for the rest of the core (Appendix 2d and Fig. 3-13). The relative distribution of individual amino acids is very similar to FO-840401, FO-840402 and FO-840403, with GLY being the most abundant (18.3 to 1.6 μM/g), followed by ASP (10.4 to 0.6 μM/g) (Appendix 2d). Other abundant amino acids in this core are GLU (7.2 to 0.2 μM/g), SER (5.3 to 0.2 μM/g), THR (5.4 to 0.2 μM/g) and ALA (6.1 to 0.6 μM/g) (Appendix 2d). Methionine is the least abundant amino acid (0.8 to 0.0μM/g) (Appendix 2d). Coincident with the sharp discontinuity observed at 30 cm at which individual amino acid concentrations rapidly decrease is a sharp decline in the total amino acid concentration (Appendix 2d and Fig. 3-13). Total concentrations decrease from 81.3 μM/g at 20 cm, to 25.1 μM/g at 30 cm, and to 14 μM/g at 40 cm (Appendix 2d and Fig. 3-13). Above the discontinuity the total amino acid concentration varies between 81.3 to 57.1 μM/g, whereas below the break values vary between 19.6 and 7.2 μM/g (Appendix 2d and Fig. 3-13). The discontinuity is also seen in the amino acid fraction profile (Fig. 3-13). The concentrations of the acidic fraction, hydroxy, basic, aromatic and neutral fractions vary from 15 .6 to 17.5 μM/g, 7.3 to 10.7 μM/g, 8.0 to 11.7 μM/g, 3.6 to 5.8 μM/g and 29.8 to 36.3 μM/g, respectively, from the surface to 20 cm (Appendix 3d). Below the discontinuity the amino acid fractions decrease drastically, from 4.5 to 0.8 μM/g, 2.5 to 0.4 μM/g, 3.7 to 1.1 μM/g, 1.5 to 0.4 μM/g and 13.0 to 3.1 μM/g in the same respective order as above (Appendix 3d and Fig. 3-13).

Figure 3-12: FO-840404 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.


9
8
7
6
5
4
δ15N (o/oo)
0
20
40
60
80
100
120

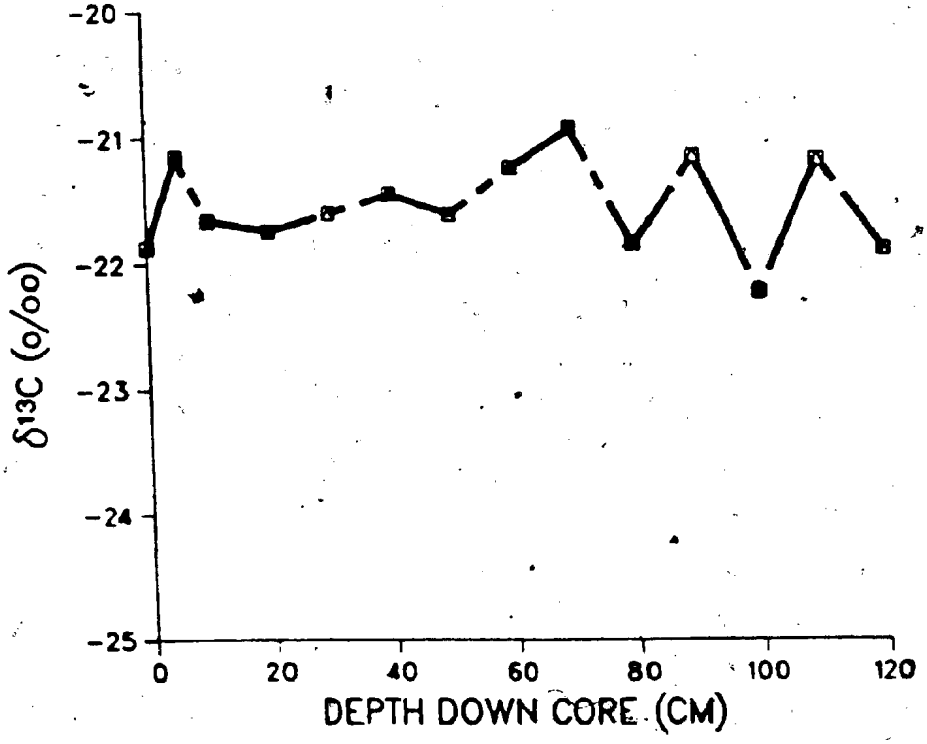

-20
-21
-22
-23
-24
-25
δ13C (o/oo)
0
20
40
60
80
100
120
DEPTH DOWN CORE (CM)

Figure 3-13: FO-840404 sediment profile:
Individual and amino acid fractions.

AMINO ACID CONCENTRATION (uM/g)
0
20
40
60
80
100
DEPTH DOWNCORE (CM)
0
5
10
20
30
40
50
60
70
80
90
100
110
120
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID

AMINO ACID CONCENTRATION (uM/g)
0
10
20
30
40
0
20
40
60
80
100
120
Legend
AC
OH
BA
AR
NT

The organic carbon and total nitrogen contents follow the same trend as the total amino acid concentration (Table 2). Organic carbon ranges from 4.0% at the surface to 1.7% at 20 cm and then remains fairly constant downcore between 0.8 and 0.6% (Table 2 and Fig. 3-14). Between 0 to 20 cm the nitrogen content varies from 0.4 to 0.3%, and then decreases to about .1% for the rest of the core (Table 2 and Fig. 3-14). The C/N values vary between 6.8 and 12.1 with the largest fluctuations in the upper 20 cm, below which C/N are relatively constant at about 9.0.

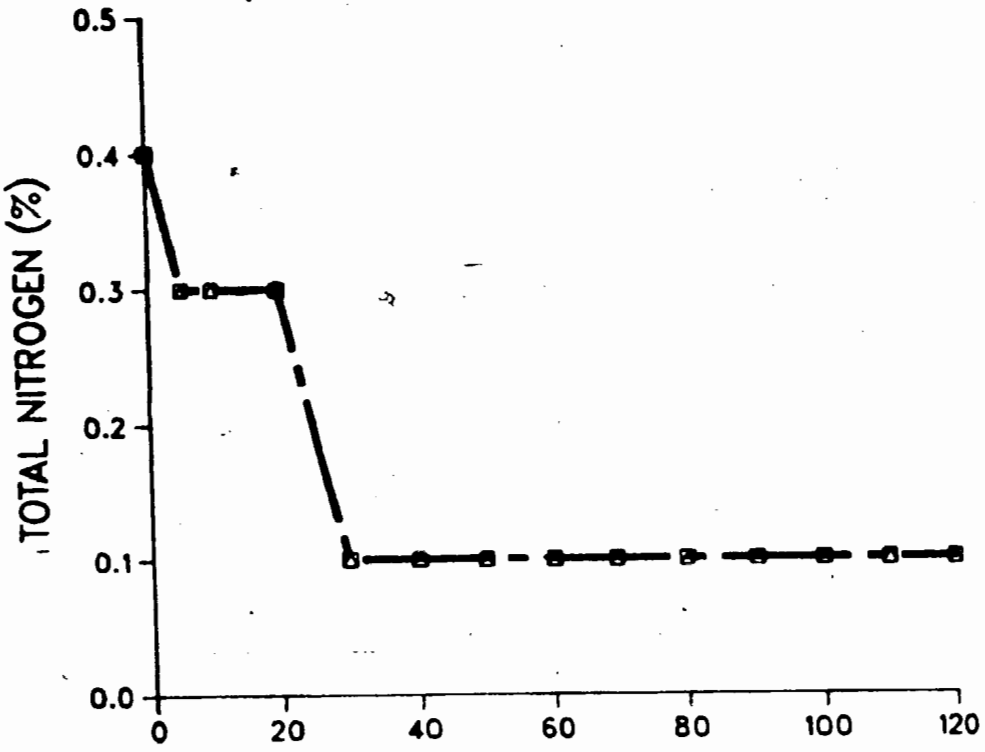
The carbonate content is highest at the surface (23.1%) and decreases to about half this value for the rest of the core (Appendix 1). A discontinuity is also seen in the foraminiferal assemblage, where the abundance of *Globobulimina auriculata* decreases from 32% at the surface, to 21.5% at 30 cm and to less than 1% below 35 cm. (Appendix 1). The $\delta^{18}O$ and $\delta^{13}C$ signals of the carbonate in tests of *Globobulimina auriculata* vary in the same direction downcore (Appendix 1 and Fig. 3-7). The $\delta^{18}O$ composition varies from 4.0°/oo at the surface to 2.2°/oo at the bottom of the core. Similarly, the $\delta^{13}C$ composition of 0.0°/oo at the surface decreases to -1.6°/oo at 120 cm (Appendix 1 and Fig. 3-7). The D-AILE peaks for the species *Globobulimina auriculata* were below the limit of detection and estimation.

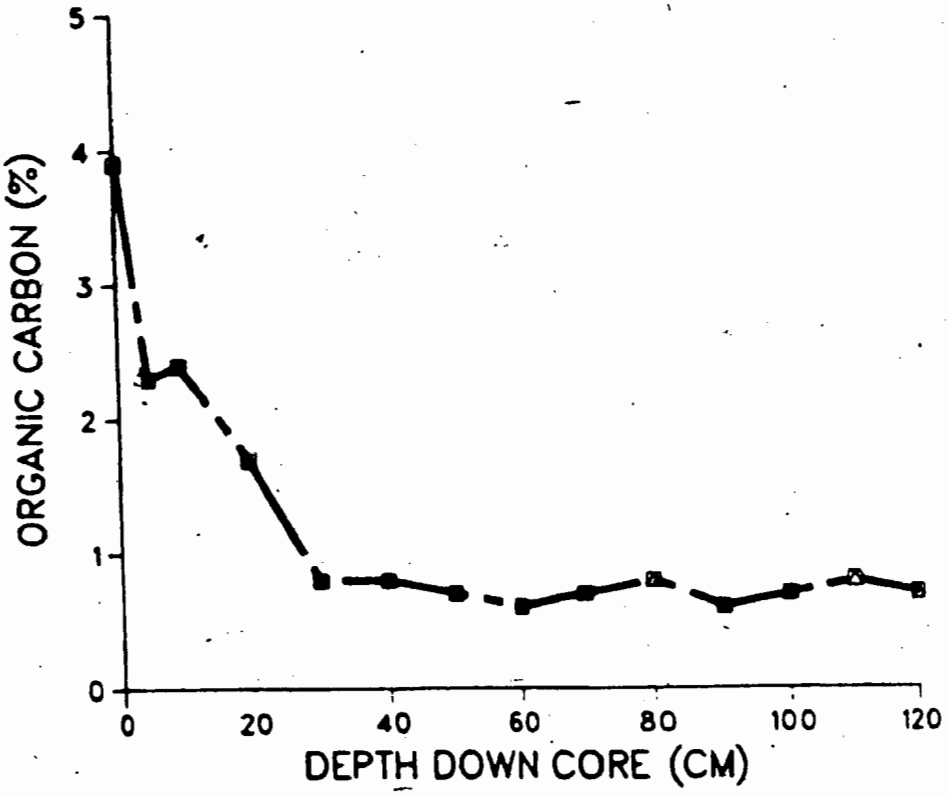
3.5. CORE FO-840405

3.5.1. Core Description

This core is 108 cm long and is very similar to FO-840404. It is dark greenish and sandy at the surface to 35 cm, below which it changes to a grey fine grained cohesive mud. The grain size data of this core is similar to that of FO-840404. However, the discontinuity is more gradual and occurs deeper, between 40 to 45 cm (Fig. 3-11). Above the discontinuity the sand fraction is high, ranging from 48.4% at the surface to 23.9% at 40 cm. At 45 cm the sand fraction decreases to 11.9% and remains relatively low for the remainder of the core (between 10.2 and 3.3%) (Appendix 1).

Figure 3-14: FO-840404 sediment profile:
Organic carbon and total nitrogen contents.


TOTAL NITROGEN (%)
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100
120


ORGANIC CARBON (%)
5
4
3
2
1
0
0
20
40
60
80
100
120
DEPTH DOWN CORE (CM)

3.5.2. Geochemical analyses

There are several similarities in the isotope and amino acid compositions of FO-840405 and FO-840404 (Table 2).

The $\delta^{13}C$ composition throughout this core ranges from -22.0 - 20.5°/oo. The lowest values are at the surface, -22.0°/oo. Below the surface, a general enrichment in ^{13}C is observed from 0 to 40 cm, below which the $\delta^{13}C$ values fluctuate throughout the rest of the core (Table 2 and Fig. 3-15). The $\delta^{15}N$ composition is fairly constant from the surface to 30 cm, with values ranging from 7.4 to 7.5°/oo. Below 30 cm, $\delta^{15}N$ values fluctuate between 8.0 to 6.6°/oo (Table 2 and Fig. 3-15).

Total amino acid concentrations range from 38.2 to 8.2μM/g (Appendix 2e and Fig. 3-16). Total amino acid concentrations vary between 38.2 to 32.1 μM/g in the upper 10 cm (Appendix 2e and Fig. 3-16). At 20 cm the total amino acid concentration decreases to 20.0 μM/g, and at 50 cm to 14.00 μM/g, and remains constant between 10.8 to 8.2μM/g throughout the rest of the core (Appendix 2e and Fig. 3-16). The most abundant amino acids are GLY, ASP and ALA, concentrations ranging from 9.5 to 1.9 μM/g, 5.7 to 1.2 μM/g and 4.2 to 1.0 μM/g, respectively (Appendix 2e). The concentrations of MET, TYR, and LYS are the lowest and are less than 1 μM/g (Appendix 2e). The variation of the amino acid fractions with depth is similar to that of the individual and total amino acid concentrations, i.e. a general decrease in abundance with depth up to 50 cm, below which values are constant (Appendix 3e and Fig. 3-16). From 0 to 50 cm the concentrations of the acidic, hydroxy, basic, aromatic and neutral fractions vary from 3.0 to 9.4 μM/g, 1.0 to 3.8 μM/g, 0.6 to 4.5 μM/g, 1.0 to 2.0 μM/g and 7.6 to 19.1 μM/g (Appendix 3e). Below 50 cm the concentrations of the above fractions range from 1.9 to 2.9 μM/g, 0.4 to 0.8 μM/g, 0.5 to 0.8 μM/g, 0.3 to 0.7 μM/g and 4.5 to 5.9 μM/g (Appendix 3e).

The organic carbon and nitrogen content follows the total amino acid trend.

Figure 3-15: FO-840405 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.

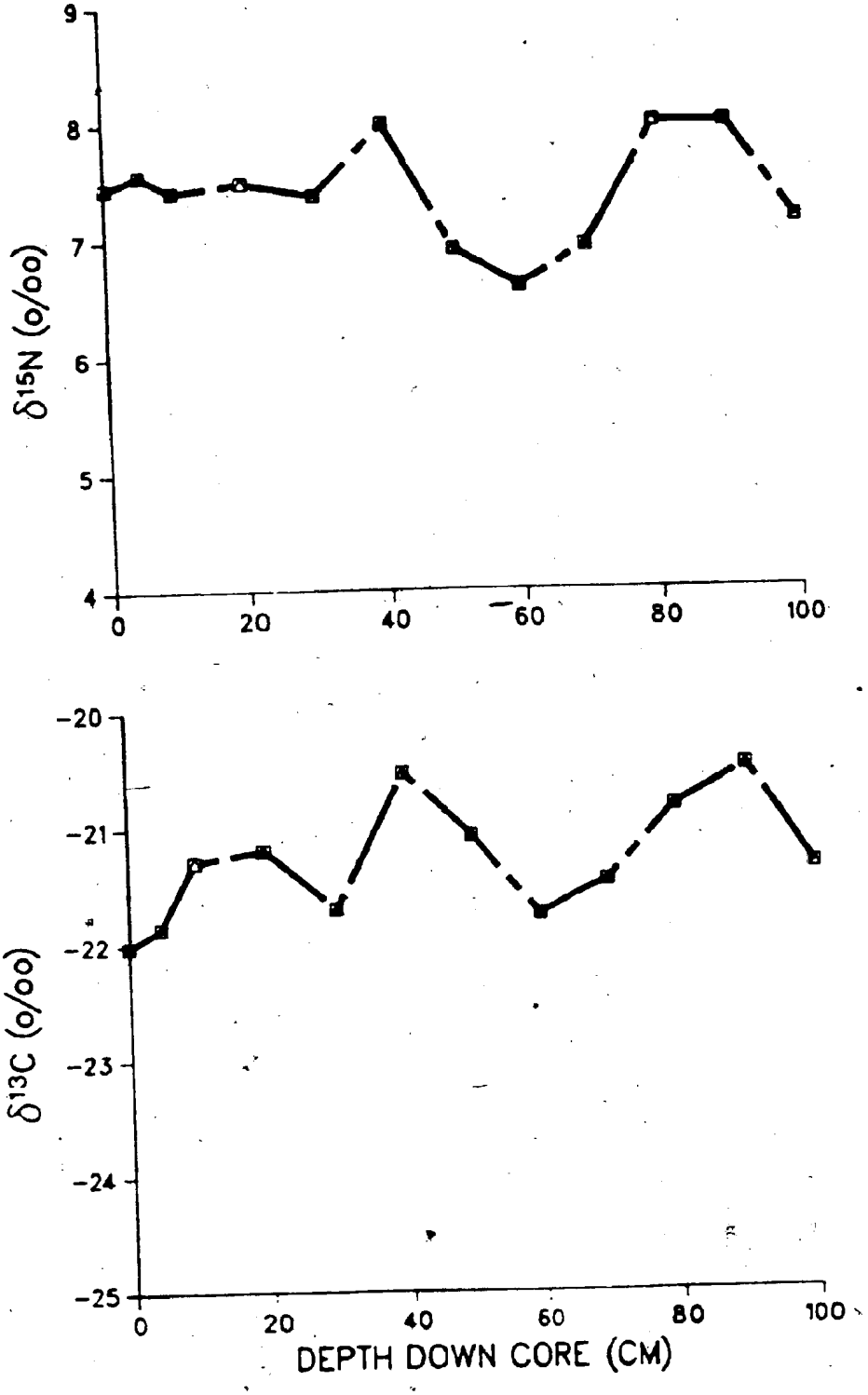

9
8
7
6
5
4
δ15N (o/oo)
0
20
40
60
80
100
-20
-21
-22
-23
-24
-25
δ13C (o/oo)
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

Figure 3-16: FO-840405 sediment profile: Individual and amino acid fractions.

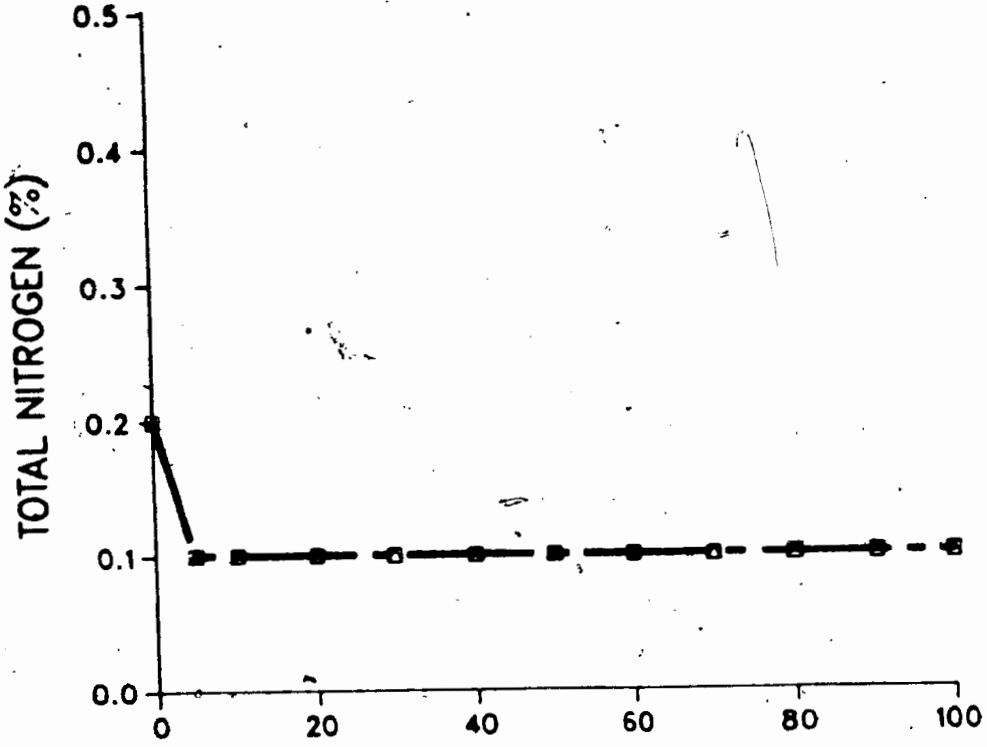
AMINO ACID CONCENTRATION (uM/g)
0
10
20
30
40
50
DEPTH DOWNCORE (CM)
0
5
10
20
30
40
50
60
70
80
90
100
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID

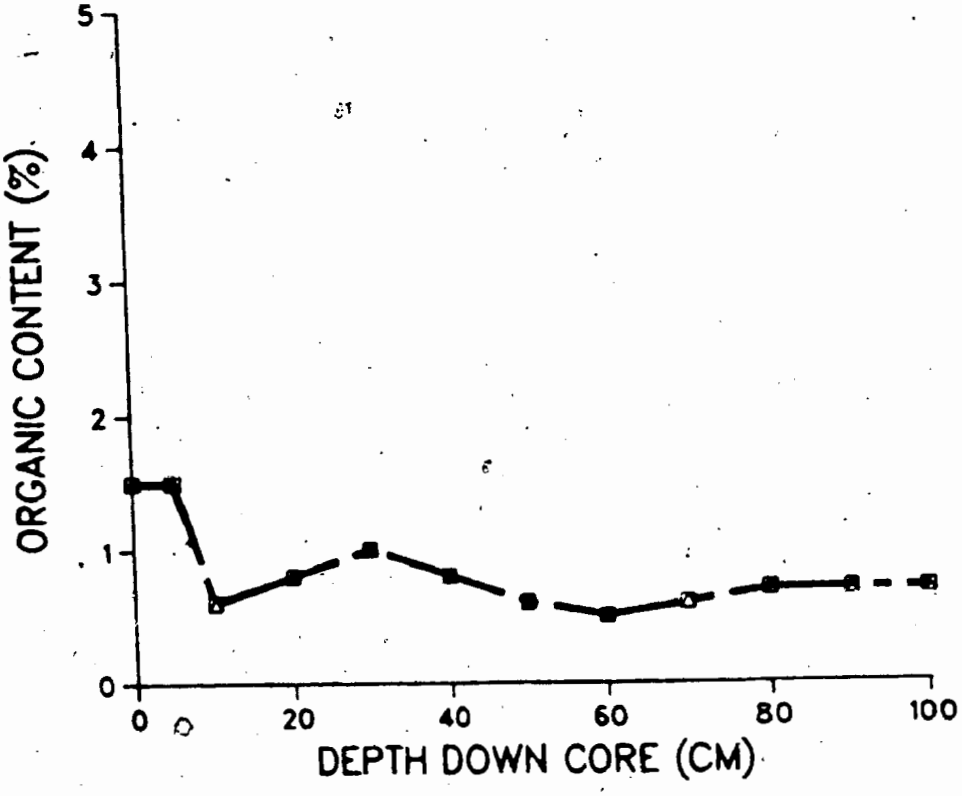
AMINO ACID CONCENTRATION (uM/g)
0
5
10
15
20
0
20
40
60
80
100
Legend
AC
OH
BA
AR
NT

Organic carbon content ranges from 1.5% to 0.5%, decreasing gradually downcore (Table 2 and Fig. 3-17). Nitrogen content ranges from 0.2% to 0.1% and also decreases downcore (Table 2 and Fig. 3-17). The C/N values vary between 12.3 to 5.5, and is similar to those of FO-840404 with fluctuations in the upper 30 cm, and remaining constant at about 9.0 for the rest of the core (Table 2)

The variation of the carbonate content is very similar to that of FO-840404, varying from 15.0% at the surface to approximately 9% for the rest of the core (Appendix 1). The variation of the foraminiferal assemblage in this core is very similar to that of FO-840404, except that the abundance of *Globobulimina auriculata* gradually fades below 40 cm (Appendix 1). The $\delta^{18}O$ composition of the tests of *Globobulimina auriculata* is relatively high at the surface (2.7°/oo) and then decreases to 1.5 and 2.0°/oo at 20 and 40 cm, respectively and then increases to 3.2 and 3.4°/oo at 60 and 100 cm, respectively (Appendix 1 and Fig. 3-7). The $\delta^{13}C$ varies approximately in the same direction as the $\delta^{18}O$ composition (Appendix 1 and Fig. 3-7). Finally, D_{AILE}/L_{ILE} for the species *Globobulimina auriculata* at 50 cm is 0.16 ± 0.025 (Appendix 1).

Figure 3-17: FO-840405 sediment profile:
Organic carbon and total nitrogen.


TOTAL NITROGEN (%)
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100


ORGANIC CONTENT (%)
5
4
3
2
1
0
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

BAY D'ESPOIR CORES

3.6. CORE BDE-11

3.6.1. Core Description

This is a homogeneous core, 105 cm long and consisting of dark gray mud.. Lighter bands (about .75 cm thick) of this dark mud occurred at 39, 43, and 50 cm and between 84 to 105 cm. A prominent feature of this core was a large, vertical worm burrow from 74 to 97 cm. This core has the highest sand content within Bay D'Espoir, values ranging from 27.8 to 11.4%, with no apparent trends (Appendix 4). The sediment of this core also appears rich in mica fragments.

3.6.2. Geochemical analyses

The ^{13}C isotopic signature is very constant throughout this core except at 20 cm depth. A slight enrichment in the ^{13}C is observed in the upper 10 cm, shown by an increase in $\delta^{13}C$ from -22.6 to 22.1°/oo (Table 3 and Fig. 3-18). At 20 cm there is an anomalous low of -24.5°/oo below which the ^{13}C composition remains fairly constant for the rest of the core, with $\delta^{13}C$ values at about -22.0°/oo. The $\delta^{15}N$ values are relatively constant and vary between 7.3°/oo and 7.9°/oo except at 20 and 90 cm where there are high values of 9.4 and 8.1°/oo, respectively (Table 3 and Fig. 3-18).

Highest total and individual amino acid concentrations are at the surface, and decrease downcore (Appendix 5a and Fig. 3-19). The surficial total amino acid concentration of 83.0 μM/g decreases sharply 20.8 μM/g at 20 cm and then increases again at 30 cm to 59.0 μM/g, with a gradual decrease until 90 cm where the total concentration value falls to 15.8 cm (Appendix 5a and Fig. 3-19). Glycine is the most abundant amino acid, with concentrations between 3.3 and 21.2 μM/g, followed by ASP, with concentrations ranging from 2.8 to 13.6 μM/g. Other abundant amino acids are GLU (1.7 to 9.1 μM/g), and ALA (1.8 to 6.1 μM/g) (Appendix 5a). The lowest concentrations (usually less than 1 μM/g) are those of

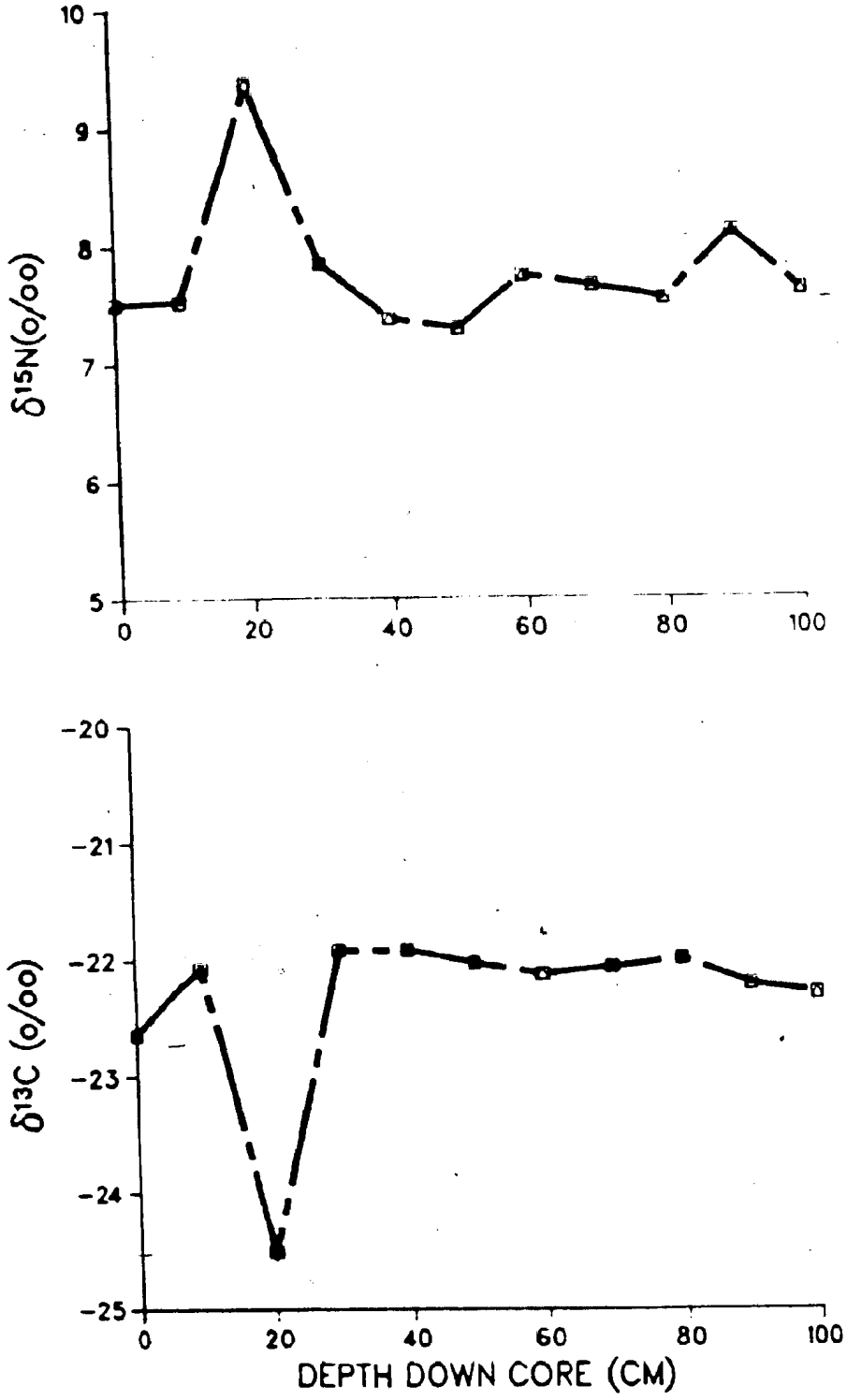
Table 3: Bay D'Espoir cores data.

CORE 1	BDE-11
CORE 2	BDE-1657
CORE 3	BDE-1643
CORE 4	BDE-NB4
CORE 5	BDE-1644
CORE 6	BDE-14.1

CORE	DEPTH	TOC	TN	C/N	TAA	$\delta^{13}C$	$\delta^{15}N$
1	0	4.9	0.5	10.9	83.0	-22.6	7.5
1	10	3.2	0.4	10.0	71.4	-22.1	7.5
1	20	2.4	0.1	21.3	20.8	-24.5	9.4
1	30	3.9	0.5	8.6	59.0	-21.9	7.8
1	40	3.7	0.4	9.7	62.2	-21.9	7.4
1	50	4.9	0.4	15.6	58.2	-22.0	7.3
1	60	3.2	0.4	10.0	66.5	-22.1	7.7
1	70	3.8	0.4	11.8	56.2	-22.1	7.7
1	80	2.9	0.3	10.1	50.4	-22.0	7.5
1	90	1.8	0.2	10.8	15.8	-22.2	8.1
1	100	2.0	0.2	12.0	24.7	-22.3	7.6
2	0	0.6	0.1	9.2	15.3	-22.3	6.8
2	10	0.1	0.0	6.1	1.2	-24.3	4.5
2	19	0.1	0.0	7.2	1.1	-24.3	4.8
2	20	0.1	0.0	5.6	0.6	-24.1	5.6
2	23	0.1	0.0	7.0	0.7	-24.0	4.6
2	30	0.1	0.0	7.8	1.1	-24.7	6.9
2	40	0.1	0.0	6.6	1.0	-24.1	6.2
2	50	0.0	0.0	5.2	0.6	-24.6	6.1
2	56	0.1	0.0	5.8	0.9	-24.4	5.6
2	60	0.1	0.0	7.3	0.4	-24.3	5.4
2	70	0.1	0.0	4.9	0.3	-24.5	6.3
3	0	0.5	0.1	5.7	17.4	-21.7	7.0
3	10	0.2	0.0	16.0	0.3	-24.9	3.1
3	20	0.2	0.1	2.8	0.5	-24.9	6.0
3	30	0.2	0.1	2.5	0.4	-24.7	4.9
3	40	0.3	0.0	16.3	0.4	-23.8	3.8
3	44	0.2	0.0	11.5	0.4	-24.0	4.1
3	50	0.2	0.0	4.7	0.9	-24.8	4.1
3	60	0.2	0.1	3.4	0.9	-25.2	4.9
3	62	0.2	0.1	2.3	0.8	-24.5	4.8
3	70	0.2	0.0	14.1	0.7	-24.6	3.2
3	80	0.2	0.0	16.8	0.5	-24.5	4.9
3	88	0.1	0.0	8.5	0.5	-23.6	4.2
3	90	0.2	0.0	11.4	0.5	-24.2	3.3
3	100	0.1	0.0	7.2	0.5	-23.4	3.0

CORE	DEPTH	TOC	TN	C/N	TAA	$\delta^{13}C$	$\delta^{15}N$
4	0	3.3	0.4	9.2	73.0	-22.3	7.8
4	10	2.8	0.3	10.6	56.2	-22.7	7.3
4	20	3.0	0.4	9.4	61.8	-21.9	7.5
4	30	3.3	0.4	9.8	61.2	-22.5	7.8
4	40	2.6	0.4	8.3	65.7	-22.0	7.5
4	45	2.7	0.2	13.0	56.2	-22.8	7.5
4	50	2.7	0.2	13.0	42.4	-22.0	7.9
4	60	3.0	0.3	10.3	54.8	-22.4	7.8
4	70	3.2	0.2	15.4	44.5	-22.0	7.9
4	80	2.7	0.2	14.1	59.9	-22.2	7.6
4	90	2.6	0.3	8.7	64.2	-22.2	7.7
4	100	2.6	0.3	8.9	53.0	-21.8	7.8
4	110	2.5	0.3	8.3	58.7	-22.1	7.9
4	120	2.5	0.3	8.2	63.3	-22.2	7.8
4	130	2.8	0.4	9.4	37.4	-22.6	7.8
5	0	4.5	0.2	26.3	73.5	-21.8	7.5
5	10	1.4	0.2	11.3	25.7	-22.3	7.7
5	20	1.2	0.1	11.6	17.7	-21.9	7.3
5	30	1.2	0.1	10.3	16.4	-21.9	7.9
5	40	1.3	0.1	11.8	24.1	-21.8	6.7
5	50	1.4	0.1	14.4	18.1	-21.8	7.8
5	60	1.1	0.1	12.2	13.9	-22.4	7.6
5	70	1.1	0.1	11.9	15.0	-22.5	8.3
5	80	0.6	0.1	11.5	18.3	-22.0	7.1
5	90	1.5	0.1	11.7	17.9	-22.0	8.0
5	100	1.2	0.1	11.2	14.7	-21.8	6.9
6	0	3.0	0.4	9.7	51.4	-21.6	7.4
6	10	2.5	0.3	8.5	61.0	-21.6	7.3
6	20	3.0	0.3	9.6	57.0	-21.5	7.3
6	23	3.1	0.4	8.6	46.0	-21.3	7.7
6	30	2.5	0.4	7.3	58.6	-21.4	8.0
6	40	2.9	0.3	10.3	45.1	-21.1	7.2
6	49	2.3	0.3	10.9	39.5	-21.7	7.8
6	60	2.9	0.2	14.9	40.3	-21.5	7.7
6	68	2.5	0.3	10.4	41.8	-21.8	7.7
6	70	2.8	0.4	9.1	42.2	-21.4	7.9

Figure 3-18: BDE-11 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.


10
9
8
7
6
5
δ15N(o/oo)
0
20
40
60
80
100
-20
-21
-22
-23
-24
-25
δ13C (o/oo)
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

MET and TYR (Appendix 5a). The abundances of the different amino acid fractions throughout the core are in the order: neutral (44.8 to 7.9 μM/g), acidic (22.7 to 4.5 μM/g), hydroxy (7.3 to 1.2μM/g) basic (7.3 to 1.6 μM/g) and aromatic (3.6 to 1.0 μM/g) (Appendix 6a). The variation with depth of the amino acid fractions is also very similar to that of the total amino acid concentration (Fig. 3-19).

Organic carbon content is high at the surface (4.9%) and gradually decreases downcore (Table 3 and Fig. 3-20). Total nitrogen content ranges from 0.5% at the surface to 0.1% at 20 cm and also gradually decreases downcore (Table 3 and Fig. 3-20). The C/N values are relatively high and constant downcore and ranges between 8.6 to 12.0, with an anomalously high ratio of 21.3 at 20 cm depth.

The carbonate content is moderately high as compared to other Bay D'Espoir cores, with percentages varying from 17.3 at the surface to 7.2 at the bottom (Appendix 4). No foraminifera are present throughout this core (Appendix 4).

3.7. CORES BDE-1657 and BDE-1643

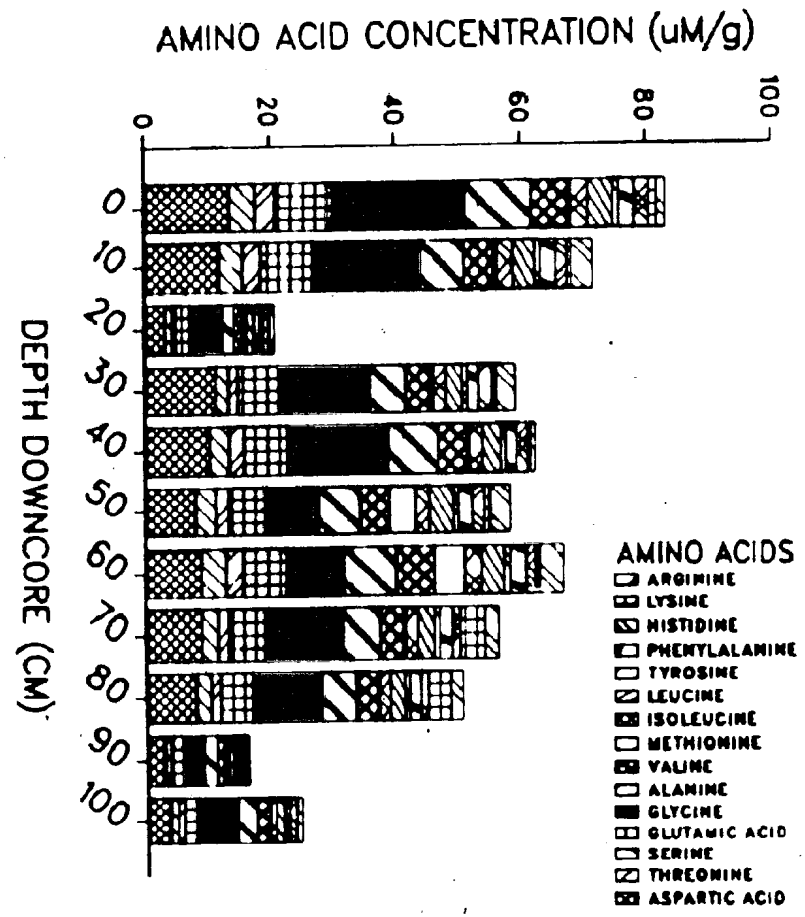
3.7.1. Core Description

The core descriptions and results of the analyses for these cores are reported together because of their similarities in appearance and composition.

Core BDE-1657 is 73 cm long and consists of predominantly medium to dark grey mud in the upper 10 cm and grey, fine grained cohesive mud from 10 cm to the bottom. A prominent feature is the dark parallel inclined bands at 19, 23 and 56 cm. There is also a dropstone at 40 cm.

Core BDE-1643 is 101 cm long. The upper 3 cm consists a very soft dark greenish mud. The rest of the core is a grey fine grained cohesive mud with dark parallel inclined bands at 44, 62 and 88 cm. It also has a dropstone at 89 cm.

Figure 3-19: BDE-11 sediment profile:
Individual and amino acid fractions.


AMINO ACID CONCENTRATION (uM/g)
0
20
40
60
80
100
DEPTH DOWNCORE (CM)
0
10
20
30
40
50
60
70
80
90
100
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID

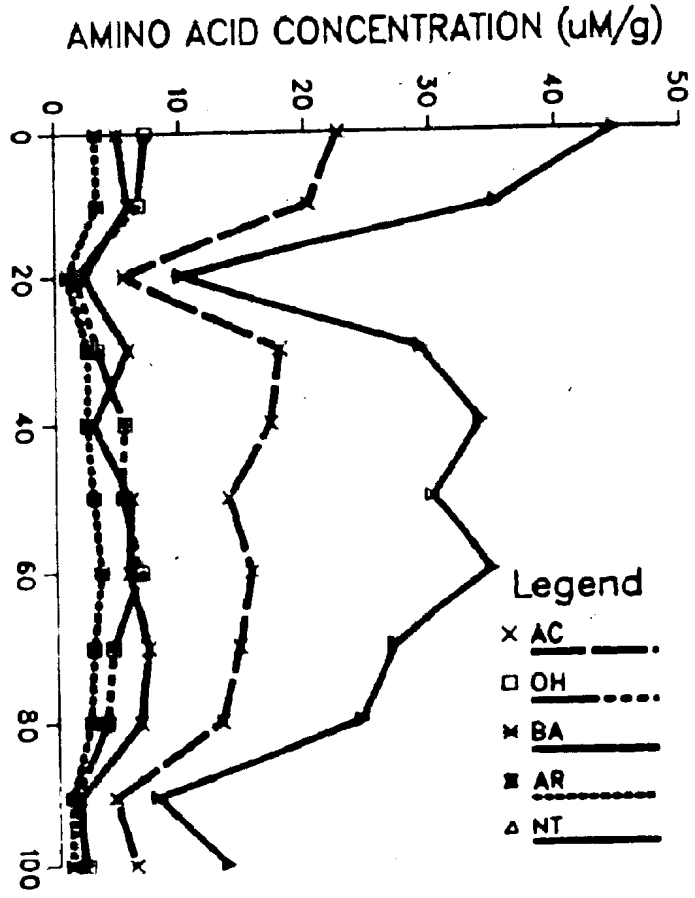
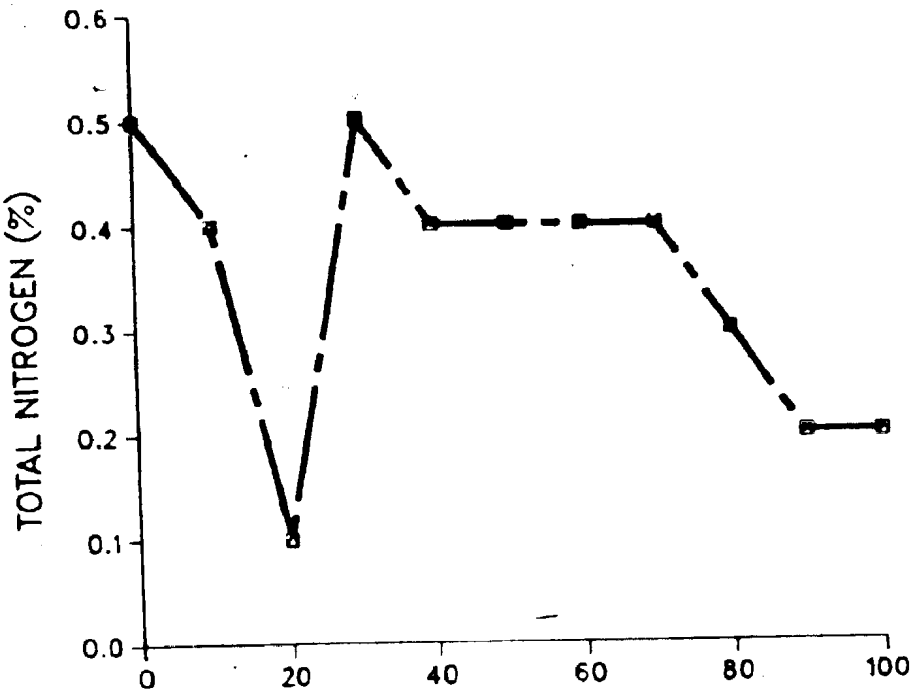
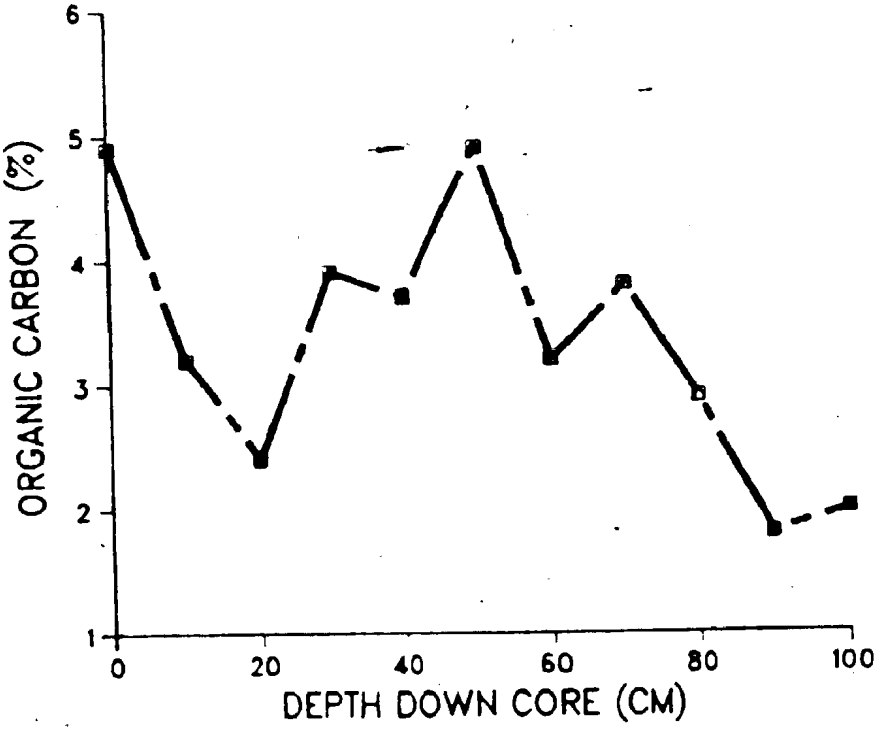

AMINO ACID CONCENTRATION (uM/g)
0
10
20
30
40
50
0
20
40
60
80
100
Legend
AC
OH
BA
AR
NT

Figure 3-20: BDE-11 sediment profile:
Organic carbon and total nitrogen contents.


TOTAL NITROGEN (%)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100


ORGANIC CARBON (%)
6
5
4
3
2
1
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

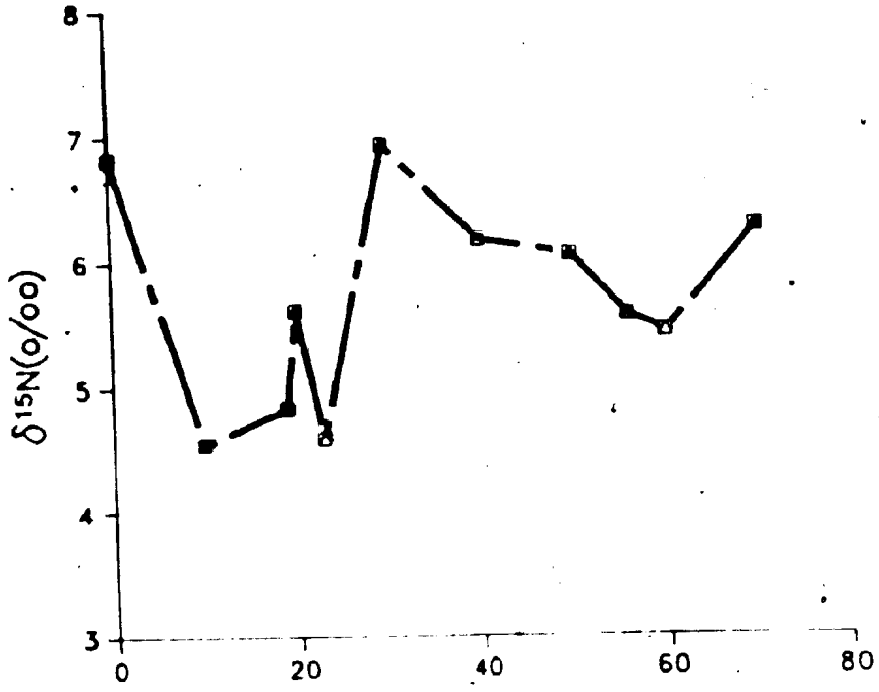
Except for surficial high levels (31.9% and 27.2% for BDE-1657 and BDE-1643, respectively), the sand fraction is extremely low throughout both cores. Below the surface, sand composition varies between 1.5 and 0.7% and 0.2 to 0.4 % for BDE-1657 and BDE-1643, respectively (Appendix 4).

3.7.2. Geochemical analyses

The organics of both cores BDE-1657 and BDE-1643 are the most depleted in ^{13}C and ^{15}N within the study area (Tables 1 and 3).The highest values of $\delta^{13}C$ occur at the surface, -22.3 and -21.7°/oo for BDE-1657 and BDE-1643, respectively, and fall to -24.3 and -24.9°/oo at 10 cm and remain relatively constant downcore (Table 3 and Figs. 3-21 and Fig. 3-22) The $\delta^{15}N$ values for both cores are also highest at the surface (6.8 and 7.0°/oo for BDE-1657 and BDE-1643, respectively)(Table 3). However, the $\delta^{15}N$ signatures throughout both cores are slightly different. Core BDE-1657 shows large fluctuations in $\delta^{15}N$ values downcore, with values ranging from 4.5 to 7.6°/oo whereas for BDE-1643, the $\delta^{15}N$ values fall abruptly from 7.0°/oo at 10 cm to 6.0°/oo at 20 cm, and remain fairly constant downcore (Table 3 and Figs. 3-21 and Fig. 3-22).

Total and individual amino acid concentrations are very low and also very similar throughout both cores (Appendices 5b and 5c and Fig. 3-23 and Fig. 3-24, respectively). The highest total concentrations are at the surface, 15.3 and 17.4 μM/g for BDE-1657 and BDE-1643, respectively, below which these values fall sharply and range from 2.1 to 0.4 μM/g and 1.0 and 0.3 μM/g for BDE-1657 and 1643 respectively (Appendices 5b and 5c, respectively). Except for surface values, individual amino acid concentrations are less than 0.2 μM/g and with several below the limit of detection (Appendices 5b and 5c, respectively). The most abundant amino acid for both cores is GLY, with concentrations ranging from 4.1 to 0.0 μM/g (Appendices 5b and 5c, respectively). The concentration of ASP is the second highest, with values between 2.8 and 0.0 μM/g, with most values below the surface being 0.1 μM/g (Appendices 5b anfd 5c, respectively). Glutamic acid concentrations are also similar to those of ASP (Appendices 5b and 5c,

Figure 3-21: BDE-1657 sediment profile: $\delta^{13}C$ and $\delta^{15}N$


8
7
6
5
4
3
$\delta^{15}N$(o/oo)
0
20
40
60
80

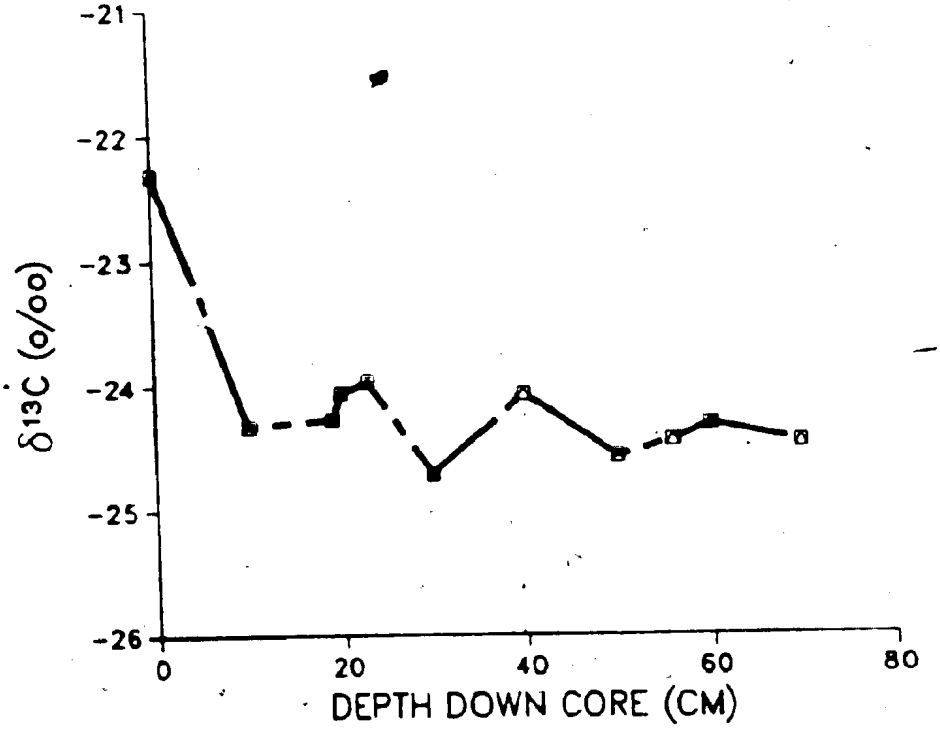
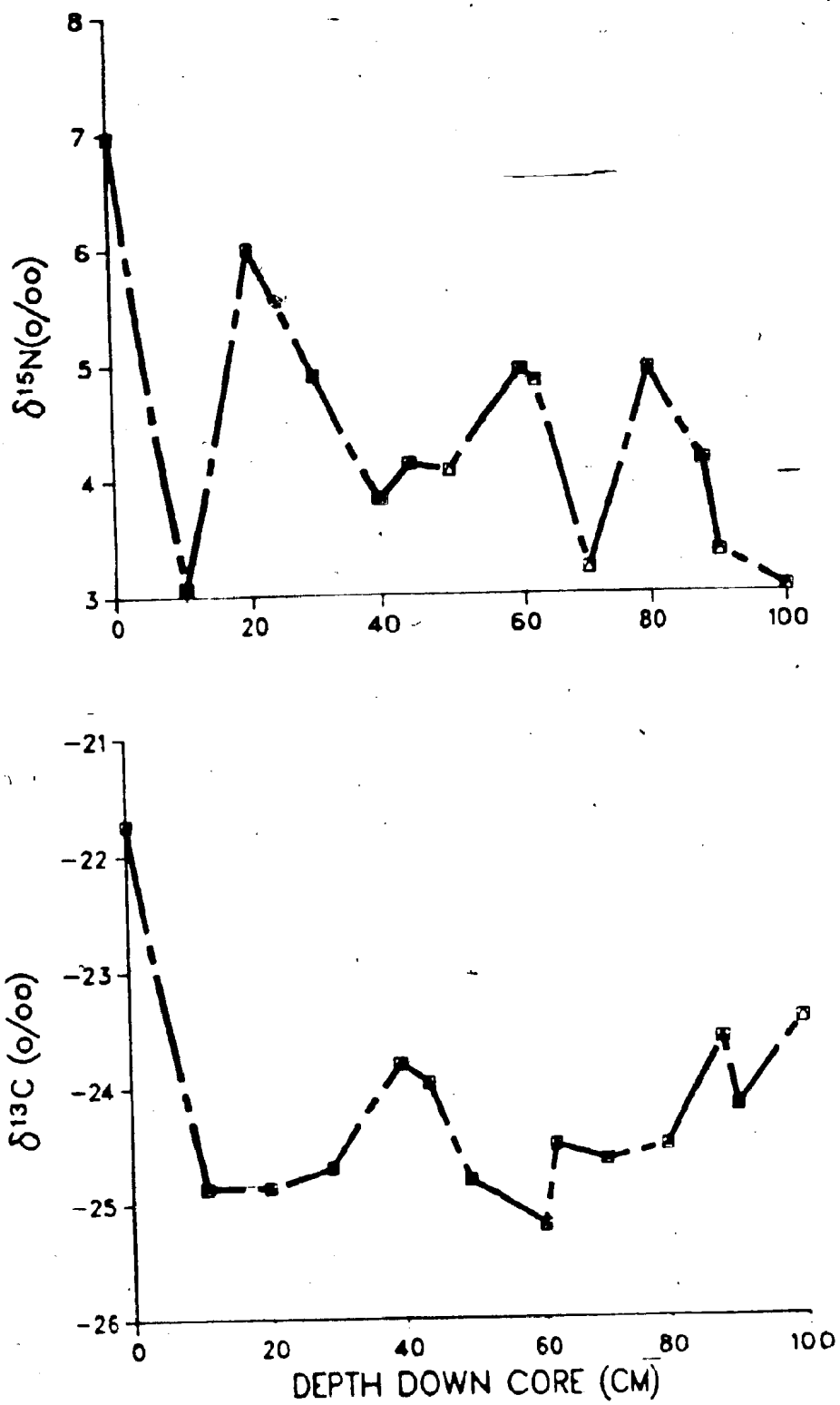

-21
-22
-23
-24
-25
-26
$\delta^{13}C$ (o/oo)
0
20
40
60
80
DEPTH DOWN CORE (CM)

Figure 3-22: BDE-1643 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.


8
7
6
5
4
3
δ15N(o/oo)
0
20
40
60
80
100
−21
−22
−23
−24
−25
−26
δ13C (o/oo)
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

respectively). Other amino acid concentrations, except those seen in the surface for ALA, are less than 1 μM/g (Appendices 5b and 5c, respectively). The amino acid fractions are low at the surface and decrease to less than 0.6 μM/g for the rest of the core (Appendix 6 and Fig. 3-23 and Fig. 3-24), with the most abundant being the neutral amino acids.

Organic carbon contents for both cores follow the same trend as the total amino acid concentration. At the surface of both cores these values are highest, 0.7% and 0.5% for BDE-1657 and BDE-1643, respectively (Table 3 and Fig. 3-25 and Fig. 3-26, respectively). Like the amino acid distributions, surface organic carbon contents decrease abruptly to 0.1% and 0.2% for BDE-1657 and BDE-1643, respectively (Table 3 and Fig. 3-25 and Fig. 3-26, respectively). These values then remain fairly constant throughout the rest of both cores. Total nitrogen contents are highest at the surface of both cores, 0.1% for both cores (Table 3 and Fig. 3-25 and Fig. 3-26, respectively). In the case of BDE-1657 , below the surface the total nitrogen contents are very low and constant (between .03% and .01%) whereas the total nitrogen content for core BDE-1643 shows a greater fluctuation, between 0.09% and 0.01% (Table 3 and Fig. 3-25 and Fig. 3-26).

The C/N values throughout BDE-1657 are fairly low and vary between 9.2 at the surface to 4.9, whereas C/N values for BDE-1643 range from 16.8 to 1.6, and fluctuates with no discernible trend.

The carbonate contents throughout both cores are very low, with values ranging from 8.9 to 12.0% (Appendix 4). No foraminifera are present throughout this core (Appendix 4).

Figure 3-23: BDE-1657 sediment profile:
Individual and amino acid fractions.

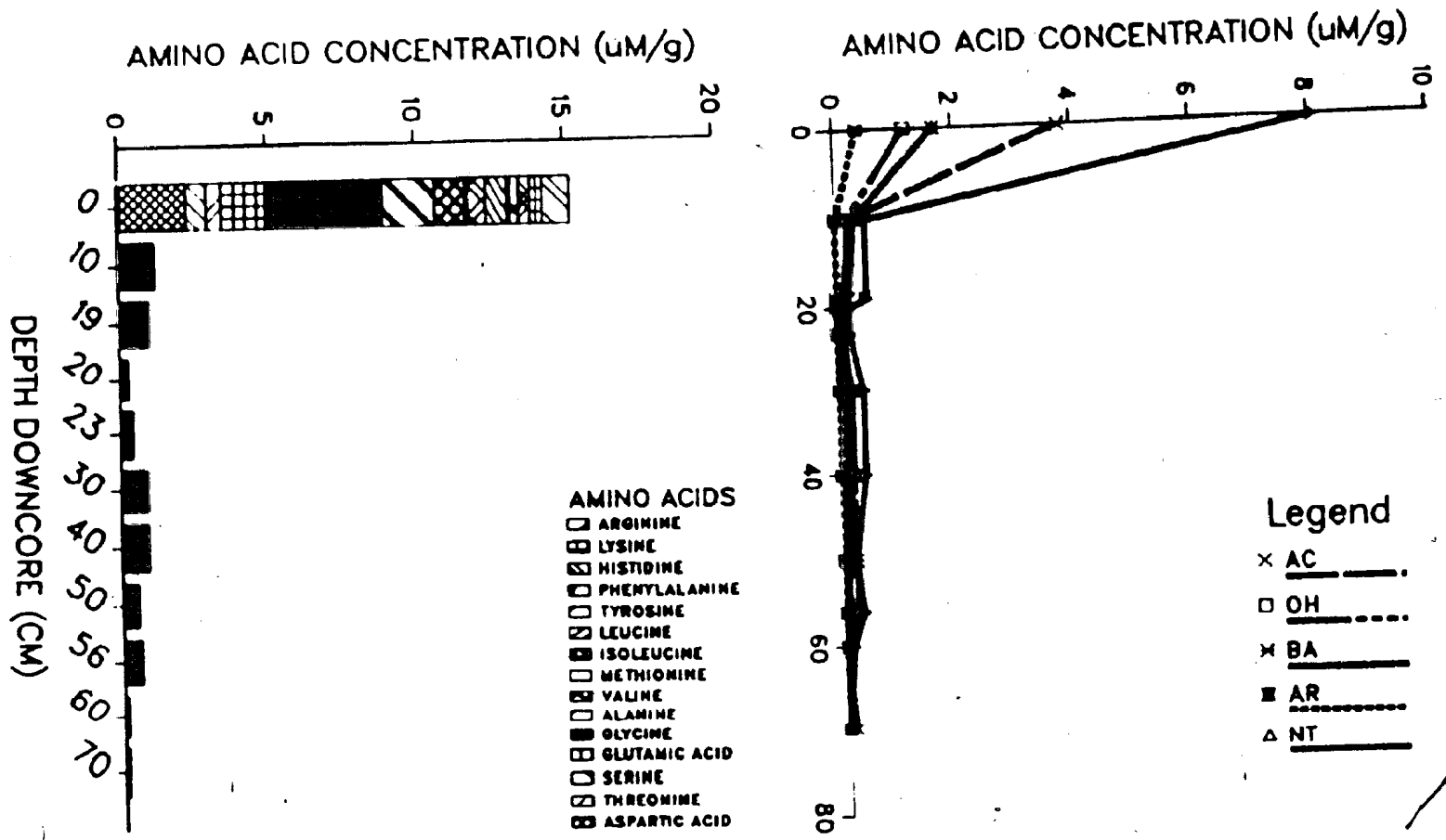

AMINO ACID CONCENTRATION (uM/g)
0
5
10
15
20
DEPTH DOWNCORE (CM)
0
10
19
20
23
30
40
50
56
60
70
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID
AMINO ACID CONCENTRATION (uM/g)
0
2
4
6
8
10
0
20
40
60
80
Legend
AC
OH
BA
AR
NT

Figure 3-24: BDE-1643 sediment profile:
Individual and amino acid fractions:

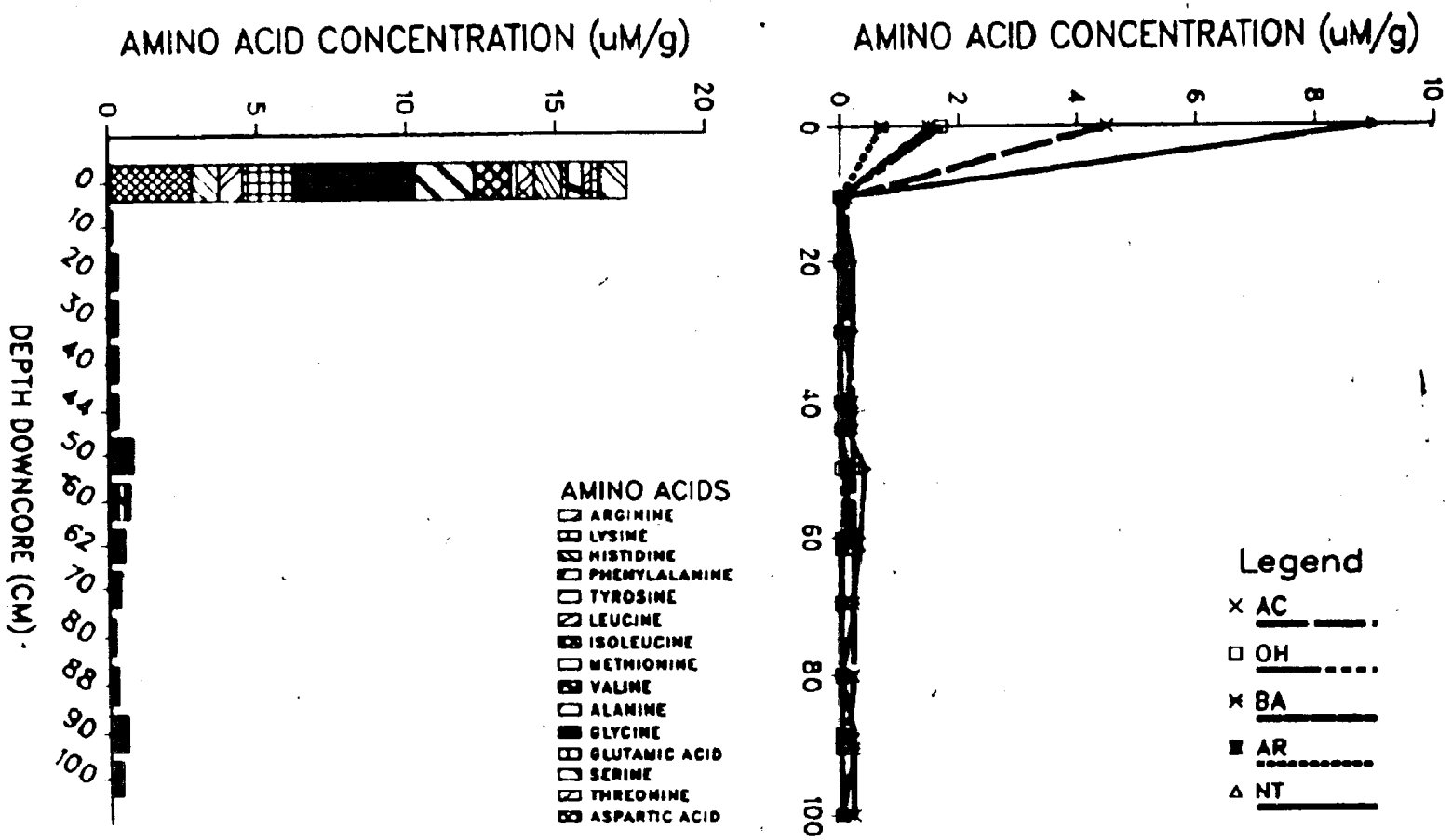
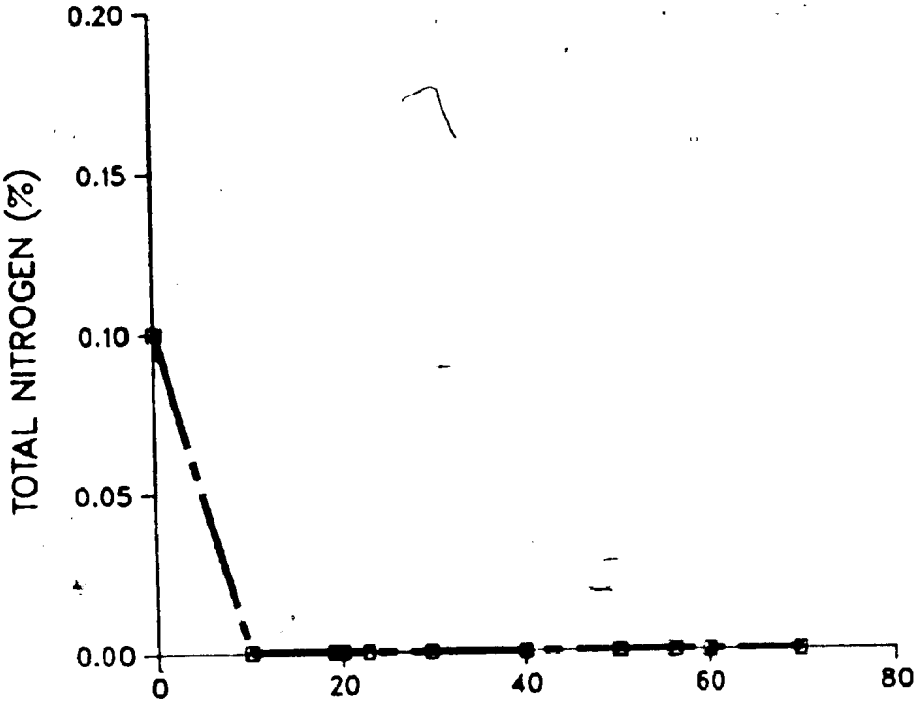

AMINO ACID CONCENTRATION (uM/g)
0
5
10
15
20
DEPTH DOWNCORE (CM)
0
10
20
30
40
44
50
60
62
70
80
88
90
100
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID
AMINO ACID CONCENTRATION (uM/g)
0
2
4
6
8
10
0
20
40
60
80
100
Legend
AC
OH
BA
AR
NT

Figure 3-25: BDE-1657 sediment profile:
Organic carbon and total nitrogen contents.


TOTAL NITROGEN (%)
0.20
0.15
0.10
0.05
0.00
0
20
40
60
80

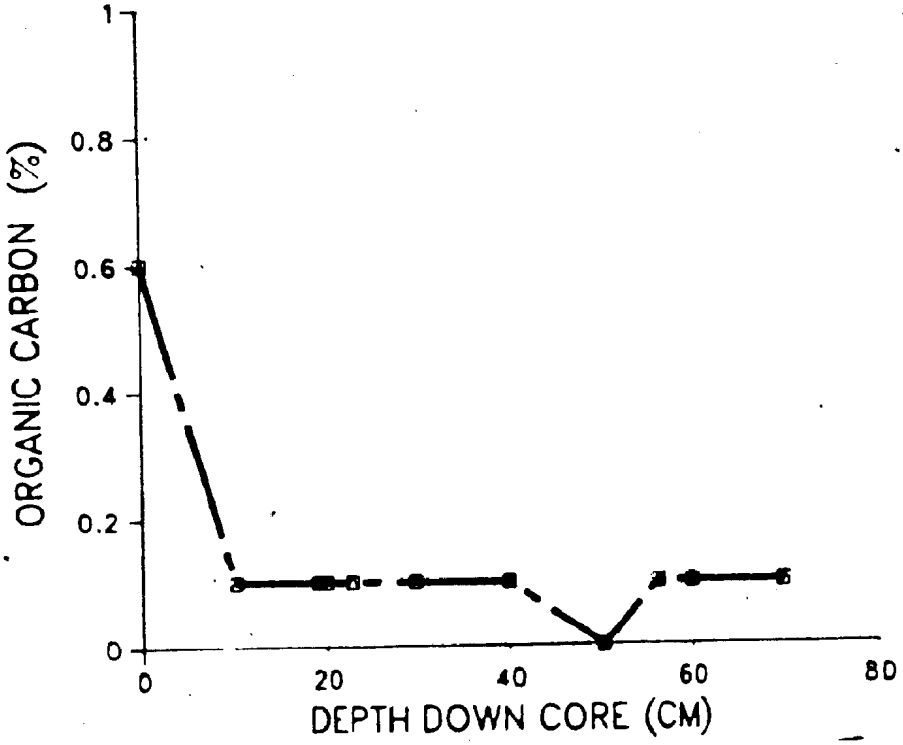
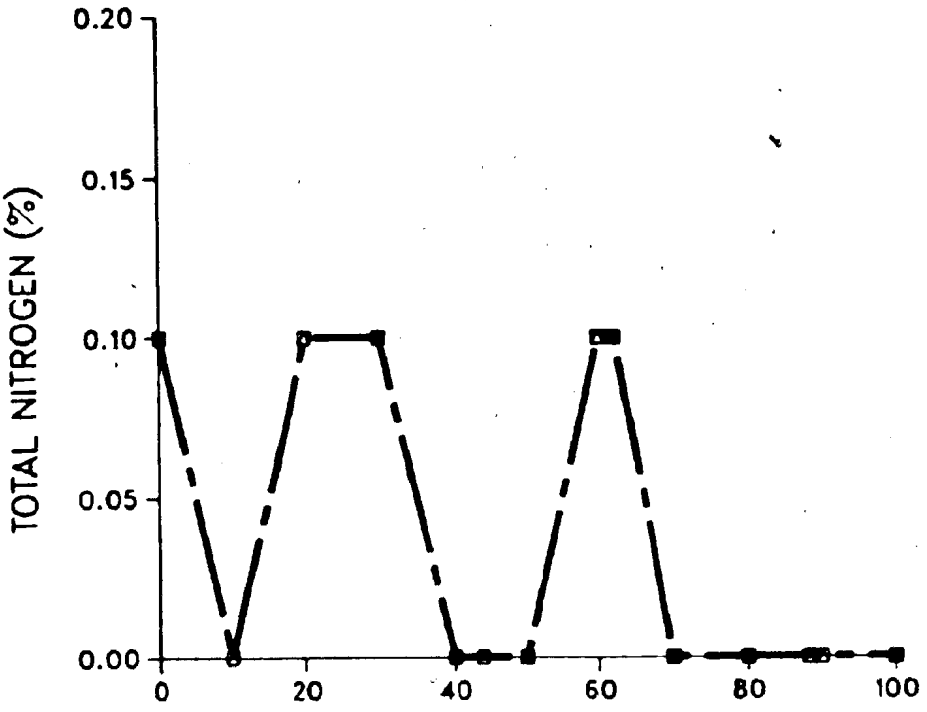
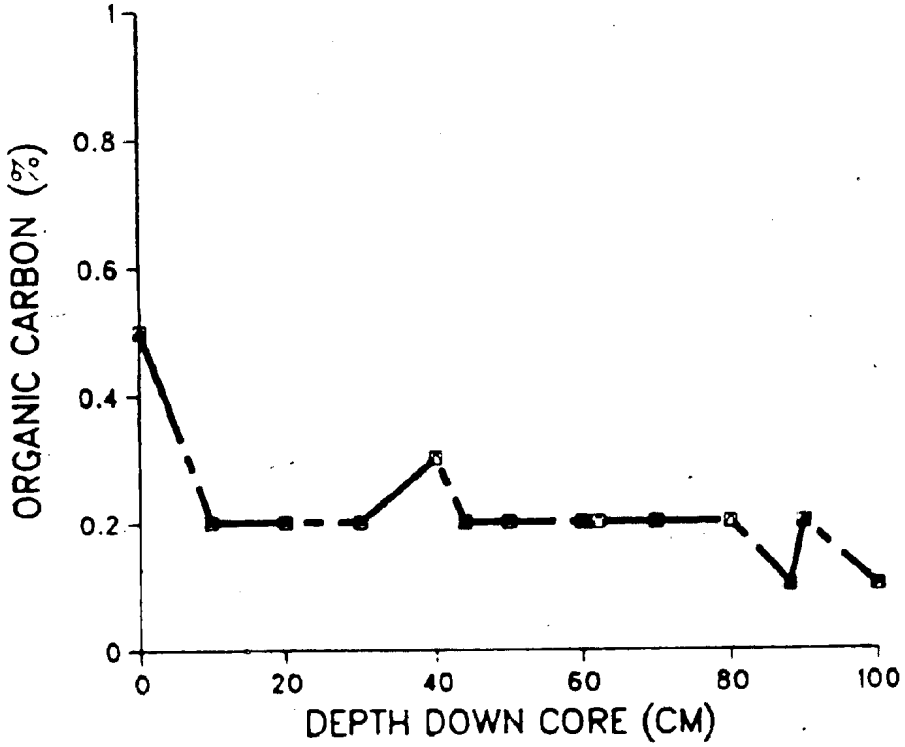

ORGANIC CARBON (%)
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
DEPTH DOWN CORE (CM)

Figure 3-26: BDE-1643 sediment profile:
Organic carbon and total nitogen contents.


TOTAL NITROGEN (%)
0.20
0.15
0.10
0.05
0.00
0
20
40
60
80
100


ORGANIC CARBON (%)
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
DEPTH DOWN CORE (CM)

3.8. CORE BDE-NB4

3.8.1. Core Description

This core is 135 cm long and appears very homogeneous. It is olive grey with dark horizons about 2 mm broad and occurring at about 3 per cm. Between 40 to 48 cm the color changes to olive black with more frequent dark horizons of about 4 to 5 per cm. The sand fraction is relatively low and constant throughout this core, with values ranging from 3.8 to 2.4% (Appendix 4).

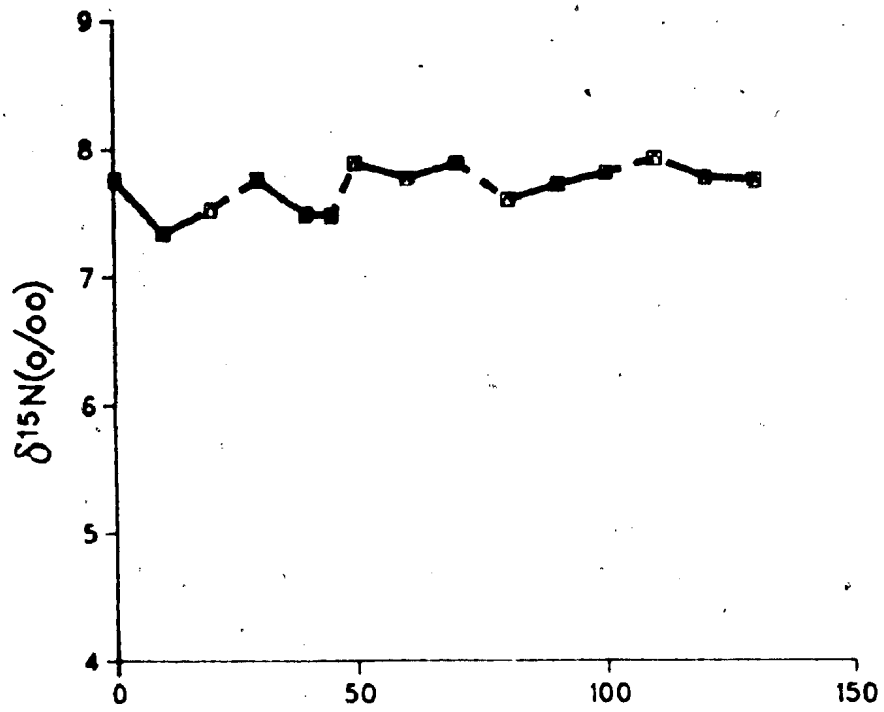
3.8.2. Geochemical analyses

The $\delta^{13}C$ and $\delta^{15}N$ compositions are relatively constant throughout this core. The $\delta^{13}C$ values range from -21.8 to -22.8°/oo (Table 3 and Fig. 3-27). The $\delta^{15}N$ values vary between 7.9 and 7.3°/oo, and increases downcore (Table 3 and Fig. 3-27).

The amino acid abundance throughout this core is relatively high and constant downcore (Appendix 5d). The total amino acid concentrations range from 73.0 μM/g at the surface to 42.4 μM/g at 50 cm, with most values between 50.0 to 65.0 μM/g (Appendix 5d and Fig. 3-28). The most abundant amino acid is GLY (18.7 to 8.3 μM/g), followed by ASP (11.2 to 6.7 μM/g). Concentrations of ALA (9.7 to 4.7 μM/g) and GLU (8.4 to 3.1 μM/g) are also high within this core (Appendix 5d). The least abundant amino acids are MET and LYS (less than 1.0 μM/g), and TYR and HIS (less than 2.0 μM/g) (Appendix 5d). The amino acid fractions in increasing order of abundance are neutral (40.0 to 20.4 μM/g), acidic (17.8 to 9.8 μM/g), hydroxy and basic (7.6 to 3.1 μM/g and 7.5 to 2.3 μM/g, respectively) and aromatic fraction (4.1 to 1.4 μM/g), with the highest values usually at the surface and then decreasing to relatively constant values downcore (Appendix 6d and Fig. 3-28).

The organic carbon content is high and constant downcore, ranging from 3.3% at the surface, to 2.5% at the bottom (Table 3 and Fig. 3-29). The total nitrogen

Figure 3-27: BDE-NB4 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.


9
8
7
6
5
4
δ15N(o/oo)
0
50
100
150

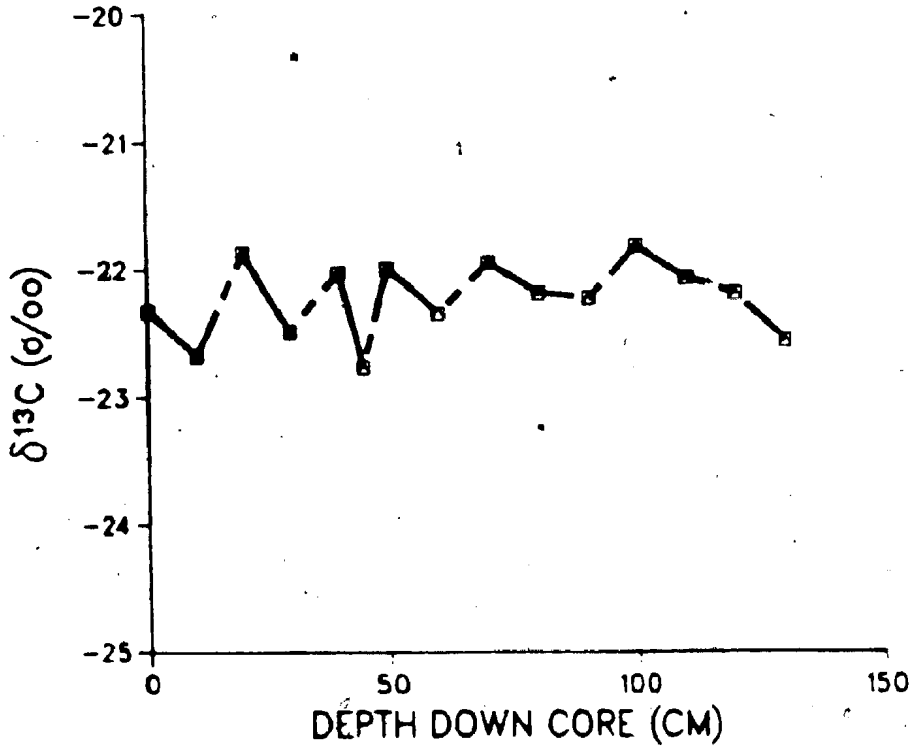
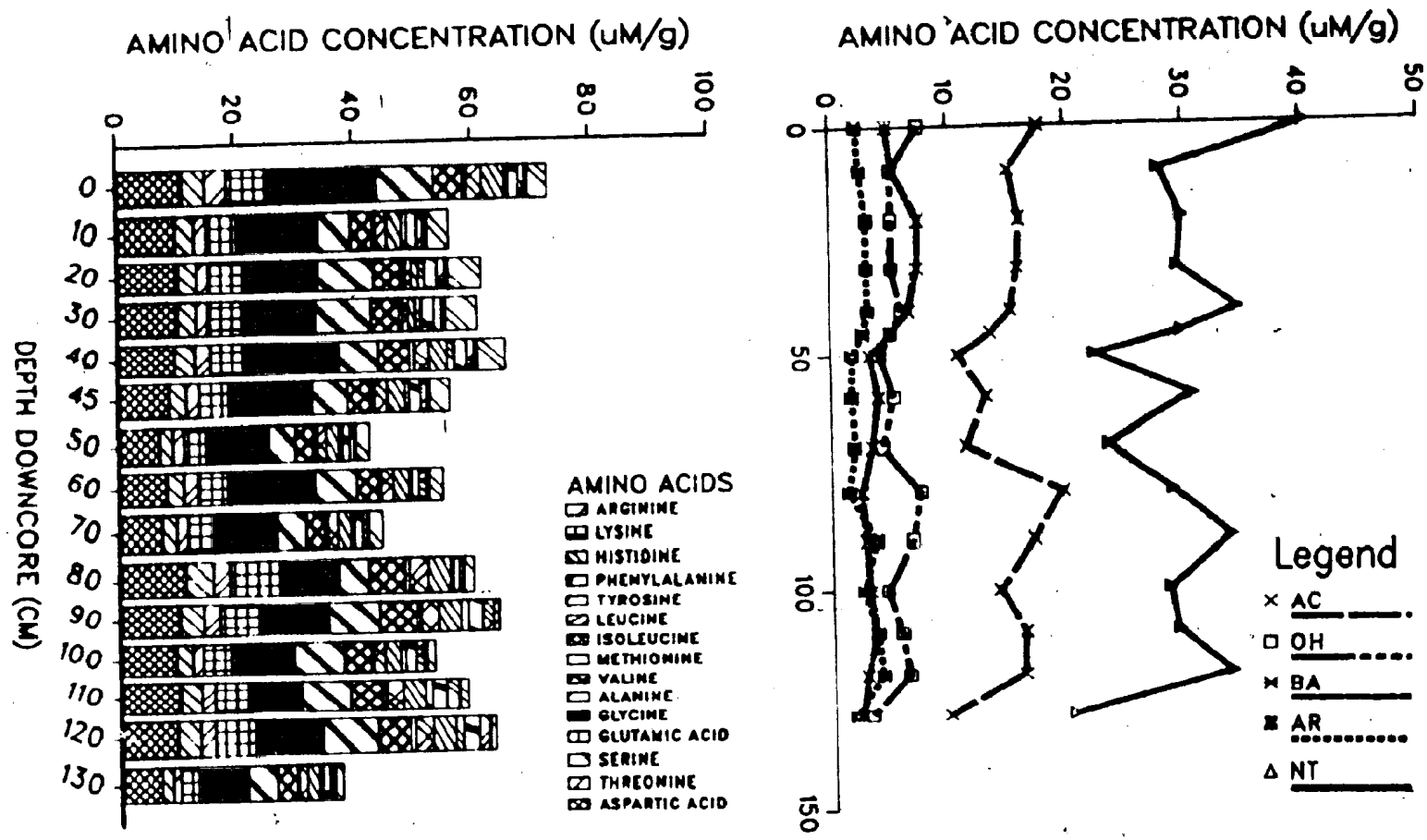

-20
-21
-22
-23
-24
-25
δ13C (o/oo)
0
50
100
150
DEPTH DOWN CORE (CM)

Figure 3-28: BDE-NB4 sediment profile:
Individual and amino acid fractions.


AMINO ACID CONCENTRATION (uM/g)
0
20
40
60
80
100
DEPTH DOWNCORE (CM)
0
10
20
30
40
45
50
60
70
80
90
100
110
120
130
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID
AMINO ACID CONCENTRATION (uM/g)
0
10
20
30
40
50
0
50
100
150
Legend
AC
OH
BA
AR
NT

contents are also constant and range from 0.4% (at the surface) to 0.2% (Table 3 and Fig. 3-29). The C/N values are constant from 0 to 40 cm, i.e. between 8.3 to 10.6. From 45 to 80 cm, C/N values increase to ratios between 10.3 to 15.4, below which, C/N values decrease to between 8.2 and 9.4 (Table 3).

The carbonate content within this core is the highest for all Bay D'Espoir cores, ranging from 27.5 at the surface to 21.3% at the bottom (Appendix 4).

3.9. CORE BDE-1644

3.9.1. Core Description

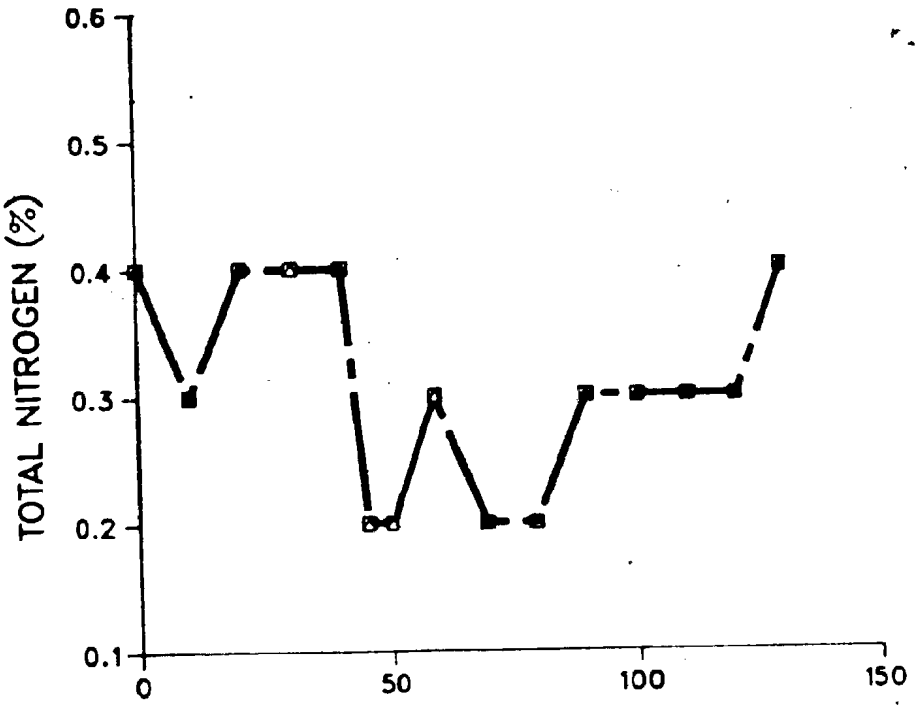
The total length of the core is 103 cm. The upper 20 cm consists of coarse olive grey sand. Below 20 cm the color progressively changes from olive grey to dark greenish grey. Particle size decrease downcore. The sand fraction is relatively high in this Bay D'Espoir core, varying between 23.1 to 7.0%, with a decrease with depth (Appendix 4).

3.9.2. Geochemical analyses

The ^{13}C isotopic composition is fairly constant throughout this core, ranging from -21.8 to -22.4°/oo. There are no apparent trends with depth (Table 3 and Fig. 3-30). Similarly, the $\delta^{15}N$ values are relatively constant throughout this core, ranging from 8.0 to 6.7°/oo (Table 3 and Fig. 3-30).

The individual and total amino acid concentrations ranges from 73.5 μM/g at the surface to 13.9 μM/g at a depth 60 cm, showing a strong decrease in concentrations after the first 10 cm (Appendix 5e and Fig. 3-31). The order of abundance of amino acids is the same as the other cores described earlier. Below the surface, however, the concentrations for GLY and ASP are quite comparable, 6.7 to 2.9 μM/g and 4.2 to 2.2 μM/g, respectively (Appendix 5e). The decrease in the concentrations of individual amino acids with depth is reflected in the amino acid profile of this core (Appendix 6e and Fig. 3-31). The order of abundance for

Figure 3-29: BDE-NB4 sediment profile:
Organic carbon and total nitrogen contents.


TOTAL NITROGEN (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
50
100
150

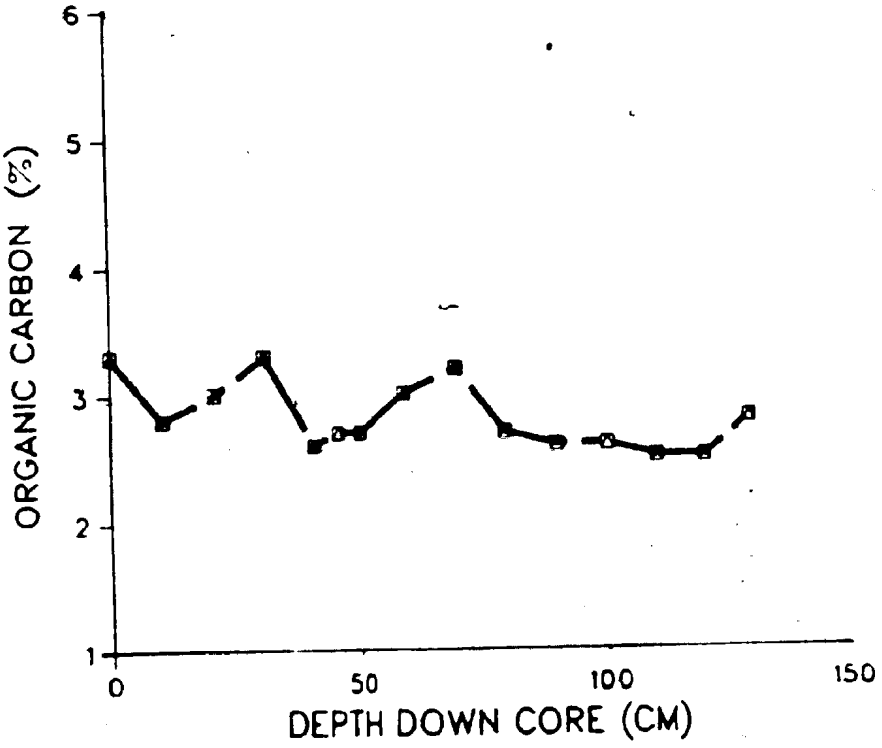
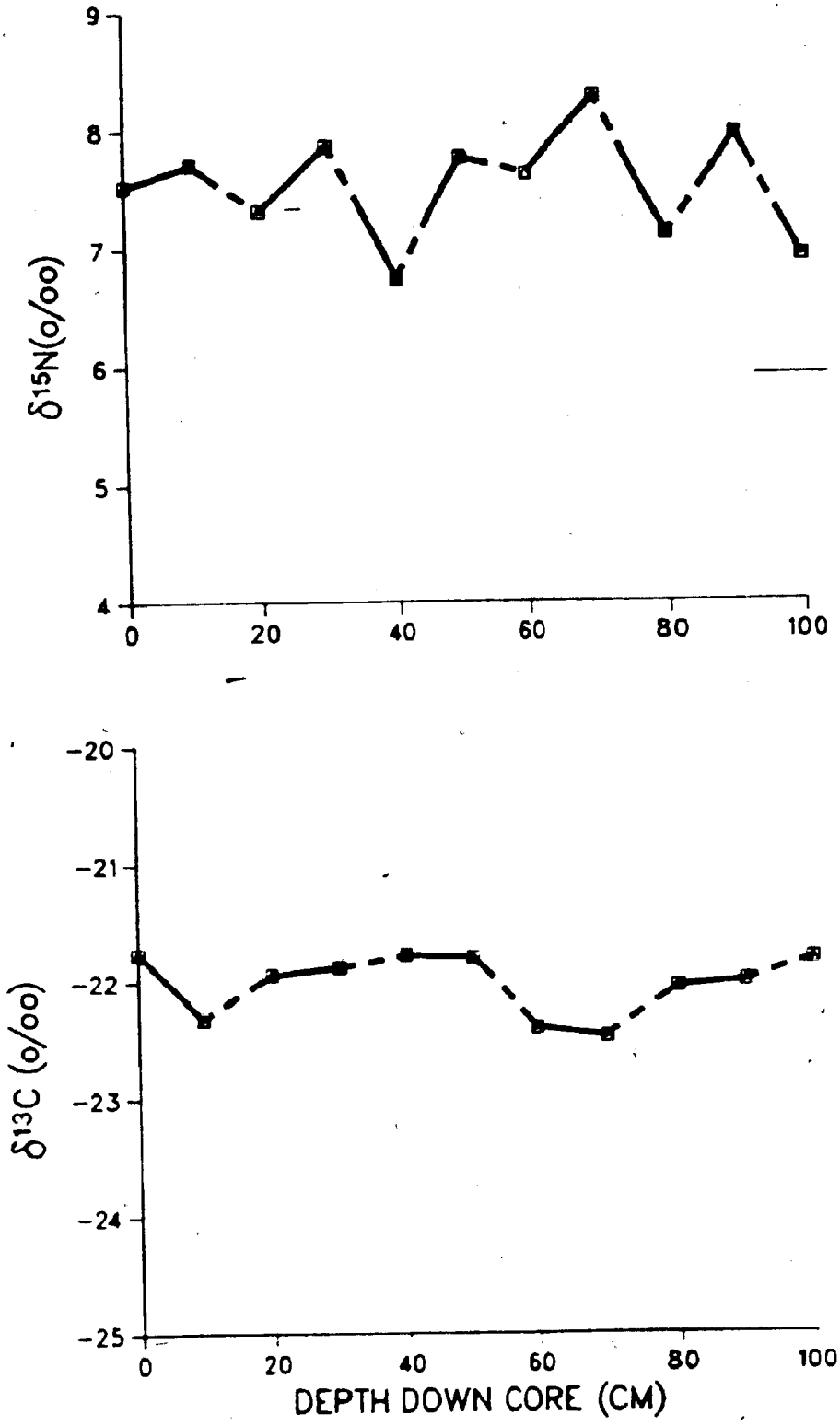

ORGANIC CARBON (%)
6
5
4
3
2
1
0
50
100
150
DEPTH DOWN CORE (CM)

Figure 3-30: BDE-1644 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.


9
8
7
6
5
4
δ15N(o/oo)
0
20
40
60
80
100
−20
−21
−22
−23
−24
−25
δ13C (o/oo)
DEPTH DOWN CORE (CM)

the amino acid fractions is similar to BDE-11, BDE-ND4 and BDE-1644, i.e. neutral (38.6 to 6.2 μM/g), acidic (18.9 to 3.5 μM/g), hydroxy (6.9 to 1.1 μM/g), basic (5.4 to 1.0 μM/g) and aromatic fraction (3.7 to 0.7 μM/g) (Appendix 6c).

Organic carbon content follows the same trend as the total amino acid concentration i.e. there is a decrease downcore, from 4.5% at the surface with values between 1.1 and 1.4% for the rest of the core (Table 3 and Fig. 3-32). Total nitrogen contents are relatively constant from the surface to 60 cm, ranging from 0.2 to 0.1%, and then decreasing to between 0.1%.and 0.6% for the rest of the core (Table 3 and Fig. 3-32). Excluding an unusually high surface ratio, C/N values are relatively high and constant between 10.3 and 14.5 with a slight increase below 40 cm (Table 3).

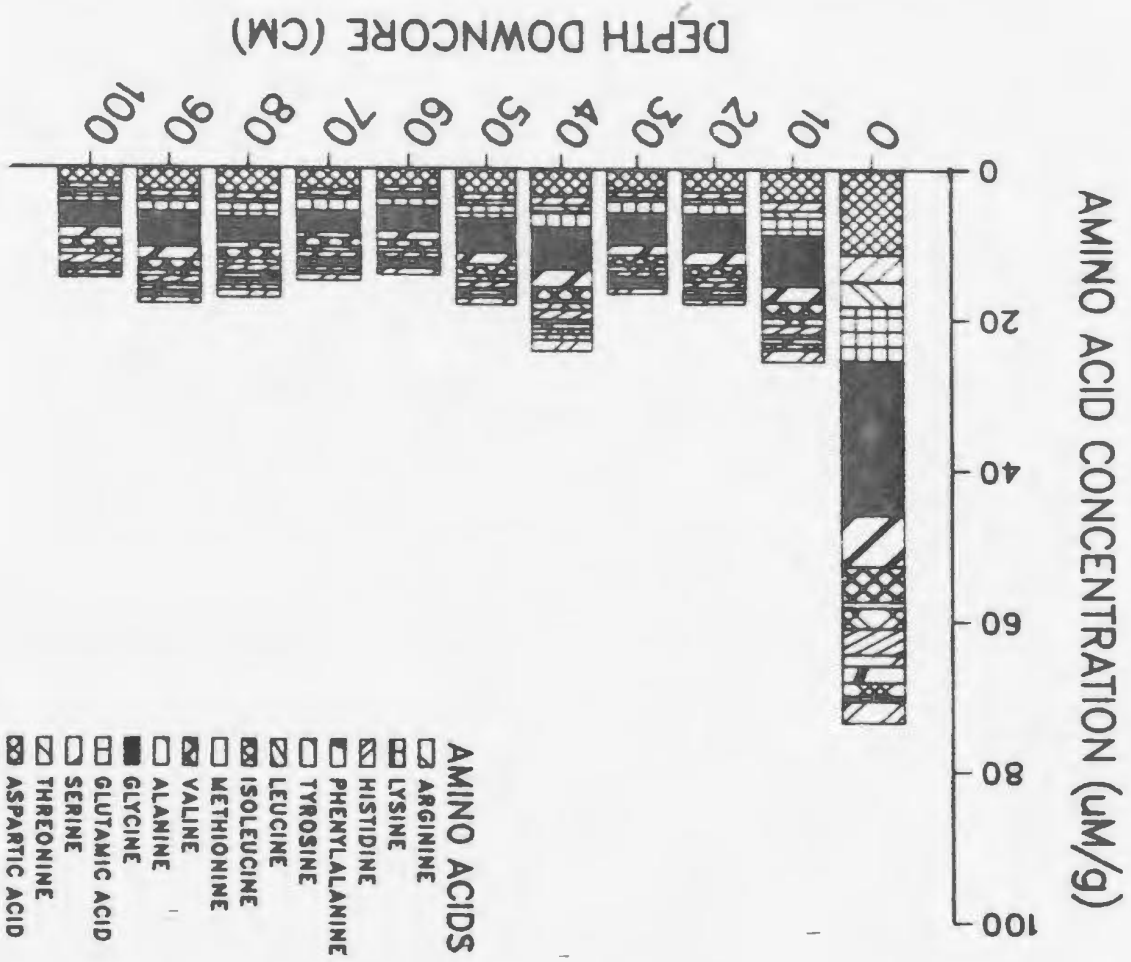
The carbonate content within this core is fairly low, with values ranging from 11.1 to 16.0% (Appendix 4). Within the foraminiferal assemblage, the species *Brazilina pseudopunetata* is the most abundant, followed by the species *Globobulimina auriculata* which shows a slight increase downcore, varying from 22.4% at 20 cm to 10.9 at 70 cm (Appendix 4). The D_{AILE}/L_{ILE} value of the species *Globobulimina auriculata* at 100 cm is 0.04 ± 0.025 (Appendix 4).

3.10. CORE BDE-14.1

3.10.1. Core Description

The upper 5 cm consists of olive grey sandy mud. Dark horizons similar to those of BDE-NB4 are seen below 5 cm and continue throughout the rest of the core, with a dark band between 23.5 to 26 cm. The frequency of the dark bands varies. The core becomes dark between 44.5 to 53 cm and 66 to 71 cm (due to frequent dark horizons) and lighter from 53 to 66 cm and 71 to 76 cm (due to less frequent dark horizons). The sand fraction throughout this core is very low, varying between 1.2 to 1.6% with no general trends (Appendix 4).

Figure 3-31: BDE-1644 sediment profile:
Individual and amino acid fractions.


DEPTH DOWNCORE (CM)
0
10
20
30
40
50
60
70
80
90
100
AMINO ACID CONCENTRATION (uM/g)
0
20
40
60
80
100
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID

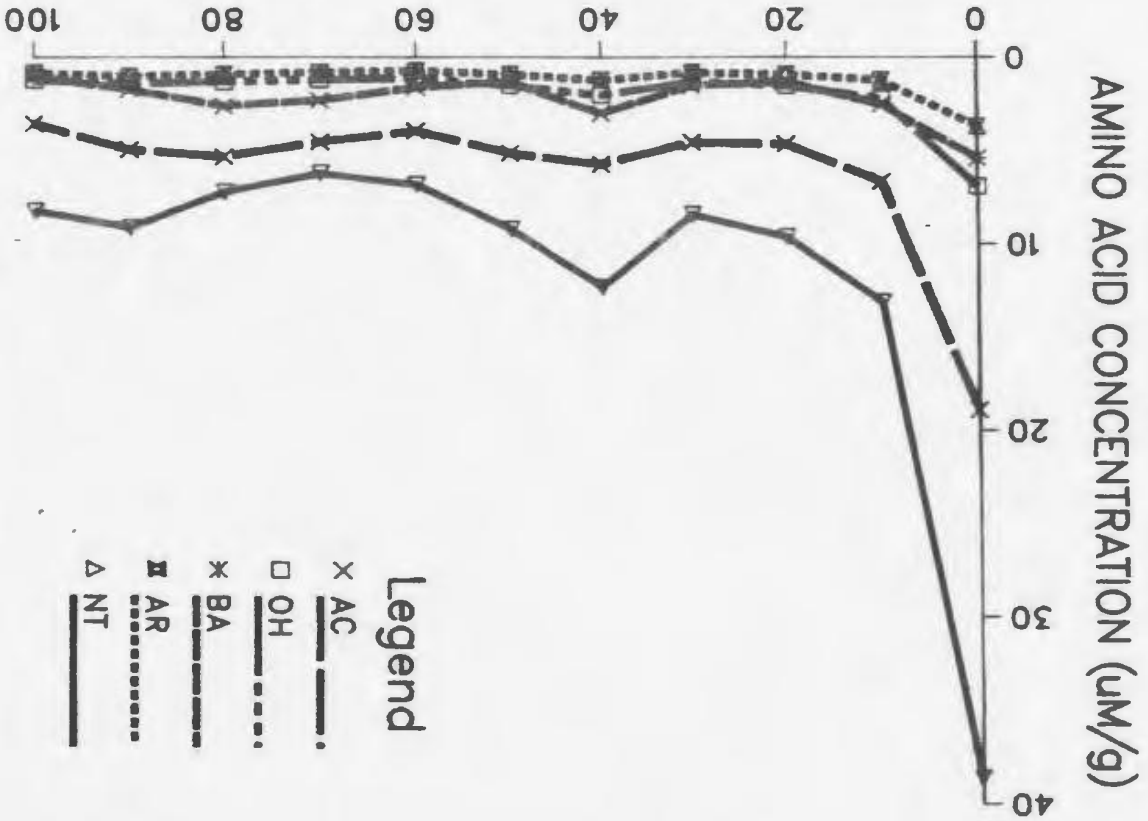
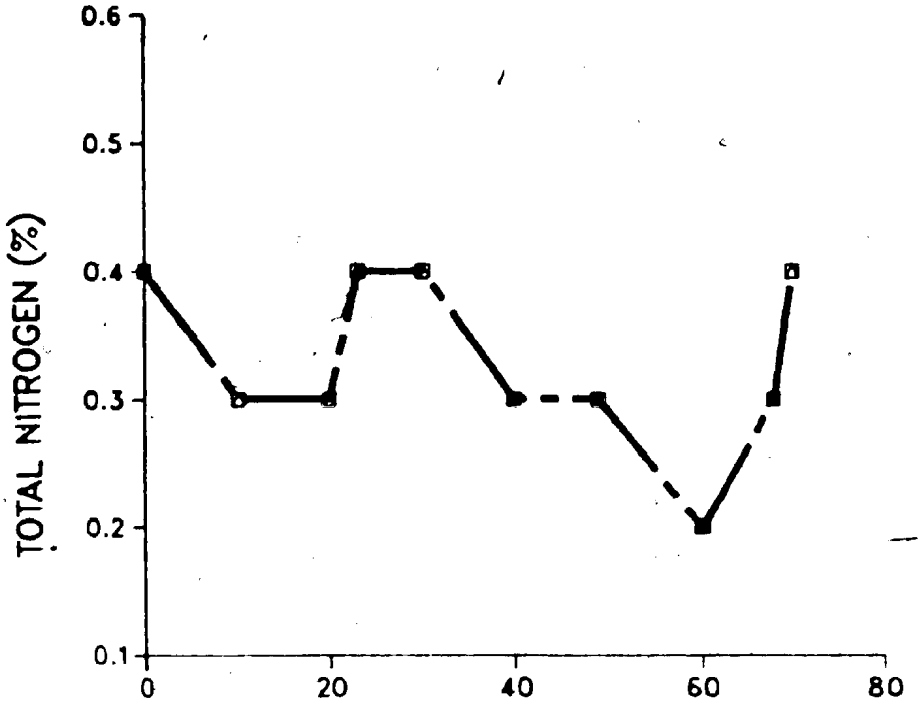
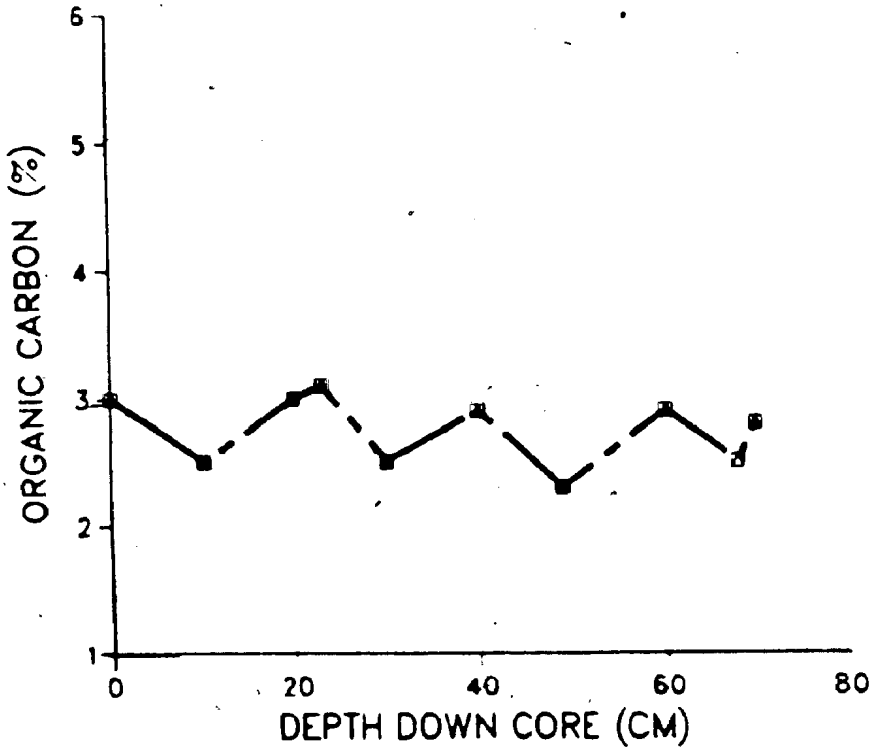

AMINO ACID CONCENTRATION (uM/g)
0
10
20
30
40
0
20
40
60
80
100
Legend
AC
OH
BA
AR
NT

Figure 3-32: BDE-1644 sediment profile:
Organic carbon and total nitrogen contents.


TOTAL NITROGEN (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
20
40
60
80


ORGANIC CARBON (%)
6
5
4
3
2
1
0
20
40
60
80
DEPTH DOWN CORE (CM)

3.11. Geochemical analyses

The ^{13}C isotopic composition is fairly constant throughout this core, with $\delta^{13}C$ ranging from -21.1 to -21.8°/oo (Table 3 and Fig. 3-33). The $\delta^{15}N$ values are low and constant in the upper 20 cm of the core, between 7.3 and 7.4°/oo.(Table 3 and Fig. 3-33). Except for a low of 7.2°/oo at 40 cm, the $\delta^{15}N$ values for the rest of the core vary between 7.7 to 8.0°/oo (Table 3 and Fig. 3-33).

Total amino acid concentrations are moderately high and relatively constant downcore (Appendix 5f and Fig. 3-34). Total concentrations range from 61.0 to 39.5 μM/g. The concentrations of individual amino acids are also very similar to those of the cores described earlier. Glycine (16.0 to 10.5 μM/g) is the most abundant amino acid, followed by ASP (10.7 to 6.8 μM/g) (Appendix 5f). Next, in the order of abundance are GLU and ALA, with comparable concentrations (6.4 to 3.8 μM/g) (Appendix 5f). The least abundant amino acids are MET, LYS and ARG, their individual concentrations being less than 1.0 μM/g (Appendix 5f). The variations of the different fractions are reflective of the individual amino acid abundance with relative constancy downcore (Appendix 6f and Fig. 3-34). The order of abundance of the amino acid fractions in increasing order is: neutral (30.6 to 21.8 μM/g), acidic (16.8 to 10.6 μM/g), hydroxy (6.3 to 3.2 μM/g), aromatic 3.2 to 2.1 μM/g) and basic (3.9 to 1.4 μM/g) (Appendix 6f). This is the only core which does not have comparable concentrations for the hydroxy and basic amino acid fractions.

The organic carbon content is highest at the surface, 3.0%, and gradually decreases downcore between 3.0 to 2.4% (Table 3 and Fig. 3-35). The total nitrogen content follows the same trend as the organic carbon content, showing an overall slight decrease downcore and ranges from 0.4 to 0.2% (Table 3 and Fig. 3-35). The C/N values are moderately high, ranging from 15.0 to 7.3, showing a slight increase downcore below 40 cm (Table 3).

The carbonate content within this core is fairly high and constant downcore

Figure 3-33: BDE-14.1 sediment profile: $\delta^{13}C$ and $\delta^{15}N$.

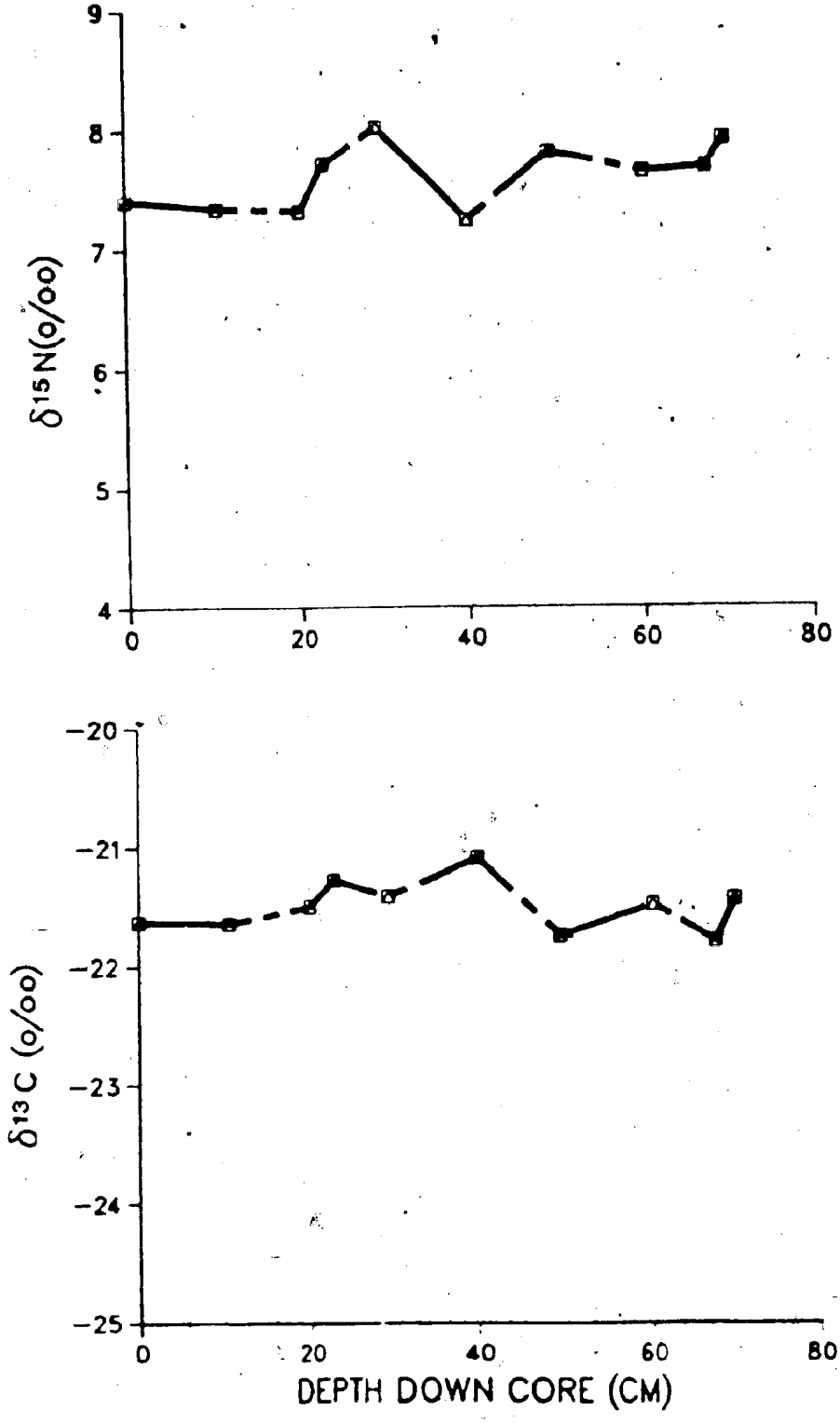
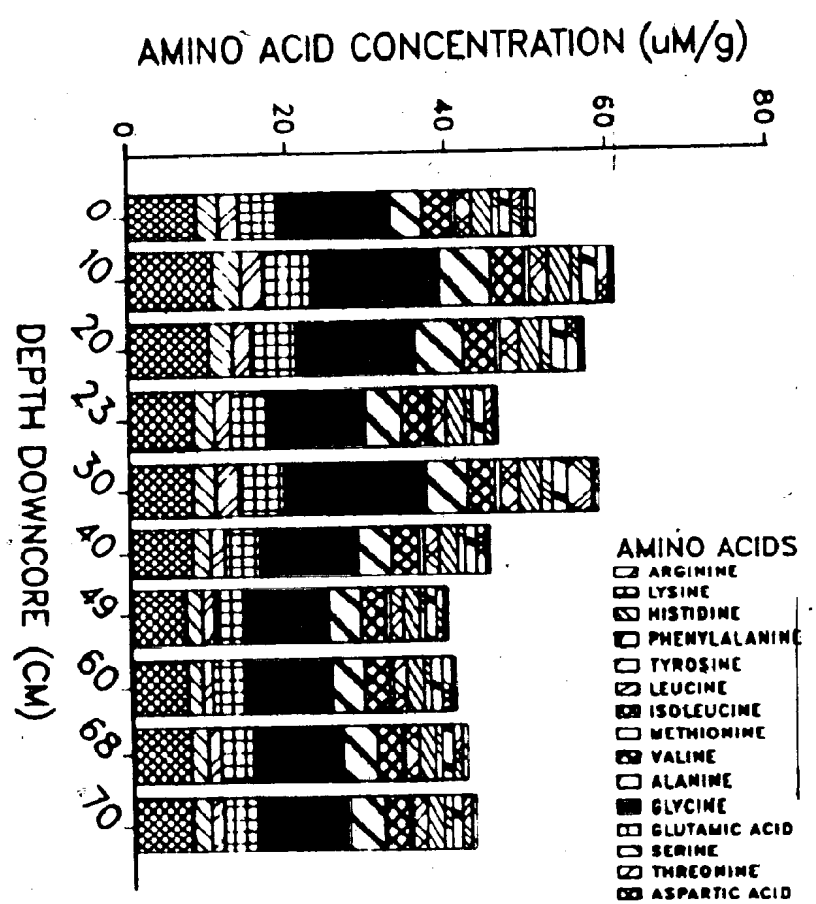

9
8
7
6
5
4
$\delta^{15}N$(o/oo)
0
20
40
60
80
−20
−21
−22
−23
−24
−25
$\delta^{13}C$ (o/oo)
0
20
40
60
80
DEPTH DOWN CORE (CM)

Figure 3-34: BDE-14.1 sediment profile:
Individual and amino acid fractions.


AMINO ACID CONCENTRATION (uM/g)
0
20
40
60
80
DEPTH DOWNCORE (CM)
0
10
20
23
30
40
49
60
68
70
AMINO ACIDS
ARGININE
LYSINE
HISTIDINE
PHENYLALANINE
TYROSINE
LEUCINE
ISOLEUCINE
METHIONINE
VALINE
ALANINE
GLYCINE
GLUTAMIC ACID
SERINE
THREONINE
ASPARTIC ACID

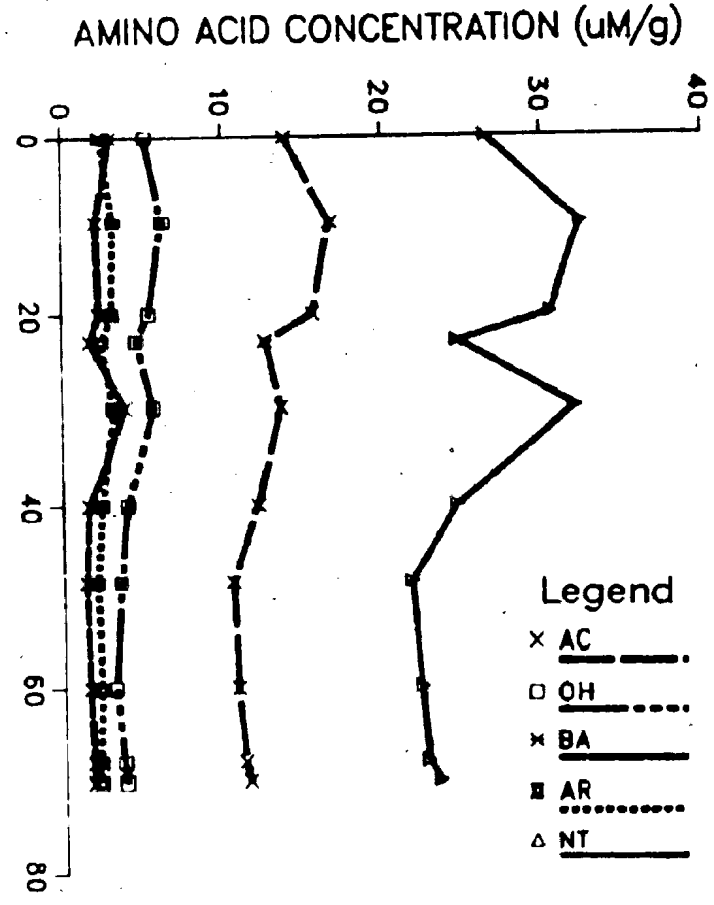
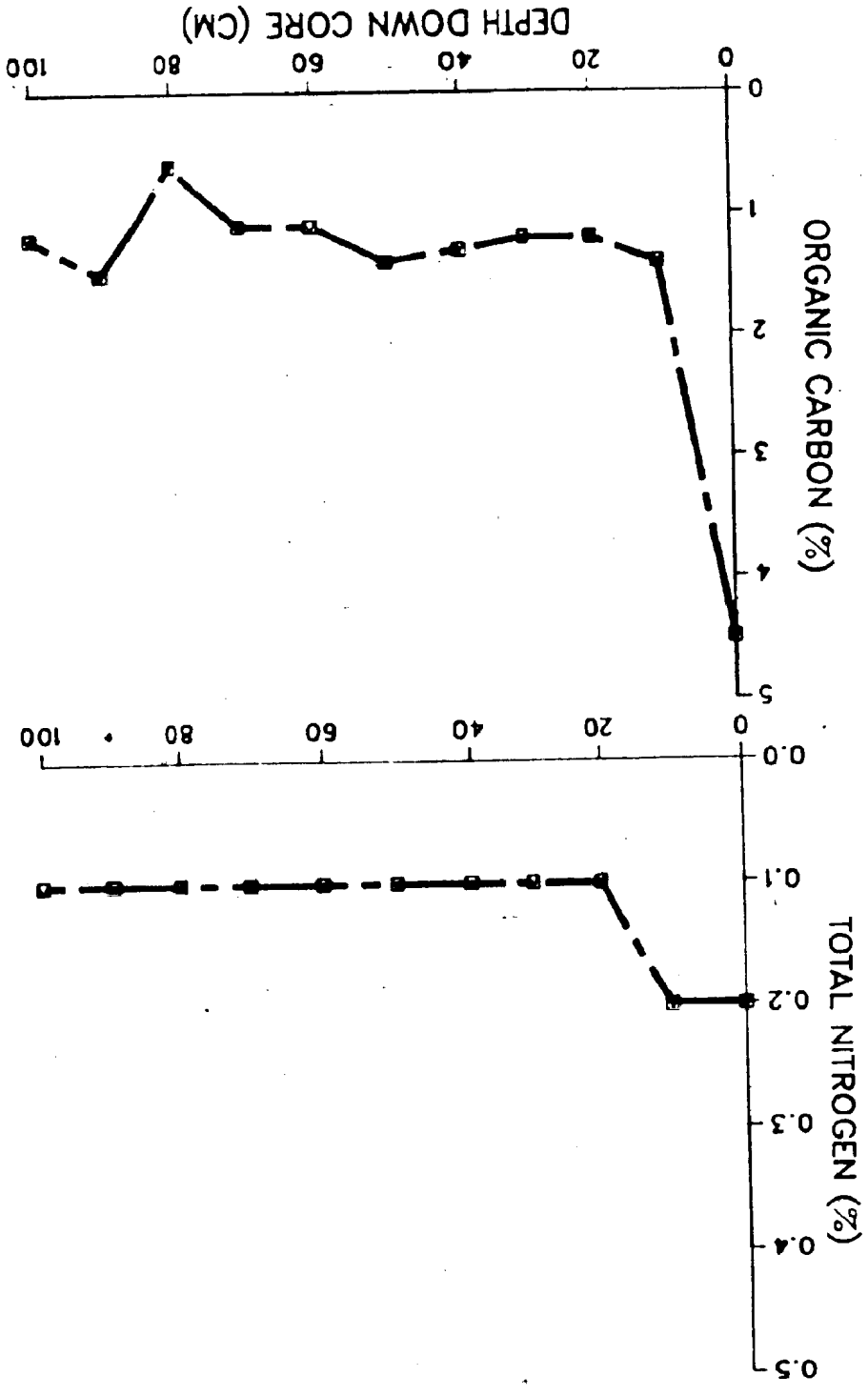

AMINO ACID CONCENTRATION (uM/g)
0
10
20
30
40
0
20
40
60
80
Legend
AC
OH
BA
AR
NT

Figure 3-36: BDE-14.1 sediment profile:
Organic carbon and total nitrogen contents.


DEPTH DOWN CORE (CM)
0
20
40
60
80
100
ORGANIC CARBON (%)
0
1
2
3
4
5
TOTAL NITROGEN (%)
0.0
0.1
0.2
0.3
0.4
0.5

with values between 19.1 and 17.5‰ (Appendix 4). Within the foraminiferal assemblage, the species *Bracilina pseudopunctata* is the most abundant and appears to increase with depth (Appendix 4). The less abundant species, *Globobulimina auriculata*, shows the trend from 1.5‰ at the surface to 11.3‰ at 70 cm (Appendix 4). Finally, significant amounts of D-AILE were detected in the tests of the species *Globobulimina auriculata*, D_{AILE}/L_{ILE} values of 0.08 ± 0.025 at 20 cm, 0.11 ± 0.025 at 30cm, 0.13 ± 0.025 at 50 cm and 0.14 ± 0.025 at 70 cm (Appendix 4).

Chapter 4
DISCUSSION

4.1. FORTUNE BAY CORES

4.1.1. CORE FO-840401

The low percentage of sand indicates a low energy environment (El-Ella and Coleman, 1985), which is in agreement with the sheltered location of FO-840401 in the deepest and innermost part of Belle Bay. The isotopic signature throughout this core is within the compositional range of marine phytoplankton and macrophytic algae (Fig. 1-5 and Fig. 1-6). However, Ivany (1985) found a $\delta^{15}N$ range of about 7 to 8°/oo for high latitude sediments which reflects a macrophytic algal source of the organics. Compared to the other Fortune Bay cores, the $\delta^{13}C$ composition of the organics of FO-840401 are relatively low, suggesting terrigenous influence on sedimentation as a result of the numerous small streams in the region (Parker, 1972; Newman et al., 1973; Gearing et al., 1977). The slight increase in $\delta^{13}C$ values at 30 and 40 cm may be the result of an increase in marine sedimentation. Furthermore, the relatively low values of $\delta^{15}N$ correlates positively with the ^{13}C isotopic signature, indicative of terriginous inputs. The relative constancy of the $\delta^{15}N$ composition downcore suggests no significant changes in sedimentation patterns and/or microbial activity in the nitrogenous content of the organics FO-840401.

The amino acid signature also supports a macrophytic source of organics. Relatively high ASP/GLU (1.5 to 2.0) and GLY/ALA (2 to 3.2) also characterizes macrophytic algal sources (Pulchan, 1985). The very high amino acid

concentrations and organic and nitrogen contents are the result of high organic productivity and/or high sedimentation rate (Morris,1975) and the relative constancy of the individual amino acids and amino acid fractions downcore indicates no preferential utilization of any individual amino acids or amino acid fractions. The persistence of high organic content downcore also indicates a lack of microbial degradation, which is also reflected in the relatively low C/N values throughout the core (Bordovskiy,1965; Stevenson and Cheng,1968; Rosenfeld, 1079).

A high percentage of carbonates throughout this core may result from high productivity of calcareous organisms, which reflects availability of nutrients in the water of Belle Bay. Finally the high percentage of total amino acids and organic carbon may be related to absorption by carbonates (Carter and Mitterer, 1978).

4.1.2. CORE FO-840402

Like FO-840401, the low percentage of sand reflects the low energy environment located at a deep end of the bay (El-Ella and Coleman, 1985).

The $\delta^{15}N$ and $\delta^{13}C$ composition of FO-840402 is similar to that of FO-840401, typifying a macrophytic algal source of organics (Ivany, 1985). However, the $\delta^{13}C$ composition is slightly more enriched in the heavier isotope, indicating a possible stronger marine influence on sedimentation in this area of Fortune Bay than Belle Bay (where FO-840401 is located)(Parker, 1972; Newman et al., 1973; Gearing et al., 1977; Ivany, 1985). Like FO-840401 the $\delta^{13}C$ isotopic signature is relatively constant except for the slight enrichment at 20 cm. This may be the result of microbial activity involving cleavage of isotopically enriched labile groups by preferential breaking of ^{12}C - ^{12}C over ^{13}C - ^{12}C bonds (Smith, 1975). The amino acid signature also points to an algal source of organics. However, the amino acid signature is different for FO-840402. The ASP/GLU values are higher than those for FO-840401, another indicator of a stronger marine influence (Pulchan, 1985).

Unlike FO-840401, FO-840402 shows slight evidence of degradation of organics. Total amino acid abundance decreases downcore, and there appears to be a slight increase of the C/N values in the same direction, indicating preferential degradation of nitrogeneous organics. However, the amino acid signature remains fairly constant downcore indicating no preferential degradation of the individual amino acids or the amino acid fraction, as seen in FO-840401. The slightly lower amino acid concentrations (as compared to FO-840401), organic carbon and total nitrogen content also indicate that the input of organics in the location of FO-840402 is diminished and/or that productivity is lower.

Again, high carbonate content may reflect high productivity of calcareous organisms. These include the foraminiferal species *Islandiella pseudopunctata* and *Globobulimina auriculata*, which are faunal types characteristic of the cold Labrador water current (Scott et al., 1984). The carbonate content may also be related to the high organic content and total amino acid concentrations throughout this core (Carter and Mitterer, 1978). Finally, the relatively low D_{AlLE}/L_{ILE} value is indicative of a high sedimentation rate (Miller et. al., 1983).

4.1.3. CORE FO-840403

The more abundant sand fraction of this core may be explained by it being in the middle of the Fortune Bay where the energy of the environment is higher than that of the location of FO-840401 and FO-840402 (El-Ella and Coleman, 1985).

The $\delta^{13}C$ and $\delta^{15}N$ composition is very similar to that of FO-840401 and FO-840402, reflecting a macrophytic algal source of organics (Ivany, 1985). Compared to FO-840401, the $\delta^{13}C$ isotopic composition is slightly depleted in the heavier isotope, indicating a stronger marine influence on sedimentation in the area of location of FO-840403 (Parker, 1972; Newman et al., 1973; Gearing et al., 1977; Ivany, 1985). The relative constancy of the isotopic composition downcore may be a result of minimum fractionation due to microbial degradation and other diagenetic reactions, and reflects that of the primary source.

The amino acid signature supports the isotopic evidence of a macrophytic source of organics. Within the individual amino acids, the high ASP/GLU values are very similar to those of FO-840402, indicating strong marine sourced organics (Pulchan, 1985).

Amino acid concentrations, organic carbon and total nitrogen contents are the result of high marine organic productivity and/or influx of organic-rich sediments. However, the slight decrease in the amounts of organics downcore may be the result of microbial degradation. Also a general increase in C/N values downcore is suggestive of preferential degradation of the nitrogeneous content of the organic matter (Bordovskiy, 1965; Rosenfeld, 1979).

The percentage carbonate is also very similar to that of FO-840402 and may be related to the high level of organics throughout the core (Carter and Mitterer, 1978). The relatively constant isotopic signal from benthic foraminiferal species *Globobulimina auriculata* is a result of no changes in the salinity of Recent seas of the study area (Gao et. al., 1985).

4.1.4. CORE FO-840404

"The sharp discontinuity in grain size may be explained by a change in source of sediments and/or energy of the environement, which can only change as a result of changes in sea level or circulation patterns. However, the changes in texture and color hint at a change in the sediment source as the primary cause of the discontinuity. From the surface to 35 cm depth, this core is similar to the other cores, FO-840401, FO-840402 and FO-840403, being typically marine. The grain size data suggests that the rest of the core was probably deposited as 'rock flour' or as very fine grained sediment as a result of the presence of an overlying ice sheet (Greensmith, 1978) during the late Wisconsin period.

The isotopic composition is very similar to those described earlier. However, the relatively low $\delta^{13}C$ values are indicative of stronger marine sedimentation

influence (Parker, 1972; Newman et al., 1973; Gearing et al., 1977; Ivany, 1985). A constant $\delta^{13}C$ signature for the upper 50 cm suggests steady bottom conditions and sediment source and minor fractionation below the zone of active reworking. However, the fluctuations in isotopic composition below 50 cm may be related to changes in source, diagenetic reactions and/or temperature fluctuations occurring during the Late Wisconsin event.

The amino acid signature is also similar to that of the other cores. However, ASP/GLU shows a relative decrease downcore, which is suggestive of increased terrestrial debris inputs by processes which include ice-rafting and transport by meltwater runoff (Pulchan, 1985).

All of the data are consistent, corroborating the idea of a change of sedimentation pattern - glaciomarine sedimentation below the discontinuity, followed by normal Holocene sedimentation.

The C/N values are relatively constant, except for slightly higher values of 10.4 to 12.1 at 0, 10, 80 and 110 cm. The relative constancy of C/N and the slightly higher values suggest that minimal diagenetic alteration occurs downcore (Bordovskiy, 1965; Degens, 1970) and that the C/N of the source is preserved.

Finally, it appears that the productivity of calcareous organisms was low during the last glacial period. The disappearance of the species *Globobulimina auriculata* was interpreted by Scott et al. (1984) in their analysis of a Canso Bank Basin core as a reflection of the progressive cooling of the Outer Labrador Current. In FO-840404, the appearance of *Globobulimina auriculata* is interpreted as a marker of the end of the Late Wisconsin event. The low percentages of carbonate correlate positively with the organic content and total amino acid concentration (Carter and Mitterer, 1978). The $\delta^{18}O$ and $\delta^{13}C$ compositions do not support the other evidence that sedimentation below the discontinuity was during a glacial period. The isotopic signal indicates a lesser amount of continental ice during the Late Wisconsin than during the Holocene. This anomalous signal is probably the

result of variations of the relative inputs and temperature of the Labrador Current.

4.1.5. CORE FO-840405

Core FO-840405 is very similar to FO-840404. The upper 45 cm of this core corresponds to that part of FO-840404 which represents normal marine sedimentation. The part below this boundary correlates with the lower 90 cm of FO-840404, a zone of glaciomarine sedimentation.

The isotopic composition of the surface zone is similar to that of other Fortune Bay cores, typifying macrophytic algal sources of organics (Ivany, 1985). The fluctuation of $\delta^{13}C$ composition downcore may reflect one or a combination of diagenetic processes, changes in sediment source and/or changes in temperature. Diagenetic processes which produce an overall enrichment include preferential cleavage of ^{12}C - ^{12}C over ^{12}C - ^{13}C bonds (Smith, 1975) and microbial utilization of the isotopically depleted lipid content of the organics (DeNiro and Epstein, 1977). The constancy of the $\delta^{15}N$ values for the upper 30 cm may reflect an unchanging environment, whereas the fluctuations below 30 cm are reflective of variations in the sediment source and/or diagenesis.

The amino acid signature also reflects a macrophytic source. Like FO-840404, the low ASP/GLU below the discontinuity indicates influxes of terrigenous sediments (Pulchan, 1985).

Cores FO-840404 and FO-840405 have two noticeable differences. Firstly, the levels of organics and total amino acid concentration of the Holocene portion of FO-840405 are relatively low compared to that of FO-840404. This may be related to the location. Core FO-840405 is located on a topographic high where erosion may be stronger than in the location of FO-840404. Hence the sedimentation rate is expected to be lower with less accumulation of organics (Bordovskiy, 1965).

Secondly, the discontinuity of FO-840404 is sharp as opposed to the very gradual discontinuity of FO-840405. This gradual change from organic-rich to organic-poor sediments may be related to mixing induced by turbulence in this high energy location.

Evidence of diagenesis in the upper 30 cm comes from the C/N values of the core. However,the constancy in C/N values below 30 indicates little change in diagenetic conditions and sediment sources (Bordovskiy, 1965; Rosenfeld, 1979) The disappearance of *Globobulimina auriculata* in FO-840405 is interpreted in a similar manner to that of FO-840404. The decrease in total amino acids may be related to the decrease in the carbonate content with depth (Carter and Mitterer, 1978). The enrichment of the stable isotopic composition of the carbonate of the foraminiferal tests is indicative of increased volume of continental ice during the Late Wisconsin, which resulted in preferential evaporation of isotopically light water from the ocean (Gao et. al.,1985).

Assuming the upper 50 cm of sediment represents the end of the Late Wisconsin, which was dated as about 16,000 years (Fader and King, 1986), the K_{ILE} for the species *Globobulimina auriculata* is calculated to be 1.07×10^{-5} $year^{-1}$. This compares favorably with the K_{ILE} determined by Bada and Schroeder (1972) for calcareous sediments.

4.2. BAY D'ESPOIR CORES

4.2.1. CORE BDE-11

The high sand fraction of this core may be a result of the influx of large particle size debris in the sub-basin in which this core is located (El-Ella and Coleman, 1985).

The isotopic signature is suggestive of a macrophytic algal source of organics (Ivany, 1985). Also, the relatively depleted ^{13}C composition indicates terriginous influxes of sediments and hence terriginously derived organics (Parker, 1972; Newman et al., 1973; Gearing et al., 1977; Ivany, 1985). The anomalous isotopic composition at 20 cm may be the result of a chance event such as a turbidity flow of mud of similar composition to that of the lower parts of BDE-1657 and BDE-1643 (described in the next section). More evidence of such a process comes from the very low concentrations of organics and total amino acids at 20 cm. Another such event may be responsible for the low organic content and total amino acid concentration at 90cm. The gradual overall decrease in the organic content is reflective of microbial degradation. Furthermore, the increase in C/N values at 90 and 100 cm indicates preferential utilization of the nitrogeneous content of organics (Bordovskiy, 1965; Rosenfeld, 1979).

The amino acid content also exemplifies a macrophytic source with the low ASP/GLU values also indicating a terriginous influence on sedimentation in the locality of this core (Pulchan, 1985). The total amino acids, individual amino acids, organic carbon and total nitrogen contents are all indicators of high productivity.

The absence of formainifera throughout this core may be the result of reduced circulation in this part of the basin. Finally, the decrease in carbonate content with depth is accompanied by a similar decrease in the organic content, probably indicative of absorption of organic substances by carbonates (Carter and Mitterer, 1978).

4.2.2. CORES BDE-1657 and BDE-1643

Cores BDE-1657 and BDE-1643 are located apart from each other in different sub-basins within Bay D'Espoir, but appear to be derived from the same sediment source and by the same sedimentary processes. The very fine-grained nature of the cores suggest that they may be derived from 'rock flour' or sedimentation in the presence of an overlying ice cover (Greensmith, 1978). The fine-grained sediment in both localities were likely formed by ice-rafting of exposed glacial till during a lower sea level stand associated with the Late Wisconsin event. This accounts for the absence of foraminifera throughout the core. The subsequent Holocene transgression resulted in the deposition of the surface layer (approximately about 3 cm) under normal marine conditions.

The above sedimentation pattern is supported by the isotopic signature. The depleted $\delta^{13}C$ and $\delta^{15}N$ compositions of the organics of the surface reflect normal marine organics (Parker, 1972; Newman et al., 1973; Gearing et al., 1977; Ivany, 1985). Below the surface the isotopic signature decreases to one of organics from terriginously-sourced sediment, supporting the idea of land derived 'rock flour' by ice-rafting. The erratic fluctuations of the isotopic and C/N profiles of both cores may be the result of chemical changes, which may be responsible for the presence of the dark bands.

Although the individual amino acids and amino acid fractions appear typical of those for the rest of the Bay D'Espoir cores, the low ASP/GLU values further support the idea of terriginous derived sediments (Pulchan, 1985).

The very low amounts of organics in the upper 3 cm of each core reflects low organic productivity and/or influxes of organic-poor sediments. If this 3 cm of sediments represents the entire Holocene, the sedimentation rate is low.

The low percent carbonate relates to the low organic and total nitrogen content and total amino acid concentration (Carter and Mitterer, 1978).

Finally, due to very low concentrations, detection and estimation of the organic content, total nitrogen and total amino acid contents were very difficult and resulted in larger than normal errors.

4.2.3. CORE BDE-NB4

The low sand fraction is indicative of a low energy depositional environment, which may be due to constant environmental conditions (El-Ella and Coleman, 1985).

The low $\delta^{13}C$ and $\delta^{15}N$ composition are suggestive of a macrophytic algal source of organics (Ivany, 1985). However, the slightly depleted $\delta^{13}C$ composition may be the result of terrigenous processes, such as influxes from local streams. Furthermore, microbial alteration of the isotopic signature downcore is insignificant, as seen from the constant isotopic signature downcore.

The amino acid signature also reflects a macrophytic source of organics (Pulchan, 1985). However, low ASP/GLU values throughout this core correlates with the ^{13}C isotopic signature, indicating terrigenous inputs (Pulchan, 1985). High levels of amino acids, organic carbon and total nitrogen content indicate high productivity levels and/or the influx of organic-rich sediments. The slight decrease of these values downcore may be the result of minor microbial degradation of organics or diagenetic reactions leading to the consumption of organics. The C/N values reflect equal degradation of carbon and nitrogen until 40 cm (Bordovskiy, 1965; Degens, 1970; Rosenfeld, 1979). From 40 to 80 cm, there appears to be preferential degradation of nitrogeneous organics (higher C/N values) which corresponds to the small decrease in the total amino acid concentrations. From 90-120 cm, preferential utilization of nitrogeneous organics decreases and then increases at 130 cm. This increase is marked by higher C/N values and lower total amino acid concentrations.

High carbonate content may be the result of a large population of calcareous

organisms supported by a steady flow of nutrients due to the unrestricted water source of this location. The high total amino acid content correlates positively with the high percent carbonate throughout this core (Carter and Mitterer, 1978). The very low amounts of D-AILE within the tests of *Globobulimina auriculata* indicate a high sedimentation rate within this locality.

4.2.4. CORE BDE-1644

The high sand content is in agreement with the location of this core - a slope, where the environmental energy is expected to be higher (El-Ella and Coleman, 1985). The decrease in grain size downcore may be the result of changing environmental conditions or sediment source.

This core is located towards the mouth of Bay D'Espoir and hence marine influence on sedimentation becomes more important (Ivany, 1985). This is reflected in the $\delta^{13}C$ values, which are slightly heavier than those for cores BDE-1643 and BDE-11. However, the isotopic signature once again characterizes a macrophytic algal source of organics (Ivany, 1985). The variation of the $\delta^{15}N$ composition may be the result of various reactions occurring after sediment deposition - possibly deamination of amino acids resulting in a decrease in the abundances of amino acids downcore. The increase in C/N values downcore further supports preferential degradation of nitrogeneous compounds (Bordovskiy, 1965; Degens, 1970; Rosenfeld, 1979).

The amino acid abundance, organic carbon and total nitrogen contents also support the idea of microbial degradation downcore, as seen in the decrease in concentrations with depth. This may be related to bacterial population and diagenesis, which increases as grain size decreases (Bordovskiy, 1965). The amino acid composition corroborates the isotopic signature interpretation, indicating a macrophytic source of organics with relatively high ASP/GLU values (Pulchan, 1985).

Unrestricted circulation in this location results in a steady flow of nutrients, thereby supporting planktonic fauna. The presence of the species *Brazilina* is indicative of warm water circulation (Scott, et. al., 1984). Finally, the low carbonate content may be related to the low concentrations of amino acids (Carter and Mitterer, 1978). The sedimentation rate for this area is also fairly high, resulting in low D_{ALE}/L_{ILE} values at the bottom of the core.

4.2.5. CORE BDE-14.1

The small grain size of this core can be related to a low energy environment and a mainly marine source, since it is located closest to the mouth of the fjord (El-Ella and Coleman, 1985).

Although the isotopic signature typifies a macrophytic source of organics (Ivany, 1978), the $\delta^{13}C$ isotopic composition for samples from this core are the least depleted in the study area, indicating a very strong marine influence on sedimentation (Parker, 1972; Newman et al., 1973; Gearing et al., 1977; Ivany, 1985). The relative constancy of the $\delta^{13}C$ and $\delta^{15}N$ downcore indicates minor alteration of the isotopic signature, which may be a result of little microbial degradation of organics with depth. Evidence of this is seen in the moderately constant organic carbon and total nitrogen contents and amino acid concentrations throughout the core. The fluctuations of the $\delta^{15}N$ may be due to microbial alteration. Below 40 cm, deamination of amino acids may be one of the main degradation processes as reflected in the slight decrease in total amino acids downcore and a corresponding increase in C/N values (Degens, 1970; Rosenfeld, 1978)

The amino acid signature also establishes macrophytic algae as the main source of organics, with high ASP/GLU indicating strong marine influence on sedimentation (Pulchan, 1985). From the amino acid fraction distribution it also appears that the environment of BDE 14.1 is unsuitable for the survival of basic amino acids, as seen from the decrease of the nitrogen rich basic fraction with depth.

The foraminiferal assemblage of BDE-14.1 is interpreted similarly to that of BDE-1644. Being located at the mouth of the fjord results in unrestricted circulation of nutrients for primary production on which planktonic faunas grow. Again, the species *Brazilina pseudopunetata* indicates circulation of warm waters (Scott et al., 1984). The relatively high carbonate content may also be related to the organic content and amino acid concentration (Carter and Mitterer, 1978). The relatively high D_{ALE}/L_{ILE} indicates fairly slow sedimentation rate, which may be constant downcore . Also, sediment at a depth of 70 cm is dated at 15,000 years B.P..

4.3. SUMMARY AND GENERAL DISCUSSION

Both the amino acid concentration, organic carbon and total nitrogen contents for Fortune Bay are generally higher than those for Bay D'Espoir. This is an indication of higher productivity and/or influxes of organic rich sediments. The productivity within Fortune Bay is expected to be higher because of increased levels of nutrient-laden seawater resulting from greater intra-fjordic circulation.

The sections of cores at FO-840401, FO-840402 and FO-840403 are principally derived by marine sedimentation and show high levels of organics. Sedimentation rate of FO-840402 is relatively high. Cores FO-840404 and FO-840405 show a discontinuity in the sedimentary record which represents a change in sedimentation pattern. Sediments above the discontinuity result from normal marine sedimentation, whereas sediments below the discontinuity are glaciomarine in origin. Normal marine sediments in the Fortune Bay are characterized by high contents of organics and carbonates and relatively high ASP/GLU and have the species *Globobulimina auriculata* included in the foraminiferal assemblage. Glaciomarine sediments show low levels of organics and carbonates and low ASP/GLU and are devoid of the species *Globobulimina auriculata*. Also, the presence of the species *Islandiella islandica* indicates the influence of the Labrador Current in Fortune Bay.

In Bay D'Espoir, the levels of organics is generally lower. This may be a result of lower productivity levels created by depletion of nutrients for the producers resulting from restricted intra-fjordic circulation. Cores BDE 14.1, BDE-NB4 and BDE-1644 are located in areas where circulation is not restriced, as in the localities of the other cores. This is reflected in the relatively high levels of organics. However, BDE-1644 shows evidence of microbial degradation with depth. Also the length of BDE-14.1 represents a fairly long time period.

Evidence of the glacial history is manifested in the cores BDE-1657 and BDE-1643. These show the lowest levels of organics within the entire study area, reflecting the source - terrigenous glacial till. The ^{13}C and ^{15}N and amino acid signatures are characteristic of terrigenous sourced organics. Finally, because the sediments are land derived, there are no foraminifera present throughout the cores.

Core BDE-11 is located in a restricted sub-basin within Bay D'Espoir with relatively high levels of organics. The amino acid and isotopic signatures are characteristic of macroalgal sources of organics, with slight terrigenous overprint. An interesting feature of this core is evidence of an event, such as turbidity flow of mud of composition similar to that of BDE-1657 and BDE-1643.

The presence of the species *Brazilina pseudopunctata* only in Bay D'espoir and the absence of the species *Islandiella islandica* indicates that Bay D'espoir does not receive significant amounts of water from the Labrador Current. Correlations can be made between the carbonate content and total amino acid concentrations, organic carbon and total nitrogen contents (Figs. 4-1, 4-2 and 4-3). This relationship may be the result of the interaction of organics with carbonates.

Figure 4-1: Carbonate content verses total amino acid concentrations

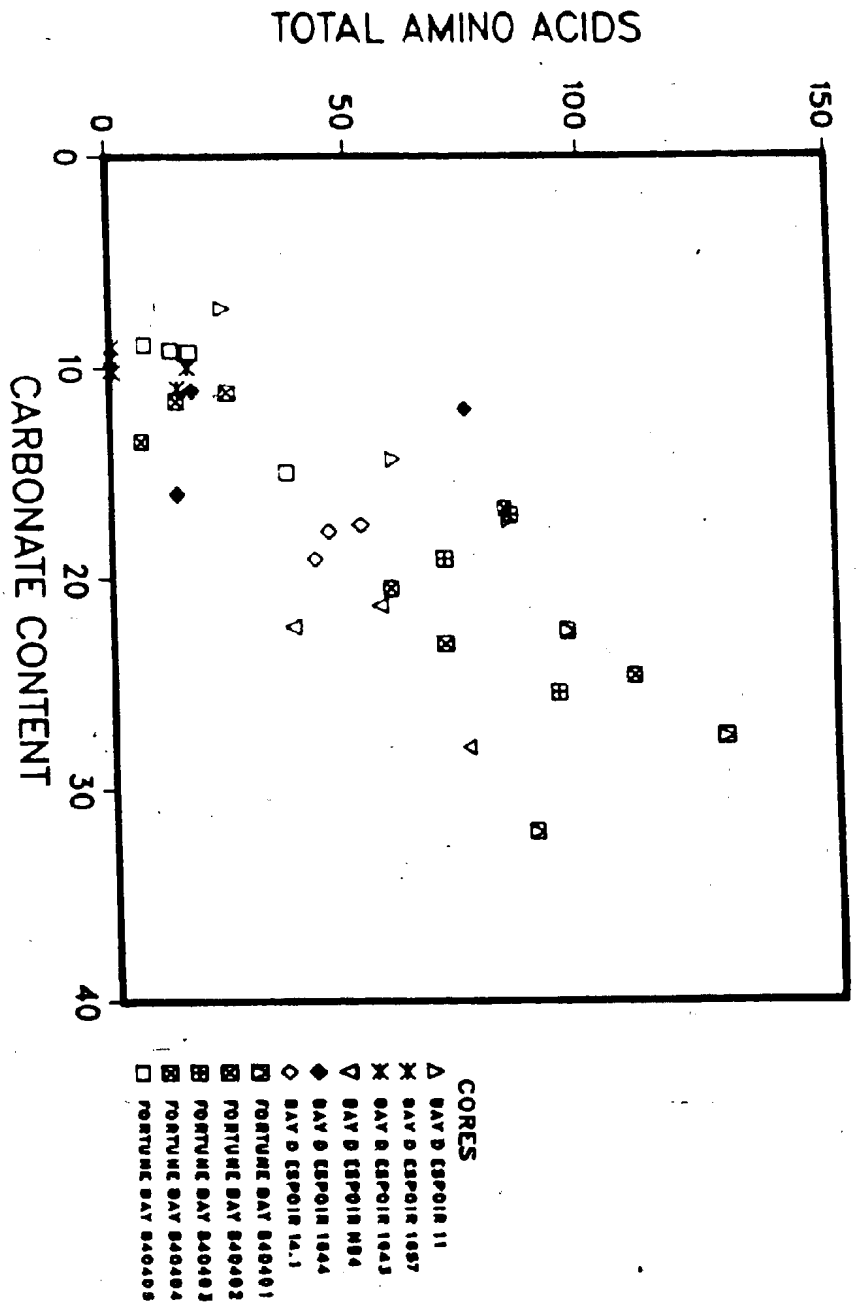
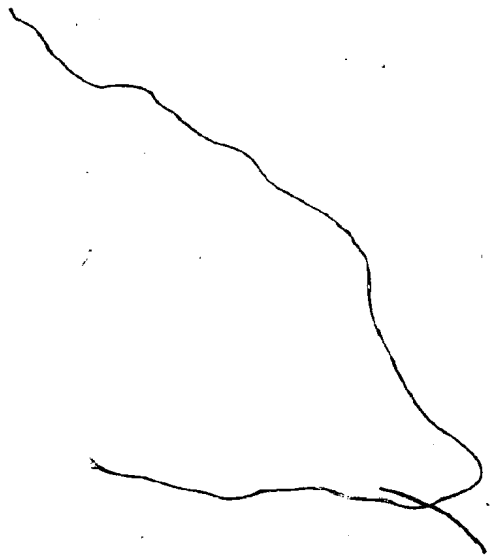

TOTAL AMINO ACIDS
0
50
100
150
CARBONATE CONTENT
0
10
20
30
40
CORES
BAY D ESPOIR 11
BAY D ESPOIR 1987
BAY D ESPOIR 1983
BAY D ESPOIR MB4
BAY D ESPOIR 1984
BAY D ESPOIR 14.1
FORTUNE BAY 840401
FORTUNE BAY 840402
FORTUNE BAY 840403
FORTUNE BAY 840404
FORTUNE BAY 840405

Figure 4-2: Carbonate content verses organic carbon content



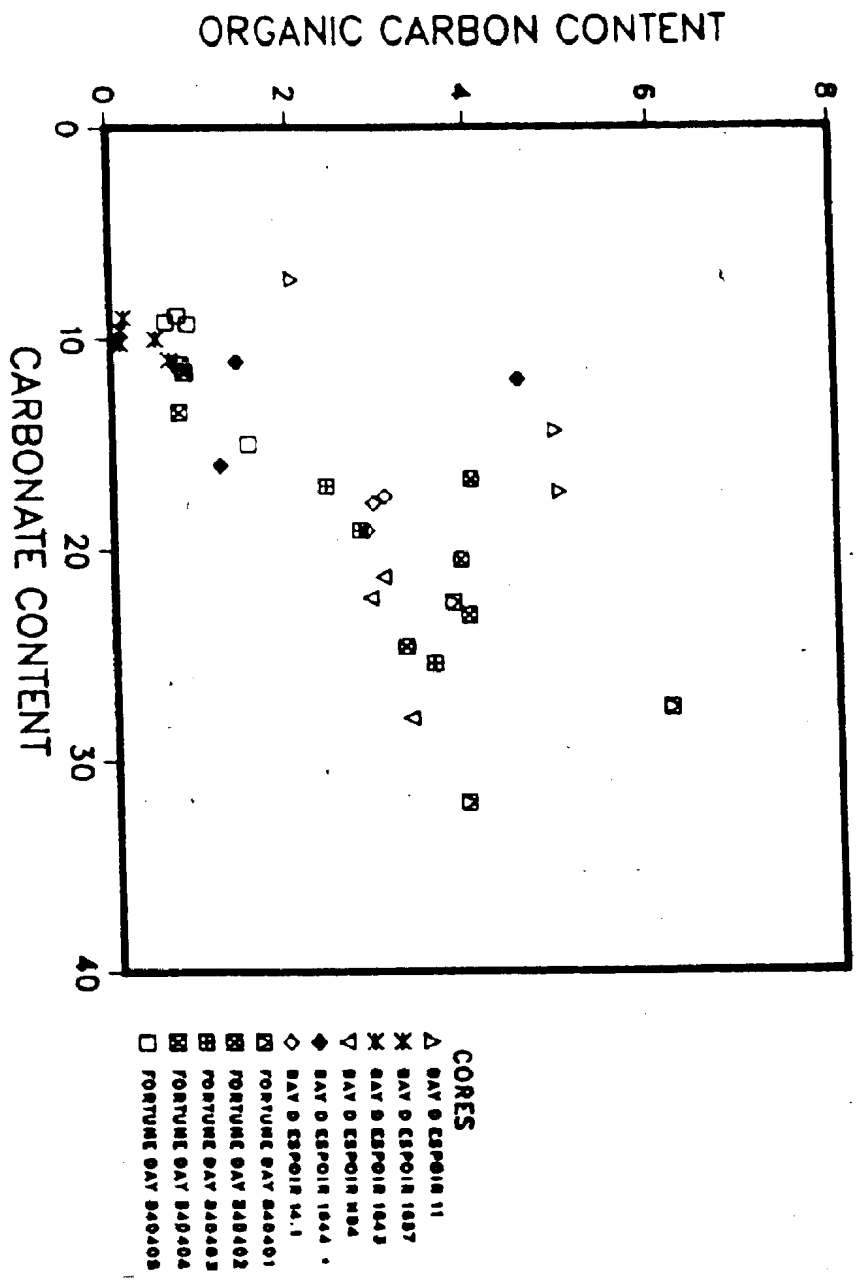
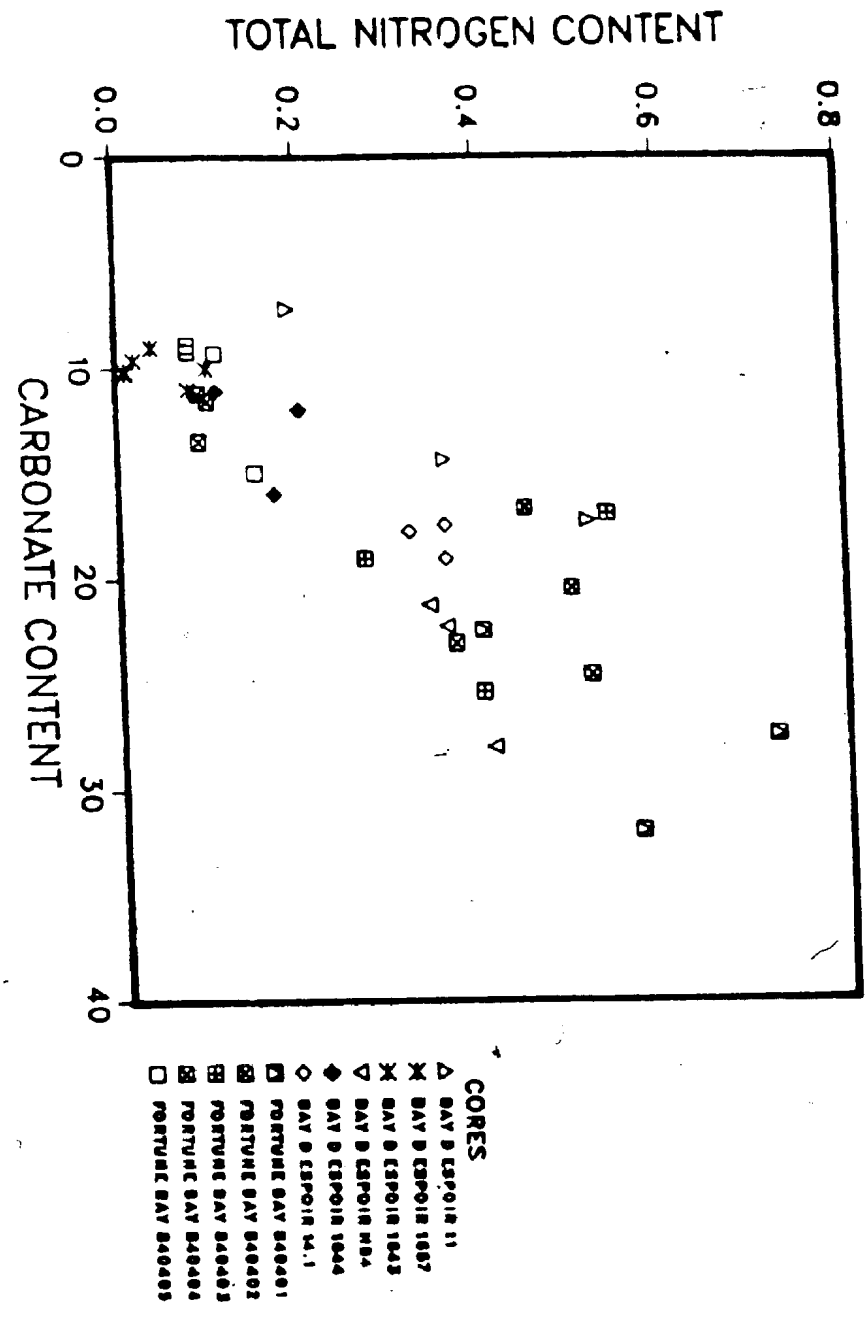

ORGANIC CARBON CONTENT
0
2
4
6
8
CARBONATE CONTENT
0
10
20
30
40
CORES
BAY D ESPOIR 11
BAY D ESPOIR 1987
BAY D ESPOIR 1983
BAY D ESPOIR 1984
BAY D ESPOIR 1984 *
BAY D ESPOIR 14.1
FORTUNE BAY 840401
FORTUNE BAY 840402
FORTUNE BAY 840403
FORTUNE BAY 840404
FORTUNE BAY 840405

Figure 4-3: Carbonate content verses total nitrogen content


TOTAL NITROGEN CONTENT
0.0
0.2
0.4
0.6
0.8
CARBONATE CONTENT
0
10
20
30
40
CORES
BAY D ESPOIR 11
BAY D ESPOIR 1987
BAY D ESPOIR 1983
BAY D ESPOIR NB4
BAY D ESPOIR 1984
BAY D ESPOIR 14-1
FORTUNE BAY 840401
FORTUNE BAY 840402
FORTUNE BAY 840403
FORTUNE BAY 840404
FORTUNE BAY 840405

Finally, correlations between $\delta^{13}C$ and $\delta^{15}N$ and $\delta^{13}C$ and ASP/GLU can also be made (Fig. 4-4 and 4-5). These correlations define "end members" with respect to types of sediment inputs. Terrigenous "end members" are isotopically depleted with respect to $\delta^{13}C$ and $\delta^{15}N$ and have low ASP/GLU values, whereas marine "end members" are relatively enriched in ^{13}C and ^{15}N isotopes and have high ASP/GLU values.

Figure 4-4: Isotopic comparisons of sediments

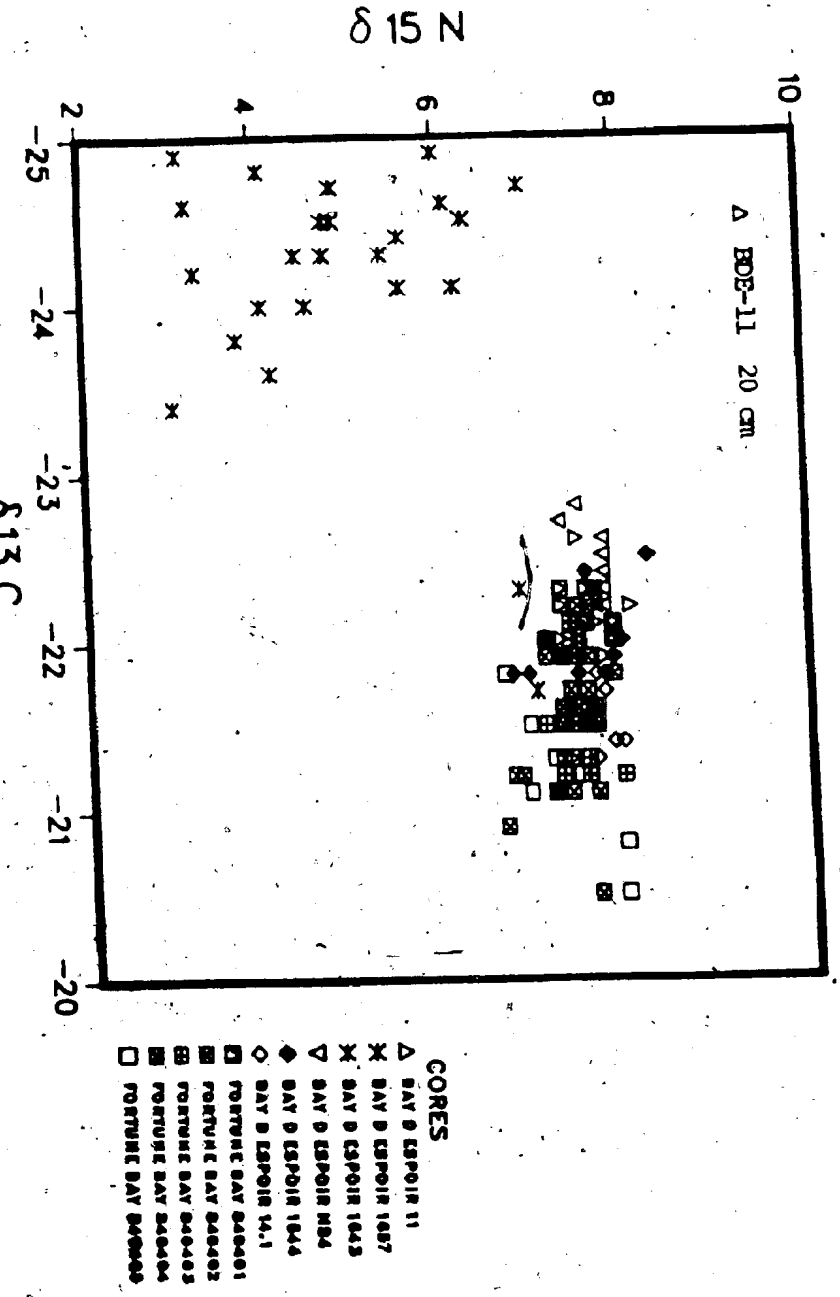
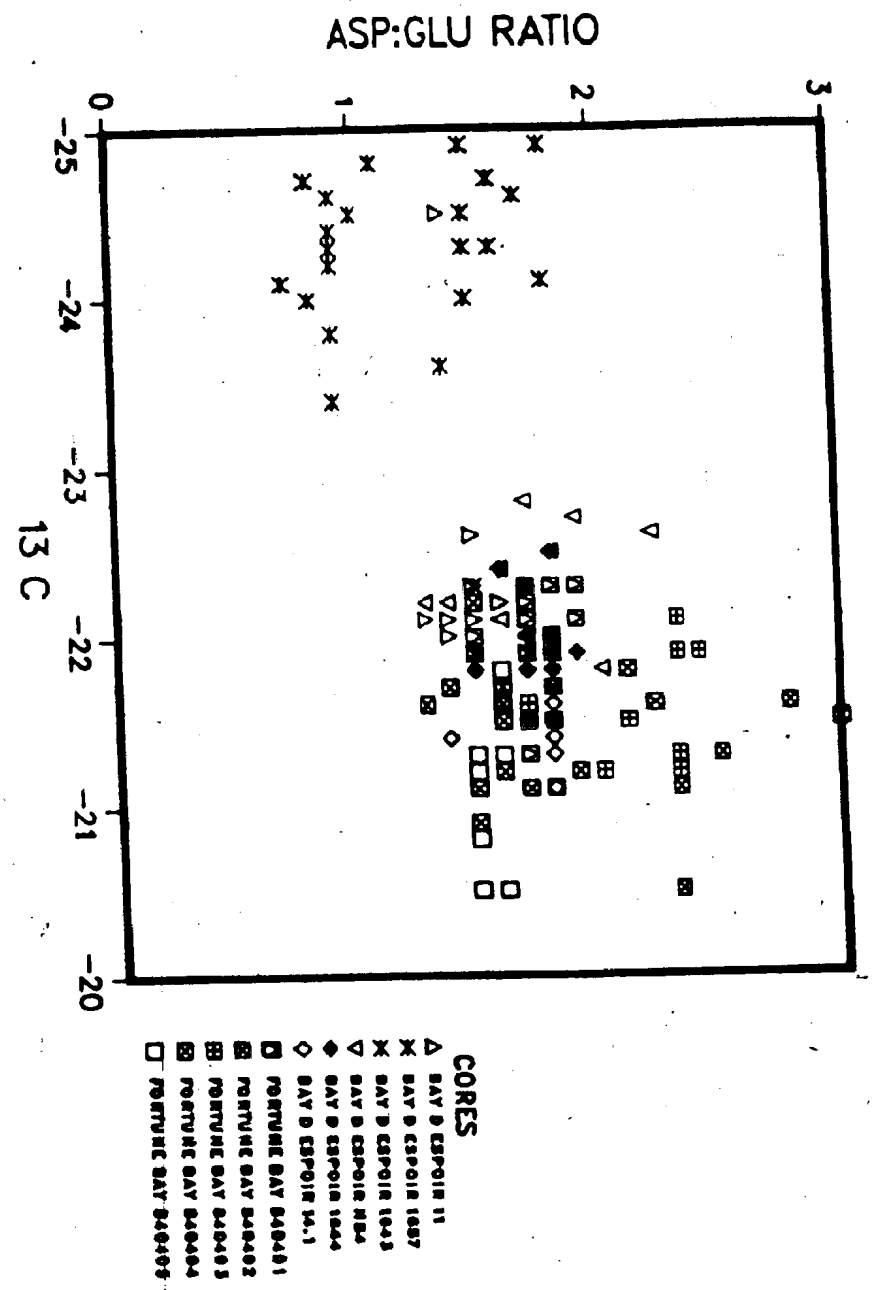

δ 15 N
10
8
6
4
2
−25
−24
−23
−22
−21
−20
δ 13 C
△ BDE-11 20 cm
CORES
△ BAY D ESPOIR 11
✕ BAY D ESPOIR 1687
✕ BAY D ESPOIR 1643
▽ BAY D ESPOIR HB4
◆ BAY D ESPOIR 1644
◇ BAY D ESPOIR 14-1
□ FORTUNE BAY 848401
■ FORTUNE BAY 848402
⊞ FORTUNE BAY 848403
■ FORTUNE BAY 848404
□ FORTUNE BAY 848405

Figure 4-5: ASP/GLU verses $\delta^{13}C$


ASP:GLU RATIO
0
1
2
3
-25
-24
-23
-22
-21
-20
13 C
CORES
BAY D ESPOIR 11
BAY D ESPOIR 1987
BAY D ESPOIR 1983
BAY D ESPOIR 1984
BAY D ESPOIR 1984
BAY D ESPOIR 14-1
FORTUNE BAY B40401
FORTUNE BAY B40402
FORTUNE BAY B40403
FORTUNE BAY B40404
FORTUNE BAY B40405

Chapter 5
CONCLUSIONS

1. Multiple tracer analyses in this study - stable isotopes of C and N, amino acid abundances, grain size analyses and foraminiferal counts have been useful in tracing the origin of organics and hence the sediment sources. Different glacial histories are also indicated.

2. Organic carbon and total nitrogen contents and amino acid abundances have been related to productivity levels and sediment influxes. Th· carbonate content show large differencs between the two bays with respect to productivity levels and influxes of sedimentary organic matter.

3. Sediments in Bay D'Espoir are more depleted in ^{13}C and have lower ASP/GLU values and levels of organics. These parameters define 'end members' in the study area with respect to sediment source. Bay D'Espoir samples are more towards the terrigenous end than Fortune Bay samples.

4. Correlations exist between the carbonate content, organic carbon and total nitrogen contents and total amino acid abundances. These correlations are very similar to those between $\delta^{13}C$ and $\delta^{15}N$, and $\delta^{13}C$ and ASP/GLU.

5. Foraminiferal assemblages characterize the water masses and also indicate that temperature differences exist between Bay D'Espoir and Fortune Bay.

6. The changes in sedimentation patterns that accompany climatic fluctuations can be traced by the levels of organics in the sediment, grain size, foraminiferal assemblage and amino acid abundance and amino acid signature. The $\delta^{18}O$ composition of the carbonate of foraminiferal tests can also be useful as a paleosalinity indicator, providing there is no mixing of sediments within the sedimentary column.

7. The D_{ALE}/L_{LE} values indicate higher sedimentation rates in Fortune Bay than Bay D'espoir.

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APPENDICES

Appendix 1: Grain size, carbonate content, foraminiferal counts and isotopic composition and D_{AILE}/L_{ILE} of Fortune Bay cores.

Isotopic analyses were carried out on the species *Globobulimina auriculata*.

A = Percent *Brazilina pseudopunctata* of the total foraminiferal population.
B = Percent *Globobulimina auriculata* of the total foraminiferal population.

CORE	CODE
7	FO-840401
8	FO-840402
9	FO-840403
10	FO-840404
11	FO-840405

CORE	DEPTH	% SAND	% CARBONATE	FORAMINIFERAL COUNT A	FORAMINIFERAL COUNT B
7	0	3.9	27.5		
7	20	1.5			
7	40	1.4	22.5		
7	70	1.0			
7	90	2.0	32.0		
8	0	2.7	24.6	0.00	46.9
8	20	1.1		0.00	37.2
8	40	1.5	20.5	0.00	42.9
8	60	1.4		0.00	58.2
8	80	1.4	16.7	0.00	13.4
9	0	6.5	25.4		
9	20	6.5			
9	40	8.9	19.1		
9	60	9.6			
9	90	11.3	17.0		
10	0	33.2	23.1	0.00	14.8
10	15	16.1			
10	20	10.7			
10	30	12.4	11.2	0.00	21.5
10	35	2.6			
10	40	2.0	11.6	0.00	<1.0
10	50	1.8			
10	70	2.3		0.00	0.0
10	100	3.5		0.00	0.0
10	120	1.6	13.5		
11	0	48.4	15.0	0.00	3.0
11	20	41.5		0.00	6.1
11	35	36.3			
11	40	23.9	9.3	0.00	4.5
11	45	11.9			
11	50	9.0	9.2	0.00	<1.0
11	60	10.2			
11	80	6.8		0.00	0.0
11	100	3.3	8.9	0.00	0.0

	DEPTH	$\delta^{18}O$	$\delta^{13}C$
8	00	-0.8	2.3
8	40	-0.5	1.5
8	80	0.2	1.8
10	0	0.0	4.0
10	30	-0.7	3.2
10	60	-1.1	3.2
10	120	-1.6	2.2
11	0	-0.7	2.7
11	20	-0.3	1.5
11	40	-0.3	2.0
11	50	-0.9	3.2
11	100	-0.6	3.4

CORE	DEPTH	D/L
8	80	0.09
11	50	0.16

Appendix 2: Amino acid composition of Fortune Bay cores.

FO-840401 AMINO ACID CONCENTRATION - μM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	19.1	10.2	10.6	11.1	28.2	10.8	7.1	0.7	4.7	5.4	1.0	3.6	3.1	8.1	3.4	126.9
5	16.9	8.9	9.0	9.3	24.4	9.2	6.0	0.3	5.6	5.7	1.6	3.2	3.1	7.1	3.1	113.5
10	17.5	9.7	9.3	9.9	26.2	9.9	6.1	3.7	6.1	6.8	1.8	3.7	3.7	7.9	3.5	125.6
20	14.7	7.6	7.7	8.7	21.9	8.0	5.2	0.3	3.7	4.0	1.4	2.5	2.4	7.0	2.5	97.5
30	13.1	6.8	6.8	7.7	19.5	7.6	4.8	0.9	2.9	4.5	1.4	3.1	3.8	10.0	5.2	98.1
40	14.0	6.3	7.5	8.1	20.5	7.9	5.3	0.8	3.4	4.5	3.4	2.7	2.6	3.6	5.0	95.5
50	16.1	6.4	7.5	8.7	21.0	9.0	5.7	1.1	3.5	5.8	4.4	3.0	2.9	7.9	4.7	107.5
60	15.5	6.9	7.4	8.6	20.9	8.9	5.6	0.7	3.1	4.4	2.0	3.2	2.0	7.3	4.5	101.3
70	15.9	7.2	7.6	9.2	22.1	9.3	5.9	1.0	3.5	4.8	4.1	3.3	3.0	7.4	4.1	108.4
80	18.5	7.1	7.9	9.6	22.7	9.8	6.2	0.9	3.6	5.4	4.7	3.5	3.3	7.9	3.9	115.0
90	13.2	6.0	5.9	7.2	18.1	13.5	4.4	0.9	3.0	5.0	4.0	2.2	2.5	0.8	1.1	88.0

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
0	15.1	8.0	8.4	8.7	22.2	8.5	5.6	0.6	3.7	4.3	0.8	2.8	2.4	6.4	2.7
5	14.9	7.8	7.9	8.2	21.5	8.1	5.3	0.3	4.9	5.0	1.4	2.8	2.7	6.3	2.7
10	13.9	7.7	7.4	7.9	20.9	7.9	4.9	2.9	4.9	5.4	1.4	2.9	2.9	6.3	2.8
20	15.1	7.8	7.9	8.9	22.5	8.2	5.3	0.3	3.8	4.1	1.4	2.6	2.5	7.2	2.6
30	13.4	6.9	6.9	7.8	19.9	7.7	4.9	0.9	3.0	4.6	1.4	3.2	3.9	10.2	5.3
40	14.7	6.6	7.9	8.5	21.5	8.3	5.5	0.8	3.6	4.7	3.6	2.8	2.7	3.8	5.2
50	15.0	6.0	7.0	8.1	19.5	8.4	5.3	1.0	3.3	5.4	4.1	2.8	2.7	7.3	4.4
60	15.3	6.8	7.3	8.5	20.6	8.8	5.5	0.7	3.1	4.3	2.0	3.2	2.0	7.2	4.4
70	14.7	6.6	7.0	8.5	20.4	8.6	5.4	0.9	3.2	4.4	3.8	3.0	2.8	6.8	3.8
80	16.1	6.2	6.9	8.3	19.7	8.5	5.4	0.8	3.1	4.7	4.1	3.0	2.9	6.9	3.4
90	15.0	6.8	6.7	8.2	20.6	15.3	5.0	1.0	3.4	5.7	4.5	2.5	2.8	0.9	1.3

FO-840402 AMINO ACID CONCENTRATION - μM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	17.2	6.2	9.5	7.7	23.9	8.8	4.9	1.1	4.9	4.8	1.5	2.6	4.6	6.4	4.6	108.8
5	18.8	5.7	8.1	6.6	21.2	7.0	4.6	0.4	4.7	4.4	1.5	2.4	3.1	6.1	2.9	97.5
10	18.2	8.1	8.5	7.9	26.5	10.5	5.7	2.6	5.7	5.9	2.2	3.0	2.9	6.3	4.1	118.0
20	14.8	6.8	7.5	6.5	21.4	8.4	4.3	2.0	4.4	4.6	1.5	2.1	2.2	4.5	3.5	94.6
30	14.6	7.7	7.2	5.8	20.3	7.8	4.5	0.5	3.2	3.6	1.3	2.1	1.9	4.4	4.2	89.1
40	8.2	4.1	4.5	4.6	13.8	4.4	3.0	0.5	2.8	2.4	0.7	1.5	1.5	3.4	1.7	57.2
50	8.7	3.8	4.2	4.2	12.9	4.2	3.0	0.3	2.2	2.3	0.8	0.6	1.4	3.1	1.6	52.9
60	7.7	3.6	4.2	4.3	12.8	4.4	2.8	1.0	3.2	2.8	0.7	1.5	1.6	3.5	1.6	55.8
70	12.2	5.9	6.8	7.4	21.1	7.1	4.5	2.0	3.9	4.7	0.7	2.5	2.4	5.5	2.5	89.1
80	11.3	5.3	6.0	6.5	18.2	7.0	4.3	1.5	4.1	4.4	1.3	2.1	2.3	5.5	2.5	82.1

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
0	15.8	5.7	8.7	7.1	22.0	8.1	4.5	1.0	4.5	4.4	1.4	2.4	4.2	5.9	4.2
5	19.3	5.8	8.3	6.8	21.7	7.2	4.7	0.4	4.8	4.5	1.5	2.5	3.2	6.3	3.0
10	15.4	6.9	7.2	6.7	22.5	8.9	4.8	2.2	4.8	5.0	1.9	2.5	2.5	5.3	3.5
20	15.6	7.2	7.9	6.9	22.6	8.9	4.5	2.1	4.7	4.9	1.6	2.2	2.3	4.8	3.7
30	16.4	8.6	8.1	6.5	22.8	8.8	5.1	0.6	3.6	4.0	1.5	2.4	2.1	4.9	4.7
40	14.3	7.2	7.9	8.0	24.1	7.7	5.2	0.9	4.9	4.2	1.2	2.6	2.6	5.9	3.0
50	16.4	7.2	7.9	7.9	24.4	7.9	5.7	0.6	4.2	4.3	1.5	1.1	2.6	5.9	3.0
60	13.8	6.5	7.5	7.7	22.9	7.9	5.0	1.8	5.7	5.0	1.3	2.7	2.9	6.3	2.9
70	13.7	6.6	7.6	8.3	23.7	8.0	5.1	2.2	4.4	5.3	0.8	2.8	2.7	6.2	2.8
80	13.8	6.5	7.3	7.9	22.2	8.5	5.2	1.8	5.0	5.4	1.6	2.6	2.8	6.7	3.0

FO-840403 AMINO ACID CONCENTRATION - μM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	14.2	7.4	7.0	8.3	19.4	8.4	5.1	0.8	3.1	4.5	2.0	2.3	1.8	0.7	8.0	93.4
5	12.9	5.8	7.2	7.2	18.3	7.6	4.4	0.7	2.6	3.8	1.2	2.1	1.8	2.1	5.5	83.5
10	11.9	5.0	5.7	5.9	15.0	6.4	3.9	0.6	2.0	2.9	1.2	2.1	1.8	2.1	5.5	67.0
20	16.0	4.1	6.8	6.9	23.9	3.6	3.9	1.0	3.2	3.5	1.3	2.0	1.4	0.3	4.7	82.5
30	15.8	4.9	6.5	6.7	22.5	3.6	4.0	0.7	3.2	3.4	1.4	2.0	1.4	0.3	4.7	80.6
40	13.7	3.5	5.5	6.0	15.2	6.4	3.6	0.8	2.7	2.9	1.0	1.8	1.2	0.4	4.1	68.6
50	14.1	3.6	5.7	6.1	19.1	3.2	3.6	1.1	3.2	3.2	1.1	1.7	1.2	0.4	4.8	72.1
60	11.1	3.3	5.3	5.3	15.4	8.0	3.4	0.9	2.7	2.9	0.9	1.7	1.1	0.3	5.6	68.1
70	16.3	4.1	6.2	7.2	23.2	4.1	4.2	1.4	3.5	4.2	1.5	2.1	1.4	0.3	8.9	88.7
80	9.9	3.9	5.1	5.9	14.8	6.6	3.6	1.2	2.6	3.6	1.1	1.7	1.2	0.2	5.3	66.7
90	15.4	3.1	5.7	6.8	22.4	4.0	4.0	1.4	3.1	4.0	1.6	2.1	1.7	0.2	8.3	83.8

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
0	15.2	7.9	7.5	8.9	20.8	9.0	5.5	0.9	3.3	4.8	2.1	2.5	1.9	0.7	8.6
5	15.4	6.9	8.6	8.6	21.9	9.1	5.3	0.8	3.1	4.6	1.4	2.5	2.2	2.5	6.6
10	17.8	7.5	8.5	8.8	22.4	9.6	5.8	0.9	3.0	4.3	1.8	3.1	2.7	3.1	8.2
20	19.4	5.0	8.2	8.4	29.0	4.4	4.7	1.2	3.9	4.2	1.6	2.4	1.7	0.4	5.7
30	19.6	6.1	8.1	8.3	27.9	4.5	5.0	0.9	4.0	4.2	1.7	2.5	1.7	0.4	5.8
40	20.0	5.1	8.0	8.7	22.2	9.3	5.2	1.2	3.9	4.2	1.5	2.6	1.7	0.6	6.0
50	19.6	5.0	7.9	8.5	26.5	4.4	5.0	1.5	4.4	4.4	1.5	2.4	1.7	0.6	6.7
60	16.3	4.8	7.8	7.8	22.6	11.7	5.0	1.3	4.0	4.3	1.3	2.5	1.6	0.4	8.2
70	18.4	4.6	7.0	8.1	26.2	4.6	4.7	1.6	3.9	4.7	1.7	2.4	1.6	0.3	10.0
80	14.8	5.8	7.6	8.8	22.2	9.9	5.4	1.8	3.9	5.4	1.6	2.5	1.8	0.3	7.9
90	18.4	3.7	6.8	8.1	26.7	4.8	4.8	1.7	3.7	4.8	1.9	2.5	2.0	0.2	9.9

PO-840404 AMINO ACID CONCENTRATION - μM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	10.4	5.3	5.2	6.0	15.6	5.0	4.0	0.6	2.1	2.6	1.7	1.9	1.6	4.0	2.4	68.4
5	10.2	5.4	5.3	5.9	15.9	5.2	4.3	0.4	2.8	3.4	2.2	2.0	2.6	3.5	2.0	71.0
10	10.0	3.5	3.8	5.6	14.8	5.4	3.6	0.5	2.4	3.1	2.6	2.4	2.0	3.6	2.8	57.1
20	10.3	5.2	4.8	7.2	18.3	6.1	4.4	0.8	2.8	3.9	2.8	3.0	2.7	4.8	4.2	81.3
30	2.5	1.3	1.2	2.0	6.6	2.2	1.3	0.3	1.0	1.6	0.5	1.0	0.9	1.3	1.5	25.1
40	0.6	0.2	0.2	0.2	4.7	1.8	0.5	0.2	1.4	1.4	0.4	0.7	0.5	1.2	0.7	14.9
50	1.1	0.5	0.4	0.7	2.1	0.7	0.5	0.0	0.4	0.5	0.1	0.3	0.2	0.6	0.6	8.9
60	1.9	0.8	0.5	1.0	2.8	1.0	0.9	0.1	0.5	0.6	0.1	0.4	0.4	0.7	0.3	11.8
70	1.6	0.6	0.6	1.1	2.6	1.0	0.7	0.1	0.4	0.6	0.2	0.3	0.3	0.7	1.0	12.0
80	2.4	1.1	1.0	1.6	4.0	1.5	1.1	0.4	0.9	1.4	0.4	0.7	0.6	1.2	1.5	19.6
90	1.6	0.7	0.7	1.1	2.5	1.0	0.7	0.2	0.6	0.6	0.1	0.3	0.1	0.7	0.4	11.3
100	1.2	0.5	0.4	0.8	2.4	0.9	0.6	0.1	0.6	0.6	0.5	0.4	0.4	0.9	0.3	10.7
110	1.6	0.7	0.6	1.0	2.4	0.9	0.6	0.2	0.6	0.6	0.1	0.3	0.3	0.7	0.6	11.2
120	0.9	0.5	0.4	0.6	1.6	0.6	0.3	0.0	0.2	0.4	0.1	0.3	0.3	0.4	0.4	7.2

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
0	15.2	7.7	7.6	8.8	22.8	7.3	5.8	0.9	3.1	3.8	2.5	2.8	2.3	5.8	3.5
5	14.4	7.6	7.5	8.3	22.4	7.3	6.1	0.6	3.9	4.8	3.1	2.8	3.7	4.9	2.8
10	17.5	6.1	6.7	9.8	25.9	9.5	6.3	0.9	4.2	5.4	4.6	4.2	3.5	6.3	4.9
20	12.7	6.4	5.9	8.9	22.5	7.5	5.4	1.0	3.4	4.8	3.4	3.7	3.3	5.9	5.2
30	10.0	5.2	4.8	8.0	26.3	8.8	5.2	1.2	4.0	6.4	2.0	4.0	3.6	5.2	6.0
40	4.0	1.3	1.3	1.3	31.5	12.1	3.4	1.3	9.4	9.4	2.7	4.7	3.4	8.1	4.7
50	12.4	5.6	4.5	7.9	23.6	7.9	5.6	0.0	4.5	5.6	1.1	3.4	2.2	6.7	6.7
60	16.1	6.8	4.2	8.5	23.7	8.5	7.6	0.8	4.2	5.1	0.8	3.4	3.4	5.9	2.5
70	13.3	5.0	5.0	9.2	21.7	8.3	5.8	0.8	3.3	5.0	1.7	2.5	2.5	5.8	8.3
80	12.2	5.6	5.1	8.2	20.4	7.7	5.6	2.0	4.6	7.1	2.0	3.6	3.1	6.1	7.7
90	14.2	6.2	6.2	9.7	22.1	8.8	6.2	1.8	5.3	5.3	0.9	2.7	0.9	6.2	3.5
100	11.2	4.7	3.7	7.5	22.4	8.4	5.6	0.9	5.6	5.6	4.7	3.7	3.7	8.4	2.8
110	14.3	6.3	5.4	8.9	21.4	8.0	5.4	1.8	5.4	5.4	0.9	2.7	2.7	6.3	5.4
120	12.5	6.9	5.6	8.3	22.2	8.3	4.2	0.0	2.8	5.6	1.4	4.2	4.2	5.6	5.6

FO-840405 AMINO ACID CONCENTRATION - μM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	5.6	1.6	1.4	3.7	9.5	4.2	2.3	0.2	1.0	1.5	0.5	0.9	1.1	0.7	2.4	36.6
5	5.7	1.7	2.1	3.7	9.5	4.2	2.3	0.3	1.3	1.5	0.5	1.0	1.1	0.7	2.7	38.2
10	4.7	1.4	1.7	3.1	8.6	3.6	2.0	0.2	1.2	1.3	0.7	1.3	1.0	0.5	0.8	32.1
20	2.9	0.8	0.8	1.9	5.2	2.2	1.3	0.2	0.8	0.9	0.4	0.9	0.8	0.4	0.6	20.0
30	2.6	0.7	0.6	1.6	3.9	1.7	1.2	0.2	0.6	0.8	0.3	0.5	0.3	0.1	0.3	15.4
40	2.9	0.8	0.6	1.8	4.7	2.0	1.3	0.1	0.7	0.8	0.5	0.7	0.6	0.1	0.4	17.8
50	2.5	0.6	0.4	1.4	3.5	1.6	1.2	0.1	0.6	0.6	0.2	0.8	0.4	0.0	0.2	14.0
60	1.8	0.5	0.3	1.1	2.6	1.3	0.9	0.1	0.5	0.5	0.2	0.3	0.4	0.0	0.3	10.8
70	1.2	0.3	0.2	0.7	2.2	1.1	0.8	0.0	0.4	0.4	0.2	0.5	0.3	0.1	0.2	8.8
80	1.7	0.4	0.2	1.1	2.6	1.2	0.9	0.1	0.5	0.5	0.2	0.5	0.3	0.0	0.2	10.5
90	1.7	0.4	0.1	1.1	2.6	1.3	0.9	0.1	0.4	0.5	0.2	0.5	0.3	0.0	0.2	10.3
100	1.3	0.3	0.1	0.8	1.9	1.0	0.7	0.1	0.3	0.5	0.1	0.2	0.6	0.0	0.2	8.2

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
0	15.3	4.4	3.8	10.1	26.0	11.5	6.3	0.5	2.7	4.1	1.4	2.5	3.0	1.9	6.6
5	14.9	4.5	5.5	9.7	24.9	11.0	6.0	0.8	3.4	3.9	1.3	2.6	2.9	1.8	7.1
10	14.6	4.4	5.3	9.7	26.8	11.2	6.2	0.6	3.7	4.0	2.2	4.0	3.1	1.6	2.5
20	14.5	4.0	4.0	9.5	26.0	11.0	6.5	1.0	4.0	4.5	2.0	4.5	4.0	2.0	3.0
30	16.9	4.5	3.9	10.4	25.3	11.0	7.8	1.3	3.9	5.2	1.9	3.2	1.9	0.6	1.9
40	16.3	4.5	3.4	10.1	26.4	11.2	7.3	0.6	3.9	4.5	2.8	3.9	3.4	0.6	2.2
50	17.9	4.3	2.9	10.0	25.0	11.4	8.6	0.7	4.3	4.3	1.4	5.7	2.9	0.0	1.4
60	16.7	4.6	2.8	10.2	24.1	12.0	8.3	0.9	4.6	4.6	1.9	2.8	3.7	0.0	2.8
70	13.6	3.4	2.3	8.0	25.0	12.5	9.1	0.0	4.5	4.5	2.3	5.7	3.4	1.1	2.3
80	16.2	3.8	1.9	10.5	24.8	11.4	8.6	1.0	4.8	4.8	1.9	4.8	2.9	0.0	1.9
90	16.5	3.9	1.0	10.7	25.2	12.6	8.7	1.0	3.9	4.9	1.9	4.9	2.9	0.0	1.9
100	15.9	3.7	1.2	9.8	23.2	12.2	8.5	1.2	3.7	6.1	1.2	2.4	7.3	0.0	2.4

Appendix 3: Amino acid fractions of Fortune Bay cores.

FO-840401 AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	30.2	20.8	14.6	4.6	56.9	126.9
5	26.2	17.9	13.3	4.8	51.2	113.5
10	27.4	19.0	15.1	5.5	58.8	125.6
20	23.4	15.3	11.9	3.9	43.1	97.5
30	20.8	13.6	19.0	4.5	40.2	98.1
40	22.1	13.8	11.2	6.1	42.4	95.5
50	24.8	13.9	15.5	7.4	46.1	107.5
60	24.1	14.3	13.8	5.2	43.6	101.3
70	25.1	14.8	14.5	7.4	46.6	108.4
80	28.1	15.0	15.1	8.2	48.6	115.0
90	20.4	11.9	4.4	6.2	44.9	88.0

FO-840401 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	23.8	16.4	11.5	3.6	44.8
5	23.1	15.8	11.7	4.2	45.1
10	21.8	15.1	12.0	4.4	46.8
20	24.0	15.7	12.2	4.0	44.2
30	21.2	13.9	19.4	4.6	41.0
40	23.1	14.5	11.7	6.4	44.4
50	23.1	12.9	14.4	6.9	42.9
60	23.8	14.1	13.6	5.1	43.0
70	23.2	13.7	13.4	6.8	43.0
80	24.4	13.0	13.1	7.1	42.3
90	23.2	13.5	5.0	7.0	51.0

FO-840402 AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	24.9	15.7	15.6	4.1	48.4	108.8
5	25.4	13.8	12.1	3.9	42.3	97.5
10	26.1	16.6	13.3	5.2	56.9	118.0
20	21.3	14.3	10.2	3.6	45.1	94.6
30	20.4	14.9	10.5	3.4	39.9	89.1
40	12.8	8.6	6.6	2.2	26.9	57.2
50	12.9	8.0	6.1	1.4	24.9	52.9
60	12.0	7.8	6.7	2.2	27.0	55.8
70	19.6	12.7	10.4	3.2	43.3	89.1
80	17.8	11.3	10.3	3.4	39.5	82.1

FO-840402 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	22.9	14.4	14.3	3.8	44.5
5	26.1	14.2	12.4	4.0	43.4
10	22.1	14.1	11.3	4.4	48.2
20	22.5	15.1	10.8	3.8	47.7
30	22.9	16.7	11.8	3.8	44.8
40	22.4	15.0	11.5	3.8	47.0
50	24.4	15.1	11.5	2.6	47.1
60	21.5	14.0	12.0	3.9	48.4
70	22.0	14.3	11.7	3.6	48.6
80	21.7	13.8	12.5	4.1	48.1

FO-840403 AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	22.5	14.4	10.5	4.3	41.3	93.4
5	20.1	13.0	9.4	3.3	37.4	83.5
10	17.8	10.7	9.4	3.3	30.8	67.0
20	22.9	10.9	6.4	3.3	39.1	82.5
30	22.5	11.4	6.4	3.4	37.4	80.6
40	19.7	9.0	5.7	2.8	31.6	68.6
50	20.2	9.3	6.4	2.8	33.4	72.1
60	16.4	8.6	7.0	2.6	33.3	68.1
70	23.5	10.3	10.6	3.6	40.6	88.7
80	15.8	9.0	6.7	2.8	32.4	66.7
90	22.2	8.8	10.2	3.7	38.9	83.8

FO-840403 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	24.1	15.4	11.2	4.6	44.2
5	24.1	15.6	11.3	4.0	44.8
10	26.6	16.0	14.0	4.9	46.0
20	27.8	13.2	7.8	4.0	47.4
30	27.9	14.1	7.9	4.2	46.4
40	28.7	13.1	8.3	4.1	46.1
50	28.0	12.9	8.9	3.9	46.3
60	24.1	12.6	10.3	3.8	48.9
70	26.5	11.6	12.0	4.1	45.8
80	23.7	13.5	10.0	4.2	48.6
90	26.5	10.5	12.2	4.4	46.4

FO-840404: AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	16.4	10.5	8.0	3.6	29.9	68.4
5	16.1	10.7	8.1	4.2	32.0	71.0
10	15.6	7.3	8.4	5.0	29.8	57.1
20	17.5	10.0	11.7	5.8	36.3	81.3
30	4.5	2.5	3.7	1.5	13.0	25.1
40	0.8	0.4	2.4	1.1	10.0	14.9
50	1.8	0.9	1.4	0.4	4.2	8.9
60	2.9	1.3	1.4	0.5	5.9	11.8
70	2.7	1.2	2.0	0.5	5.4	12.0
80	4.0	2.1	3.3	1.1	9.3	19.6
90	2.7	1.4	1.2	0.4	5.6	11.3
100	2.0	0.9	1.6	0.9	5.2	10.7
110	2.6	1.3	1.6	0.4	5.3	11.2
120	1.5	0.9	1.1	0.4	3.1	7.2

FO-840404 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	24.0	15.4	11.7	5.3	43.7
5	22.7	15.1	11.4	5.9	45.1
10	27.3	12.8	14.7	8.8	52.2
20	21.5	12.3	14.4	7.1	44.6
30	17.9	10.0	14.7	6.0	51.8
40	5.4	2.7	16.1	7.4	67.1
50	20.2	10.1	15.7	4.5	47.2
60	24.6	11.0	11.9	4.2	50.0
70	22.5	10.0	16.7	4.2	45.0
80	20.4	10.7	16.8	5.6	47.4
90	23.9	12.4	10.6	3.5	49.6
100	18.7	8.4	15.0	8.4	48.6
110	23.2	11.6	14.3	3.6	47.3
120	20.8	12.5	15.3	5.6	43.1

FO-840405 AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	9.3	3.0	4.2	1.4	18.7	36.6
5	9.4	3.8	4.5	1.5	19.1	38.2
10	7.8	3.1	2.3	2.0	16.9	32.1
20	4.8	1.6	1.8	1.3	10.6	20.0
30	4.2	1.3	0.7	0.8	8.4	15.4
40	4.7	1.4	1.1	1.2	9.6	17.8
50	3.9	1.0	0.6	1.0	7.6	14.0
60	2.9	0.8	0.7	0.5	5.9	10.8
70	1.9	0.5	0.6	0.7	4.9	8.8
80	2.8	0.6	0.5	0.7	5.8	10.5
90	2.8	0.5	0.5	0.7	5.8	10.3
100	2.1	0.4	0.8	0.3	4.5	8.2

FO-840405 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	25.4	8.2	11.5	3.8	51.1
5	24.6	9.9	11.8	3.9	50.0
10	24.3	9.7	7.2	6.2	52.6
20	24.0	8.0	9.0	6.5	53.0
30	27.3	8.4	4.5	5.2	54.5
40	26.4	7.9	6.2	6.7	53.9
50	27.9	7.1	4.3	7.1	54.3
60	26.9	7.4	6.5	4.6	54.6
70	21.6	5.7	6.8	8.0	55.7
80	26.7	5.7	4.8	6.7	55.2
90	27.2	4.9	4.9	6.8	56.3
100	25.6	4.9	9.8	3.7	54.9

Appendix 4: Grain size, carbonate content, foraminiferal counts and isotopic composition and D_{AILE}/L_{ILE} of Bay D'Espoir cores.

Isotopic analyses were carried out on the species *Globobulimina auriculata*.

A = Percent *Brazilina pseudopunctata* of the total foraminiferal population.
B = Percent *Globobulimina auriculata* of the total foraminiferal population.

CORE CODE
1 BDE-11
2 BDE-1657
3 BDE-1643
4 BDE-MB4
5 BDE-1644
6 BDE-14.1

CORE	DEPTH	% SAND	% CARBONATE	FORAMINIFERAL COUNT A	FORAMINIFERAL COUNT B
1	0	11.8	17.3	0.0	0.0
1	20	14.0	—	0.0	0.0
1	50	20.4	14.4	0.0	0.0
1	70	27.8		0.0	0.0
1	100	11.4	7.2	0.0	0.0
2	0	31.9	11.0	0.0	0.0
2	20	1.4		0.0	0.0
2	40	1.3	10.2	0.0	0.0
2	56	1.5		0.0	0.0
2	70	0.7	10.1	0.0	0.0
3	0	27.2	10.0	0.0	0.0
3	30	0.3		0.0	0.0
3	50	0.4	9.0	0.0	0.0
3	70	0.2		0.0	0.0
3	100	0.4	9.6	0.0	0.0
4	0	2.7	28.0		
4	30	3.5			
4	60	3.7	21.3		
4	100	2.7			
4	130	2.5	22.3		
5	0	23.1	12.0	15.7	22.0
5	20	12.5		15.2	24.4
5	50	9.5	11.1	30.0	22.6
5	70	16.3		56.1	10.9
5	100	7.0	16.0	68.9	11.8
6	0	1.2	17.5	56.2	1.5
6	20	1.4		66.0	6.5
6	40	1.4	17.8	89.1	2.3
6	50	1.4		62.1	7.2
6	70	1.6	19.1	80.0	11.3

CORE	DEPTH	D/L
5	100	0.04
6	20	0.08
6	30	0.11
6	50	0.13
6	70	0.14

Appendix 5: Amino acid composition of Bay D'Espoir cores.

BDE-11 AMINO ACID CONCENTRATION - µM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	13.6	4.1	3.2	9.1	21.2	10.5	5.9	0.5	2.8	3.9	1.0	2.3	2.4	1.3	1.3	83.0
10	11.9	3.8	2.9	8.4	17.0	7.0	4.7	0.6	2.6	3.4	0.9	2.5	1.7	0.7	3.5	71.4
20	3.2	1.0	0.7	2.3	5.1	1.8	1.3	0.2	0.7	1.0	0.3	0.7	0.6	1.0	0.8	20.8
30	11.3	2.0	1.4	6.7	14.5	5.7	3.9	0.5	2.0	2.6	0.8	1.8	2.2	0.6	3.0	59.0
40	10.3	3.1	2.4	6.9	16.1	8.0	4.5	0.4	2.1	2.9	0.8	1.7	1.9	0.3	0.8	62.2
50	8.0	3.2	2.1	5.8	8.5	6.7	4.7	4.1	2.2	3.9	0.8	2.2	1.8	1.0	3.2	58.2
60	8.8	4.1	2.7	6.8	9.2	8.4	6.1	4.8	2.7	3.6	1.0	2.6	1.4	0.7	3.7	66.5
70	8.8	2.7	1.7	5.8	12.4	6.0	3.7	0.4	1.9	2.6	0.9	2.0	1.2	4.0	2.1	56.2
80	7.9	2.4	1.5	5.2	11.2	5.4	3.3	0.4	1.7	2.3	0.8	1.8	1.1	3.6	1.9	50.4
90	2.8	0.8	0.4	1.7	3.3	2.2	1.1	0.1	0.5	0.7	0.5	0.5	0.3	0.7	0.6	15.8
100	3.7	1.2	1.0	2.4	6.1	3.2	1.9	0.2	0.9	1.2	0.4	0.6	1.0	0.1	0.8	24.7

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
0	16.4	4.9	3.9	11.0	25.5	12.7	7.1	0.6	3.4	4.7	1.2	2.8	2.9	1.6	1.6
10	16.7	5.3	4.1	11.8	23.8	9.8	6.6	0.8	3.6	4.8	1.3	3.5	2.4	1.0	4.9
20	15.4	4.8	3.4	11.1	24.5	8.7	6.3	1.0	3.4	4.8	1.4	3.4	2.9	4.8	3.8
30	19.2	3.4	2.4	11.4	24.6	9.7	6.6	0.8	3.4	4.4	1.4	3.1	3.7	1.0	5.1
40	16.6	5.0	3.9	11.1	25.9	12.9	7.2	0.6	3.4	4.7	1.3	2.7	3.1	0.5	1.3
50	13.7	5.5	3.6	10.0	14.6	11.5	8.1	7.0	3.8	6.7	1.4	3.8	3.1	1.7	5.5
60	13.2	6.2	4.1	10.2	13.8	12.6	9.2	7.2	4.1	5.4	1.5	3.9	2.1	1.1	5.6
70	15.7	4.8	3.0	10.3	22.1	10.7	6.6	0.7	3.4	4.6	1.6	3.6	2.1	7.1	3.7
80	15.7	4.8	3.0	10.3	22.2	10.7	6.5	0.8	3.4	4.6	1.6	3.6	2.2	7.1	3.8
90	17.7	5.1	2.5	10.8	20.9	13.9	7.0	0.6	3.2	4.4	3.2	3.2	1.9	4.4	3.8
100	15.0	4.9	4.0	9.7	24.7	13.0	7.7	0.8	3.6	4.9	1.6	2.4	4.0	0.4	3.2

BDE-1657 AMINO ACID CONCENTRATION - μM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	2.3	0.7	0.5	1.5	3.9	1.8	1.0	0.1	0.6	0.7	0.1	0.3	0.4	0.4	0.9	15.3
10	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	1.2
19	0.1	0.1	0.0	0.1	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1	1.1
20	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
23	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.7
30	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.1
40	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.0
50	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.6
56	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
60	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
00	15.1	4.7	3.6	9.9	25.7	11.7	6.7	0.5	3.6	4.8	0.7	2.2	2.8	2.3	5.8
10	11.4	4.6	4.7	7.6	18.1	11.0	6.8	0.8	3.8	5.4	1.8	2.6	4.5	10.8	6.1
19	12.5	5.1	4.5	13.7	15.1	10.8	7.1	0.7	3.6	5.0	2.3	3.5	6.3	3.7	6.2
20	12.4	5.0	5.4	6.9	18.2	12.0	7.4	0.0	4.1	6.3	2.6	4.3	7.4	2.8	5.2
23	9.6	4.7	3.3	6.4	13.8	14.8	5.1	0.0	4.0	3.9	3.4	6.8	11.1	6.2	6.8
30	10.9	4.9	7.4	13.5	13.8	10.9	7.9	0.0	3.1	4.3	2.2	4.1	6.9	4.3	5.9
40	8.7	6.1	13.1	11.7	16.1	11.2	7.3	0.0	2.7	3.7	1.8	2.4	7.1	4.2	3.9
50	10.0	4.9	8.6	10.5	14.6	10.2	4.7	0.0	3.1	4.6	1.0	1.5	11.3	6.2	8.7
56	13.7	6.2	4.8	15.7	14.6	11.8	6.4	0.0	3.5	5.3	2.0	3.1	4.7	3.4	4.9
60	10.4	5.2	7.5	6.3	16.6	10.0	10.7	1.1	3.4	4.6	2.2	3.3	3.6	5.4	9.5
70	7.4	3.0	5.5	7.2	14.3	10.5	1.3	0.0	3.0	5.2	5.5	8.2	14.6	2.3	11.9

BDE-1643 AMINO ACID CONCENTRATION - μM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	2.8	0.9	0.8	1.7	4.1	2.0	1.2	0.2	0.6	0.9	0.2	0.5	0.3	0.3	0.9	17.4
10	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
20	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
30	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
40	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
44	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
50	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.9
60	0.1	0.1	0.0	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9
62	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
70	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
80	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
88	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
90	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.5
100	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.5

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
00	16.1	5.1	4.6	10.0	23.5	11.7	6.7	0.9	3.6	5.3	0.9	2.7	1.9	1.6	5.4
10	18.8	3.7	3.4	12.2	15.7	11.7	1.2	0.0	5.3	7.8	0.8	0.6	7.1	4.3	7.4
20	14.4	4.8	3.5	8.1	18.7	16.5	6.7	0.0	3.6	4.0	1.0	1.8	6.9	3.6	6.5
30	12.0	3.8	2.8	7.5	12.4	13.2	9.5	12.1	4.8	5.1	1.5	1.3	5.2	2.5	6.4
40	13.2	5.0	4.3	14.0	14.0	10.7	6.8	0.5	3.6	4.8	2.2	4.6	5.6	4.2	6.5
44	12.2	4.6	4.2	15.4	16.0	10.1	0.0	8.8	3.3	4.2	1.6	2.2	5.5	4.9	7.2
50	9.0	3.6	2.0	8.2	12.0	13.0	11.2	0.0	4.1	7.8	4.1	7.5	5.7	6.6	5.3
60	15.1	6.3	2.4	5.4	20.6	10.1	6.9	0.6	5.3	4.4	1.2	3.4	5.4	2.1	8.6
62	13.9	5.0	4.3	9.6	19.4	11.7	7.1	1.0	4.2	5.8	2.3	3.6	4.6	2.7	4.8
70	17.2	6.1	4.7	10.3	20.1	6.3	8.9	0.0	3.5	5.8	2.0	3.4	3.2	4.2	4.3
80	18.2	6.7	5.4	11.9	5.3	3.3	9.8	1.2	4.8	6.7	2.4	4.5	7.9	5.9	6.0
88	11.8	4.8	4.3	8.2	22.9	13.3	7.0	0.0	3.7	5.0	2.0	3.4	5.6	2.9	5.1
90	9.9	2.5	2.2	11.2	12.5	7.4	18.5	0.0	3.5	4.0	0.3	0.5	11.1	11.1	5.3
100	14.8	4.5	4.0	16.8	10.5	6.2	8.1	0.0	3.0	3.9	0.4	0.5	11.1	11.3	4.8

BDE-NB4 AMINO ACID CONCENTRATION - μM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	11.1	4.0	3.6	6.7	18.7	9.7	5.0	0.5	2.7	3.8	0.7	1.6	1.1	0.5	3.3	73.0
10	10.0	3.1	2.1	5.2	13.7	5.6	3.7	0.5	2.0	2.5	0.8	1.8	1.0	0.6	3.8	56.2
20	10.3	3.2	2.0	5.8	12.7	9.6	4.8	0.6	1.0	1.2	1.0	2.1	1.3	0.6	5.6	61.8
30	10.2	3.2	2.0	5.7	12.5	9.5	4.7	0.6	1.0	1.2	1.0	2.1	1.3	0.6	5.5	61.2
40	9.7	3.4	2.6	5.6	16.2	6.7	5.3	0.8	2.4	3.2	1.1	2.1	1.3	0.6	4.7	65.7
45	8.6	2.9	2.2	5.0	14.1	6.0	4.1	0.5	2.2	2.9	0.7	2.0	0.9	0.5	3.6	56.2
50	6.9	2.3	1.8	3.9	10.4	4.7	3.0	0.6	1.6	2.1	0.6	1.2	0.8	0.2	2.3	42.4
60	8.1	2.8	2.5	5.0	14.8	7.1	3.7	0.4	2.0	2.7	0.5	1.2	1.1	0.5	2.4	54.8
70	7.3	2.4	1.9	4.1	10.9	4.9	3.2	0.6	1.7	2.2	0.6	1.3	0.8	0.2	2.4	44.5
80	11.2	4.6	2.9	8.4	10.1	4.9	6.2	0.7	3.1	3.9	0.4	1.0	0.6	0.2	1.7	59.9
90	10.1	4.1	2.7	7.0	11.4	8.6	6.4	0.6	3.0	3.8	1.2	2.5	1.8	0.9	0.1	64.2
100	9.4	2.8	1.8	4.8	10.6	8.4	4.6	0.4	2.0	2.6	0.8	1.8	1.2	0.6	1.4	53.0
110	10.1	3.6	2.2	6.2	8.3	8.4	5.5	0.6	2.8	3.7	1.2	2.5	1.9	0.3	1.4	58.7
120	9.5	3.9	2.5	6.7	11.5	9.2	5.6	0.8	3.0	3.7	1.4	2.7	1.6	0.3	0.9	63.3
130	6.7	1.9	1.2	3.1	8.4	5.0	3.3	0.3	1.4	2.0	0.6	1.2	0.3	0.6	1.4	37.4

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
0	15.2	5.5	4.9	9.2	25.6	13.3	6.8	0.7	3.7	5.2	1.0	2.2	1.5	0.7	4.5
10	17.8	5.5	3.7	9.3	24.4	10.0	6.6	0.9	3.6	4.4	1.4	3.2	1.8	1.1	6.8
20	16.7	5.2	3.2	9.4	20.6	15.5	7.8	1.0	1.6	1.9	1.6	3.4	2.1	1.0	9.1
30	16.7	5.2	3.3	9.3	20.4	15.5	7.7	1.0	1.6	2.0	1.6	3.4	2.1	1.0	9.0
40	14.8	5.2	4.0	8.5	24.7	10.2	8.1	1.2	3.7	4.9	1.7	3.2	2.0	0.9	7.2
45	15.3	5.2	3.9	8.9	25.1	10.7	7.3	0.9	3.9	5.2	1.2	3.6	1.6	0.9	6.4
50	16.3	5.4	4.2	9.2	24.5	11.1	7.1	1.4	3.8	5.0	1.4	2.8	1.9	0.5	5.4
60	14.8	5.1	4.6	9.1	27.0	13.0	6.8	0.7	3.6	4.9	0.9	2.2	2.0	0.9	4.4
70	16.4	5.4	4.3	9.2	24.5	11.0	7.2	1.3	3.8	4.9	1.3	2.9	1.8	0.4	5.4
80	18.7	7.7	4.8	14.0	16.9	8.2	10.4	1.2	5.2	6.5	0.7	1.7	1.0	0.3	2.8
90	15.7	6.4	4.2	10.9	17.8	13.4	10.0	0.9	4.7	5.9	1.9	3.9	2.8	1.4	0.2
100	17.7	5.3	3.4	9.1	20.0	15.8	8.7	0.8	3.8	4.9	1.5	3.4	2.3	1.1	2.6
110	17.2	6.1	3.7	10.6	14.1	14.3	9.4	1.0	4.8	6.3	2.0	4.3	3.2	0.5	2.4
120	15.0	6.2	3.9	10.6	18.2	14.5	8.8	1.3	4.7	5.8	2.2	4.3	2.5	0.5	1.4
130	17.9	5.1	3.2	8.3	22.5	13.4	8.8	0.8	3.7	5.3	1.6	3.2	0.8	1.6	3.7

BDE-1644 AMINO ACID CONCENTRATION - μM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	11.3	3.6	3.3	7.6	20.1	6.8	4.7	0.8	2.7	3.5	1.5	2.2	1.8	0.7	2.9	73.5
10	4.2	1.3	0.9	2.4	6.7	2.2	1.6	0.4	1.0	1.2	0.5	0.7	0.7	0.2	1.6	25.7
20	3.0	0.9	0.6	1.6	4.8	1.8	1.3	0.2	0.7	0.8	0.3	0.6	0.4	0.2	0.7	17.7
30	2.9	0.8	0.5	1.6	4.2	1.4	1.2	0.2	0.7	0.7	0.3	0.5	0.3	0.4	0.8	16.4
40	3.6	1.2	0.8	2.1	5.6	2.4	1.7	0.3	1.0	1.3	0.5	0.7	0.7	0.8	1.5	24.1
50	3.3	0.9	0.6	1.8	4.5	1.6	1.4	0.1	0.7	0.9	0.3	0.6	0.4	0.0	0.9	18.1
60	2.4	0.7	0.4	1.5	3.3	1.2	0.9	0.1	0.6	0.7	0.2	0.5	0.4	0.3	0.9	13.9
70	2.9	0.8	0.4	1.6	2.9	0.7	1.1	0.1	0.6	0.8	0.3	0.5	0.4	1.0	0.9	15.0
80	3.4	0.9	0.4	1.9	3.4	0.8	1.3	0.1	0.7	0.9	0.3	0.6	0.4	1.2	1.0	18.3
90	3.1	0.9	0.5	1.8	4.3	1.7	1.3	0.2	0.7	0.9	0.4	0.6	0.4	0.5	0.8	17.9
100	2.2	0.7	0.5	1.3	3.3	1.5	1.1	0.2	0.8	1.3	0.3	0.5	0.7	0.0	0.3	14.7

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
0	15.4	4.9	4.5	10.3	27.3	9.3	6.4	1.1	3.7	4.8	2.0	3.0	2.4	1.0	3.9
10	16.3	5.1	3.5	9.3	26.1	8.6	6.2	1.6	3.9	4.7	1.9	2.7	2.7	0.8	6.2
20	16.9	5.1	3.4	9.0	27.1	10.2	7.3	1.1	4.0	4.5	1.7	3.4	2.3	1.1	4.0
30	17.7	4.9	3.0	9.8	25.6	8.5	7.3	1.2	4.3	4.3	1.8	3.0	1.8	2.4	4.9
40	14.9	5.0	3.3	8.7	23.2	10.0	7.1	1.2	4.1	5.4	2.1	2.9	2.9	3.3	6.2
50	18.2	5.0	3.3	9.9	24.9	8.8	7.7	0.6	3.9	5.0	1.7	3.3	2.2	0.0	5.0
60	17.3	5.0	2.9	10.8	23.7	8.6	6.5	0.7	4.3	5.0	1.4	3.6	2.9	2.2	6.5
70	19.3	5.3	2.7	10.7	19.3	4.7	7.3	0.7	4.0	5.3	2.0	3.3	2.7	6.7	6.0
80	18.6	4.9	2.2	10.4	18.6	4.4	7.1	0.5	3.8	4.9	1.6	3.3	2.2	6.6	5.5
90	17.3	5.0	2.8	10.1	24.0	9.5	7.3	1.1	3.9	5.0	2.2	3.4	2.2	2.8	4.5
100	15.0	4.8	3.4	8.8	22.4	10.2	7.5	1.4	5.4	8.8	2.0	3.4	4.8	0.0	2.0

BDE-14.1 AMINO ACID CONCENTRATION - µM/g of SEDIMENT

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG	SUM
0	8.7	2.8	2.4	5.3	13.8	4.0	3.7	0.5	2.0	2.6	0.9	1.5	1.3	0.8	0.9	51.4
10	10.7	3.5	2.8	6.1	16.0	6.4	4.3	0.6	2.3	2.9	1.2	2.0	1.5	0.2	0.4	61.0
20	10.0	3.1	2.3	5.7	14.8	6.1	4.0	0.6	2.3	2.8	1.2	1.9	1.6	0.2	0.5	57.0
23	8.1	2.6	2.0	4.6	12.2	4.6	3.2	0.5	1.9	2.3	0.9	1.5	1.1	0.2	0.4	46.0
30	8.0	2.8	2.9	5.7	17.7	5.2	3.4	0.7	2.2	2.9	1.3	1.9	3.1	0.3	0.5	58.6
40	7.8	2.3	1.7	4.4	12.2	4.3	3.3	0.7	1.9	2.3	0.9	1.5	1.1	0.1	0.4	45.1
49	6.8	2.1	1.5	3.8	10.5	4.1	3.0	0.6	1.6	2.0	0.8	1.3	0.9	0.1	0.4	39.5
60	6.9	1.9	1.3	4.0	10.9	4.1	3.1	0.5	1.7	2.1	0.9	1.4	1.1	0.1	0.4	40.3
68	7.2	2.2	1.5	4.1	11.3	4.3	3.0	0.4	1.7	2.1	0.9	1.3	1.1	0.1	0.6	41.8
70	7.4	2.3	1.5	4.2	11.6	4.4	3.1	0.4	1.8	2.2	0.9	1.3	1.1	0.1	0.6	42.2

PERCENT INDIVIDUAL AMINO ACID

DEPTH	ASP	THR	SER	GLU	GLY	ALA	VAL	MET	ILEU	LEU	TYR	PHE	HIS	LYS	ARG
0	16.9	5.4	4.7	10.3	26.8	7.8	7.2	1.0	3.9	5.1	1.8	2.9	2.5	1.6	1.8
10	17.5	5.7	4.6	10.0	26.2	10.5	7.0	1.0	3.8	4.8	2.0	3.3	2.5	0.3	0.7
20	17.5	5.4	4.0	10.0	26.0	10.7	7.0	1.1	4.0	4.9	2.1	3.3	2.8	0.4	0.9
23	17.6	5.7	4.3	10.0	26.5	10.0	7.0	1.1	4.1	5.0	2.0	3.3	2.4	0.4	0.9
30	13.7	4.8	4.9	9.7	30.2	8.9	5.8	1.2	3.8	4.9	2.2	3.2	5.3	0.5	0.9
40	17.3	5.1	3.8	9.8	27.1	9.5	7.3	1.6	4.2	5.1	2.0	3.3	2.4	0.2	0.9
49	17.2	5.3	3.8	9.6	26.6	10.4	7.6	1.5	4.1	5.1	2.0	3.3	2.3	0.3	1.0
60	17.1	4.7	3.2	9.9	27.0	10.2	7.7	1.2	4.2	5.2	2.2	3.5	2.7	0.2	1.0
68	17.2	5.3	3.6	9.8	27.0	10.3	7.2	1.0	4.1	5.0	2.2	3.1	2.6	0.2	1.4
70	17.5	5.5	3.6	10.0	27.5	10.4	7.3	0.9	4.3	5.2	2.1	3.1	2.6	0.2	1.4

Appendix 6: Amino acid fractions of Bay D'Espoir cores.

BDE-11 AMINO.ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	22.7	7.3	5.0	3.3	44.8	83.0
10	20.3	6.7	5.9	3.4	35.3	71.4
20	5.5	1.7	2.4	1.0	10.1	20.8
30	18.0	3.4	5.8	2.6	29.2	59.0
40	17.2	5.5	3.0	2.5	34.0	62.2
50	13.8	5.3	6.0	3.0	30.1	58.2
60	15.6	6.8	5.8	3.6	34.8	66.5
70	14.6	4.4	7.3	2.9	27.0	56.2
80	13.1	3.9	6.6	2.6	24.3	50.4
90	4.5	1.2	1.6	1.0	7.9	15.8
100	6.1	2.2	1.9	1.0	13.5	24.7

BDE-11 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	27.3	8.8	6.0	4.0	54.0
10	28.4	9.4	8.3	4.8	49.4
20	26.4	8.2	11.5	4.8	48.6
30	30.5	5.8	9.8	4.4	49.5
40	27.7	8.8	4.8	4.0	54.7
50	23.7	9.1	10.3	5.2	51.7
60	23.5	10.2	8.7	5.4	52.3
70	26.0	7.8	13.0	5.2	48.0
80	26.0	7.7	13.1	5.2	48.2
90	28.5	7.6	10.1	6.3	50.0
100	24.7	8.9	7.7	4.0	54.7

BDE-1657 AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	3.8	1.2	1.7	0.4	8.1	15.3
10	0.2	0.2	0.3	0.0	0.5	1.2
19	0.2	0.1	0.2	0.0	0.5	1.1
20	0.1	0.0	0.0	0.0	0.2	0.6
23	0.1	0.0	0.1	0.0	0.2	0.7
30	0.2	0.2	0.1	0.0	0.4	1.1
40	0.2	0.2	0.1	0.0	0.4	1.0
50	0.2	0.0	0.1	0.0	0.2	0.6
56	0.2	0.1	0.0	0.0	0.3	0.9
60	0.0	0.0	0.0	0.0	0.1	0.4
70	0.0	0.0	0.1	0.0	0.0	0.3

BDE-1657 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	25.0	8.3	10.9	2.9	53.0
10	19.0	9.3	21.4	4.4	45.9
19	26.2	9.6	16.2	5.8	42.3
20	19.3	10.4	15.4	6.9	48.0
23	16.0	8.0	24.1	10.2	41.6
30	24.4	12.3	17.1	6.3	40.0
40	20.4	19.2	15.2	4.2	41.0
50	20.5	13.5	26.2	2.5	37.2
56	29.4	11.0	13.0	5.1	41.6
60	16.7	12.7	18.5	5.5	46.4
70	14.6	8.5	28.8	13.7	34.3

BDE-1643 AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	4.5	1.7	1.5	0.7	9.0	17.4
10	0.1	0.0	0.0	0.0	0.0	0.3
20	0.1	0.0	0.0	0.0	0.2	0.5
30	0.1	0.0	0.0	0.0	0.2	0.4
40	0.2	0.0	0.0	0.0	0.1	0.4
44	0.2	0.0	0.0	0.0	0.1	0.4
50	0.2	0.0	0.1	0.1	0.4	0.9
60	0.2	0.1	0.1	0.0	0.3	0.9
62	0.2	0.0	0.0	0.0	0.3	0.8
70	0.2	0.0	0.0	0.0	0.2	0.7
80	0.2	0.0	0.0	0.0	0.0	0.5
88	0.1	0.0	0.0	0.0	0.2	0.5
90	0.2	0.0	0.2	0.0	0.2	0.5
100	0.2	0.0	0.2	0.0	0.0	0.5

BDE-1643 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	26.1	9.7	8.9	3.6	51.7
10	31.0	7.1	18.8	1.4	41.7
20	22.5	8.3	17.0	2.8	49.5
30	19.5	6.6	14.1	2.8	57.1
40	27.2	9.3	16.3	6.8	40.4
44	27.6	8.8	17.6	3.8	42.4
50	17.2	5.6	17.6	11.6	48.1
60	20.5	8.7	16.1	4.6	47.9
62	23.5	9.3	12.1	5.9	49.2
70	27.5	10.8	11.7	5.4	44.6
80	30.1	12.1	19.8	6.9	31.1
88	20.0	9.1	13.6	5.4	51.9
90	21.1	4.7	27.5	0.8	45.9
100	31.6	8.5	27.2	0.9	31.7

BDE-NB4 AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	17.8	7.6	4.9	2.3	40.4	73.0
10	15.2	5.2	5.4	2.6	28.0	56.2
20	16.1	5.2	7.5	3.1	29.9	61.8
30	15.9	5.2	7.4	3.1	29.5	61.2
40	15.3	6.0	6.6	3.2	34.6	65.7
45	13.6	5.1	5.0	2.7	29.8	56.2
50	10.8	4.1	3.3	1.8	22.4	42.4
60	13.1	5.3	4.0	1.7	30.7	54.8
70	11.4	4.3	3.4	1.9	23.5	44.5
80	19.6	7.5	2.5	1.4	28.9	59.9
90	17.1	6.8	2.8	3.7	33.8	64.2
100	14.2	4.6	3.2	2.6	28.6	53.0
110	16.3	5.8	3.6	3.7	29.3	58.7
120	16.2	6.4	2.8	4.1	33.8	63.3
130	9.8	3.1	2.3	1.8	20.4	37.4

BDE-NB4 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	24.4	10.4	6.7	3.2	55.3
10	27.0	9.3	9.6	4.6	49.8
20	26.1	8.4	12.1	5.0	48.4
30	26.0	8.5	12.1	5.1	48.2
40	23.3	9.1	10.0	4.9	52.7
45	24.2	9.1	8.9	4.8	53.0
50	25.5	9.7	7.8	4.2	52.8
60	23.9	9.7	7.3	3.1	56.0
70	25.6	9.7	7.6	4.3	52.8
80	32.7	12.5	4.2	2.3	48.2
90	26.6	10.6	4.4	5.8	52.6
100	26.8	8.7	6.0	4.9	54.0
110	27.8	9.9	6.1	6.3	49.9
120	25.6	10.1	4.4	6.5	53.4
130	26.2	8.3	6.1	4.8	54.5

BDE-1644 AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	18.9	6.9	5.4	3.7	38.6	73.5
10	6.6	2.2	2.5	1.2	13.1	25.7
20	4.6	1.5	1.3	0.9	9.6	17.7
30	4.5	1.3	1.5	0.8	8.4	16.4
40	5.7	2.0	3.0	1.2	12.3	24.1
50	5.1	1.5	1.3	0.9	9.2	18.1
60	3.9	1.1	1.6	0.7	6.8	13.9
70	4.5	1.2	2.3	0.8	6.2	15.0
80	5.3	1.3	2.6	0.9	7.2	18.3
90	4.9	1.4	1.7	1.0	9.1	17.9
100	3.5	1.2	1.0	0.8	8.2	14.7

BDE-1644 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	25.7	9.4	7.3	5.0	52.5
10	25.7	8.6	9.7	4.7	51.0
20	26.0	8.5	7.3	5.1	54.2
30	27.4	7.9	9.1	4.9	51.2
40	23.7	8.3	12.4	5.0	51.0
50	28.2	8.3	7.2	5.0	50.8
60	28.1	7.9	11.5	5.0	48.9
70	30.0	8.0	15.3	5.3	41.3
80	29.0	7.1	14.2	4.9	39.3
90	27.4	7.8	9.5	5.6	50.8
100	23.8	8.2	6.8	5.4	55.8

BDE-14.1 AMINO ACID FRACTION- μM/g of SEDIMENT

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL	TOTAL
0	14.0	5.2	3.0	2.4	26.6	51.4
10	16.8	6.3	2.1	3.2	32.5	61.0
20	15.7	5.4	2.3	3.1	30.6	57.0
23	12.7	4.6	1.7	2.4	24.7	46.0
30	13.7	5.7	3.9	3.2	32.1	58.6
40	12.2	4.0	1.6	2.4	24.7	45.1
49	10.6	3.6	1.4	2.1	21.8	39.5
60	10.9	3.2	1.6	2.3	22.4	40.3
68	11.3	3.7	1.8	2.2	22.8	41.8
70	11.6	3.8	1.8	2.2	23.5	42.2

BDE-14.1 AMINO ACID FRACTION PERCENTAGES

DEPTH	ACIDIC	HYDROXY	BASIC	AROMATIC	NEUTRAL
0	27.2	10.1	5.8	4.7	51.8
10	27.5	10.3	3.4	5.2	53.3
20	27.5	9.5	4.0	5.4	53.7
23	27.6	10.0	3.7	5.2	53.7
30	23.4	9.7	6.7	5.5	54.8
40	27.1	8.9	3.5	5.3	54.8
49	26.8	9.1	3.5	5.3	55.2
60	27.0	7.9	4.0	5.7	55.6
68	27.0	8.9	4.3	5.3	54.5
70	27.5	9.0	4.3	5.2	55.7

Appendix 7: Amino acid ratios.

AMINO ACID RATIOS OF FORTUNE BAY CORES

FO-840401

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.7	1.0	2.6	3.6
5	1.8	1.0	2.7	2.0
10	1.8	1.0	2.6	2.1
20	1.7	1.0	2.7	1.8
30	1.7	1.0	2.6	2.2
40	1.7	0.8	2.6	0.8
50	1.9	0.9	2.3	0.7
60	1.8	0.9	2.3	1.6
70	1.7	0.9	2.4	0.8
80	1.9	0.9	2.3	0.7
90	1.8	1.0	1.3	0.6

FO-840402

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	2.2	0.7	2.7	1.7
5	2.8	0.7	3.0	1.6
10	2.3	1.0	2.5	1.4
20	2.3	0.9	2.5	1.4
30	2.5	1.1	2.6	1.6
40	1.8	0.9	3.1	2.1
50	2.1	0.9	3.1	0.8
60	1.8	0.9	2.9	2.1
70	1.6	0.9	3.0	3.6
80	1.7	0.9	2.6	1.6

FO-840403

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.7	1.1	2.3	1.1
5	1.8	0.8	2.4	1.7
10	2.0	0.9	2.3	1.7
20	2.3	0.6	6.6	1.5
30	2.4	0.8	6.3	1.4
40	2.3	0.6	2.4	1.8
50	2.3	0.6	6.0	1.5
60	2.1	0.6	1.9	1.9
70	2.3	0.7	5.7	1.4
80	1.7	0.8	2.2	1.5
90	2.3	0.5	5.6	1.3

FO-840404

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.7	1.0	3.1	1.1
5	1.7	1.0	3.1	0.9
10	1.8	0.9	2.7	0.9
20	1.4	1.1	3.0	1.1
30	1.3	1.1	3.0	2.0
40	3.0	1.0	2.6	1.8
50	1.6	1.3	3.0	3.0
60	1.9	1.6	2.8	4.0
70	1.5	1.0	2.6	1.5
80	1.5	1.1	2.7	1.8
90	1.5	1.0	2.5	3.0
100	1.5	1.3	2.7	0.8
110	1.6	1.2	2.7	3.0
120	1.5	1.3	2.7	3.0

FO-840405

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.5	1.1	2.3	1.8
5	1.5	0.8	2.3	2.0
10	1.5	0.8	2.4	1.9
20	1.5	1.0	2.4	2.3
30	1.6	1.2	2.3	1.7
40	1.6	1.3	2.3	1.4
50	1.8	1.5	2.2	4.0
60	1.6	1.7	2.0	1.5
70	1.7	1.5	2.0	2.5
80	1.5	2.0	2.2	2.5
90	1.5	4.0	2.0	2.5
100	1.6	3.0	1.9	2.0

AMINO ACID RATIOS OF BAY D'ESPOIR CORES

BDE-11

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.5	1.3	2.0	2.3
10	1.4	1.3	2.4	2.8
20	1.4	1.4	2.8	2.3
30	1.7	1.4	2.5	2.3
40	1.5	1.3	2.0	2.1
50	1.4	1.5	1.3	2.8
60	1.3	1.5	1.1	2.6
70	1.5	1.6	2.1	2.2
80	1.5	1.6	2.1	2.3
90	1.6	2.0	1.5	1.0
100	1.5	1.2	1.9	1.5

BDE-1657

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.5	1.3	2.2	3.1
10	1.5	1.0	1.6	1.4
19	0.9	1.1	1.4	1.5
20	1.8	0.9	1.5	1.7
23	1.5	1.4	0.9	2.0
30	0.8	0.7	1.3	1.9
40	0.7	0.5	1.4	1.3
50	1.0	0.6	1.4	1.5
56	0.9	1.3	1.2	1.5
60	1.7	0.7	1.7	1.5
70	1.0	0.5	1.4	1.5

BDE-1643

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.6	1.1	2.0	3.0
10	1.5	1.1	1.3	0.8
20	1.8	1.4	1.1	1.8
30	1.6	1.4	0.9	0.9
40	0.9	1.2	1.3	2.1
44	0.8	1.1	1.6	1.4
50	1.1	1.8	0.9	1.8
60	2.8	2.6	2.0	2.8
62	1.4	1.2	1.7	1.6
70	1.7	1.3	3.2	1.7
80	1.5	1.2	1.6	1.9
88	1.4	1.1	1.7	1.7
90	0.9	1.1	1.7	1.7
100	0.9	1.1	1.7	1.3

BDE-NB4

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.7	1.1	1.9	2.3
10	1.9	1.5	2.4	2.3
20	1.8	1.6	1.3	2.1
30	1.8	1.6	1.3	2.1
40	1.7	1.3	2.4	1.9
45	1.7	1.3	2.4	2.9
50	1.8	1.3	2.2	2.0
60	1.6	1.1	2.1	2.4
70	1.8	1.3	2.2	2.2
80	1.3	1.6	2.1	2.5
90	1.4	1.5	1.3	2.1
100	2.0	1.6	1.3	2.3
110	1.6	1.6	1.0	2.1
120	1.4	1.6	1.3	1.9
130	2.2	1.6	1.7	2.0

BDE-1644

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.5	1.1	3.0	1.5
10	1.7	1.4	3.0	1.4
20	1.9	1.5	2.7	2.0
30	1.8	1.6	3.0	1.7
40	1.7	1.5	2.3	1.4
50	1.8	1.5	2.8	2.0
60	1.6	1.8	2.7	2.5
70	1.8	2.0	4.1	1.7
80	1.8	2.3	4.3	2.0
90	1.7	1.8	2.5	1.5
100	1.7	1.4	2.2	1.7

BDE-14.1

DEPTH	ASP/GLU	THR/SER	GLY/ALA	PHE/TYR
0	1.6	1.2	3.5	1.7
10	1.8	1.3	2.5	1.7
20	1.8	1.3	2.4	1.6
23	1.8	1.3	2.7	1.7
30	1.4	1.0	3.4	1.5
40	1.8	1.4	2.8	1.7
49	1.8	1.4	2.6	1.6
60	1.7	1.5	2.7	1.6
68	1.8	1.5	2.6	1.4
70	1.8	1.5	2.6	1.4