34. INSOLUBLE RESIDUE DATA AND PRELIMINARY INTERPRETATION — QUATERNARY SEDIMENT: DSDP SITES 403 AND 405

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ABSTRACT

Sites 403 and 405 were cored through the entire Quaternary interval. Plots of the downhole variation in the percentage of total insoluble residue, coarse fraction non-carbonate (greater than 0.062 mm), coarse fraction carbonate, fine fraction non-carbonate, and fine fraction carbonate are tentatively interpreted in terms of climatic cycles. The topmost high-low cycle at Site 405 shows a low uniform coarse fraction non-carbonate input (average 19.5 per cent) followed downhole by a high and variable input (average 35.1 per cent). This low-high input phase may reflect recent glacial events. Other downhole fluctuations are of less magnitude. Site 403 also has low magnitude variations.

INTRODUCTION

Variations in the proportion of insoluble residue in Quaternary age North Atlantic sediments may be related to climatic cycles. Because both DSDP Sites 403 and 405 penetrated the entire Quaternary section and contain a nearly complete record, an unusual opportunity to investigate Pleistocene climatic cycles is available. The purpose of this report is to present the raw insoluble residue data and discuss, in a preliminary manner, its interpretation.

Both sites are in the North Atlantic near the base of Rockall Bank, a sunken continental fragment (Roberts, 1975). Site 403 was cored in water 2301 meters deep southwest of Rockall (Figure 1). Nearly 100 per cent of the 18.65 meters (Cores 1 to 3) was recovered. Lithology is nannofossil ooze, marly foraminifer nannofossil ooze, and calcareous mud. The site is topographically flat.

Site 405 is also southwest of Rockall, but is separated from Site 403 by a topographic spur (Figure 1). Site 405 is close to the steep continental slope of Rockall in water 2974 meters deep. The bottom is gently inclined. Quaternary sediment was recovered in Cores 1 to 6 with Core 6 terminating at the early Pleistocene-late Miocene boundary at a depth of 47.68 meters. Recovery was 31.63 meters (67 per cent). Dominant lithologies are marly foraminifer nannofossil ooze and calcareous mud.

SAMPLE ANALYSIS

Samples were collected on a 5-cm spacing except where the core was badly disturbed or was so uniform that a wider spacing was suitable. A total of 133 samples from Site 403 was analyzed, an average of one every 12 cm (excluding unrecovered intervals). From Site 405 229 samples were analyzed, an average of one sample per 13 cm of recovered core.

The samples were dispersed, mixed in a blender (those from Site 405 were agitated with an ultrasonic probe for 1 minute), and sieved through a 0.062-mm mesh, dried, and weighed. Dilute (10%) hydrochloric acid was added to both coarse and fine fractions, and the insoluble portion recovered and weighed. The resulting data were calculated as percentages and labeled total IR, coarse fraction non-carbonate (CFNC), coarse fraction carbonate (CFC), fine fraction non-carbonate (FFNC), and fine fraction carbonate (FFC).

ERROR

The drilling process disrupts and may homogenize the core sediment. Samples were taken only where the sediment appeared to be reasonably intact. The range of variation of the data obtained is sufficiently large that analytical error, though serious (Seisser and Rogers, 1971; Ruddiman, 1977), did not mask fluctuations.

RESULTS

Plots of the downhole variation in total IR, CFNC, FFNC, CFC, and FFC are presented in Figures 2 and 3. The ages and general lithology of the cores are taken from the Initial Core Descriptions for Leg 48.

Eleven cycles (A to K), each with a high and low non-carbonate input phase, have been labeled on both figures. The choice of 11 cycles and the position of their boundaries are entirely subjective and are meant to facilitate discussion only. In addition several separately interesting peaks are numbered.

Site 405

The three large gaps in this core at 5.6, 6.82, and 3.58 meters (total 16.05 m) undoubtedly include fluctuations, the absence of which prevents accurate matching of Site 405 to Site 403 and to other published data. Fortunately the interval from the sea floor to a depth of 21.15 meters is reasonably well sampled, shows many peaks, and possibly can be matched with previously published curves.

Five cycles are recognizable in the top 21.15 meters (cycles A to E). The low total IR and CFNC values (average 19.5%, SD 2.7%) at the top of cycle A, i.e., down to 1.25 meters below the sea floor, are no doubt due to recent conditions. It is apparent from the data that there has been slight increase in CFNC input in the very recent past, i.e., half peak 1. A similar increase has been documented in many, but not all, North Atlantic cores (Kellogg, 1976; Ruddiman and McIntyre, 1976; Ruddiman, in press). The low input interval

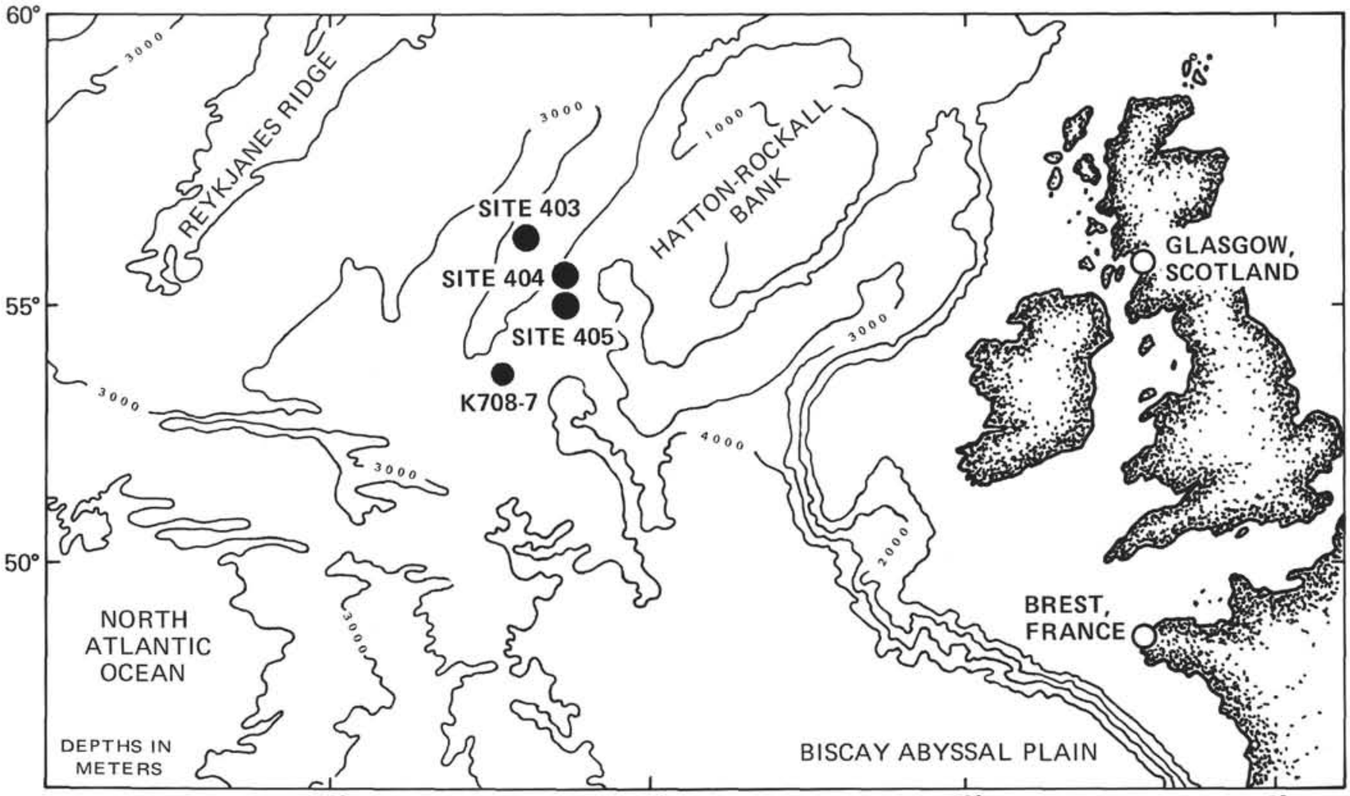

Figure 1. *Location map showing the position of Sites 403 and 405 along with Site K708-7 of Ruddiman and McIntyre (1976).*

is followed downhole by the largest mass of total IR and CFNC recorded here. From 1.25 to 7.0 meters the CFNC averages 35.1 per cent with a standard deviation of 12.4 per cent, i.e., the data are quite variable.

Cycles B and C also appear to be well defined in both the total IR and CFNC curves. Cycle D has three large peaks in the total IR that correspond to three low peaks in the CFNC. These are obviously due to fine fraction non-carbonate fluctuations as is the lower portion of the cycle C high and the low phase of cycle E. The cause of the fluctuating input of non-carbonate fines is uncertain. Cycle E has a low CFNC input interval ending in the first data gap. This gap may have contained the high CFNC input phase of cycle E.

The short interval between the first and second gaps contains 20 data points that clearly define a portion of a cycle. Its isolated location makes correlation impossible.

The interval between the second and third gaps is unusual. It contains 64 analyses that are remarkably constant; CFNC values average 12.3 per cent (range from 5.2 to 19.8%) and total IR values average 61.1 per cent (range from 51.5 to 69.0%). Amplitude of the variations is low and not adequate for curve matching to other sites. This uniformity suggests sample homogenization due to drilling effects and, unless further evidence is derived from future nearby cores, this interval cannot be interpreted.

Data below the third gap are in Core 6. The core catcher of Core 6 contains early Pliocene or late Miocene fossils and the lowermost 50 cm of the core is blue-white nannofossil ooze. Uphole from this is a marly foraminifer nannofossil ooze with four samples that define a possible peak. I place an unconformity between Pleistocene and lower Pliocene-late Miocene at the lithologic change. Further fossil dating is necessary before final positioning of the unconformity.

Site 403

The near absence of samples (only one) in the topmost 1.5 meters and the gap from 3.1 to 4.5 meters make it difficult to match the 11 cycles at Site 403 with those at Site 405; at the moment only a speculative correlation can be made.

Comparison of Sites 403 and 405

The fact that peaks cannot be confidently matched even at these relative close locations is a function of the data gaps, the different sedimentation rates, different topographic conditions, normal core-to-core variability, and drilling effects. Site 405 has a thicker sediment accumulation than Site 403 due to either downslope migration of the unconsolidated ooze at this inclined site or possibly to larger supply of sediment.

Comparison With Published Results

Ruddiman and McIntyre (1976) and Ruddiman (in press) have thoroughly investigated Core K708-7, near Site 405 (Figure 1). They related K708-7 to most of the commonly available paleoclimatic indicators, thus Site 405 interpretation may benefit by being compared to Site K708-7. The comparison should be enhanced because the uniform sedimentation rate of 2.3 cm/1000 years found in K708-7 is closely comparable to the 2.6 cm/1000 years average at Site 405; one would expect the peaks at the two sites to compare rather well. Unfortunately they do not.

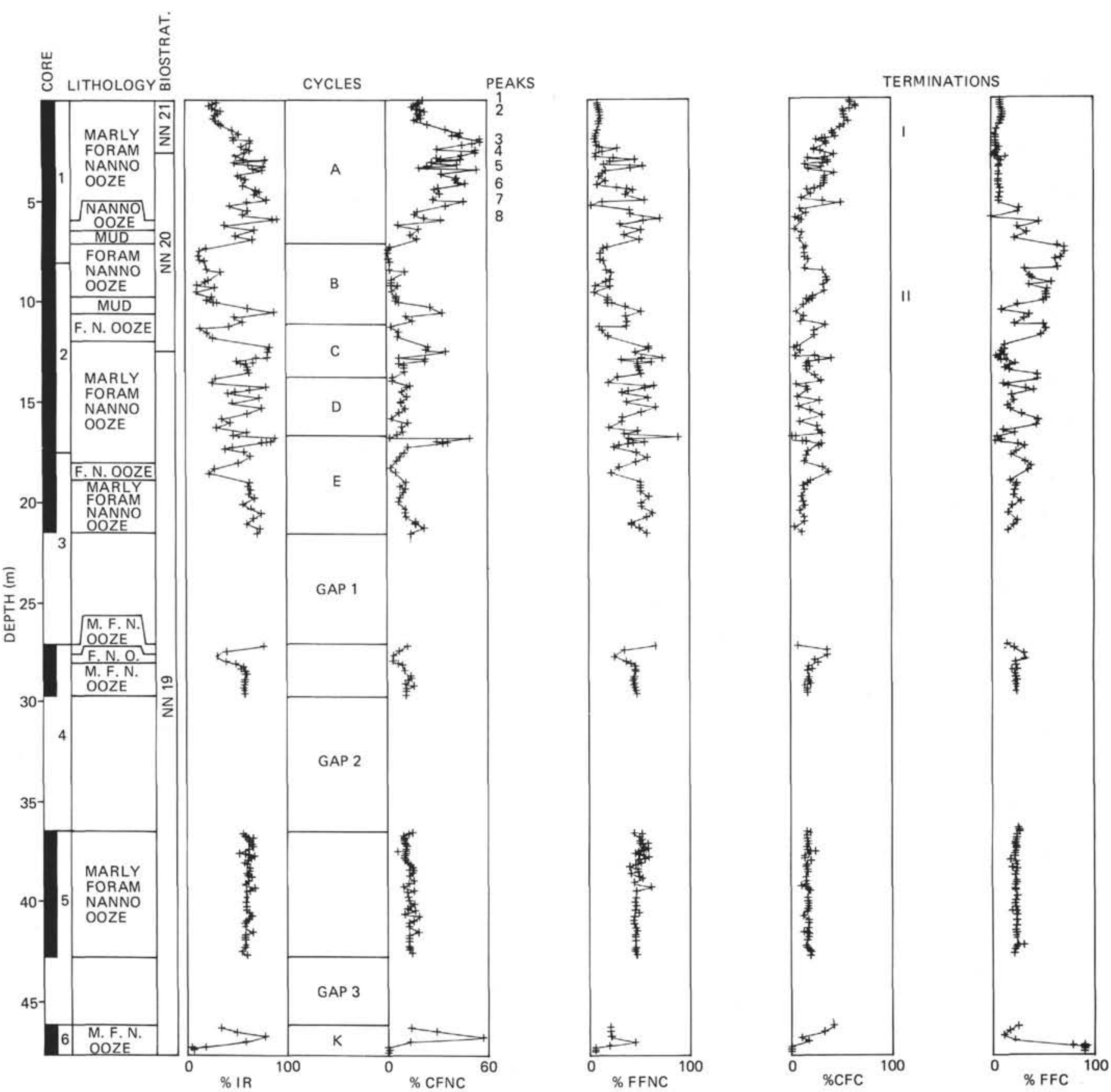

Figure 2. *Plots of per cent total insoluble, coarse fraction non-carbonate (CFNC) fine fraction non-carbonate (FFNC), coarse fraction carbonate (CFC), and fine fraction carbonate (FFC) at Site 405. Cycles, peaks, and gaps are labeled for ease of reference in the text.*

Site 403 is closest to Ruddiman's (in press) K714-3, but the published interval for K714-3 is only 6.5 meters. The considerable variability in K714-3 data makes curve-matching difficult, however, the major influx at the top of cycle A is present at both locations and the range in total CFNC values is approximately the same.

INTERPRETATION

Many authors working in both northern and southern oceans accept the premise that the coarse fraction non-carbonate sediment input in Quaternary sediments is ice-rafted debris. (Bramlette and Bradley, 1942; Keany et al., 1976; Kellogg, 1976; Ruddiman, in press; Ruddiman and Glover, 1972; Ruddiman and McIntyre, 1973; Ruddiman and McIntyre, 1976; Warnke, 1970; Watkins et al., 1970). SEM photos of the sand-size quartz grains revealed surface textures resembling those from known glacial environments (Margolis and Krinsley, 1974). Furthermore some authors believe that the bulk of the fine fraction is also ice rafted (e.g., Ruddiman, in press). X-ray analysis of selected fine fraction samples from both Sites 403 and 405 supports Ruddiman because it reveals subequal quartz, orthoclase, and

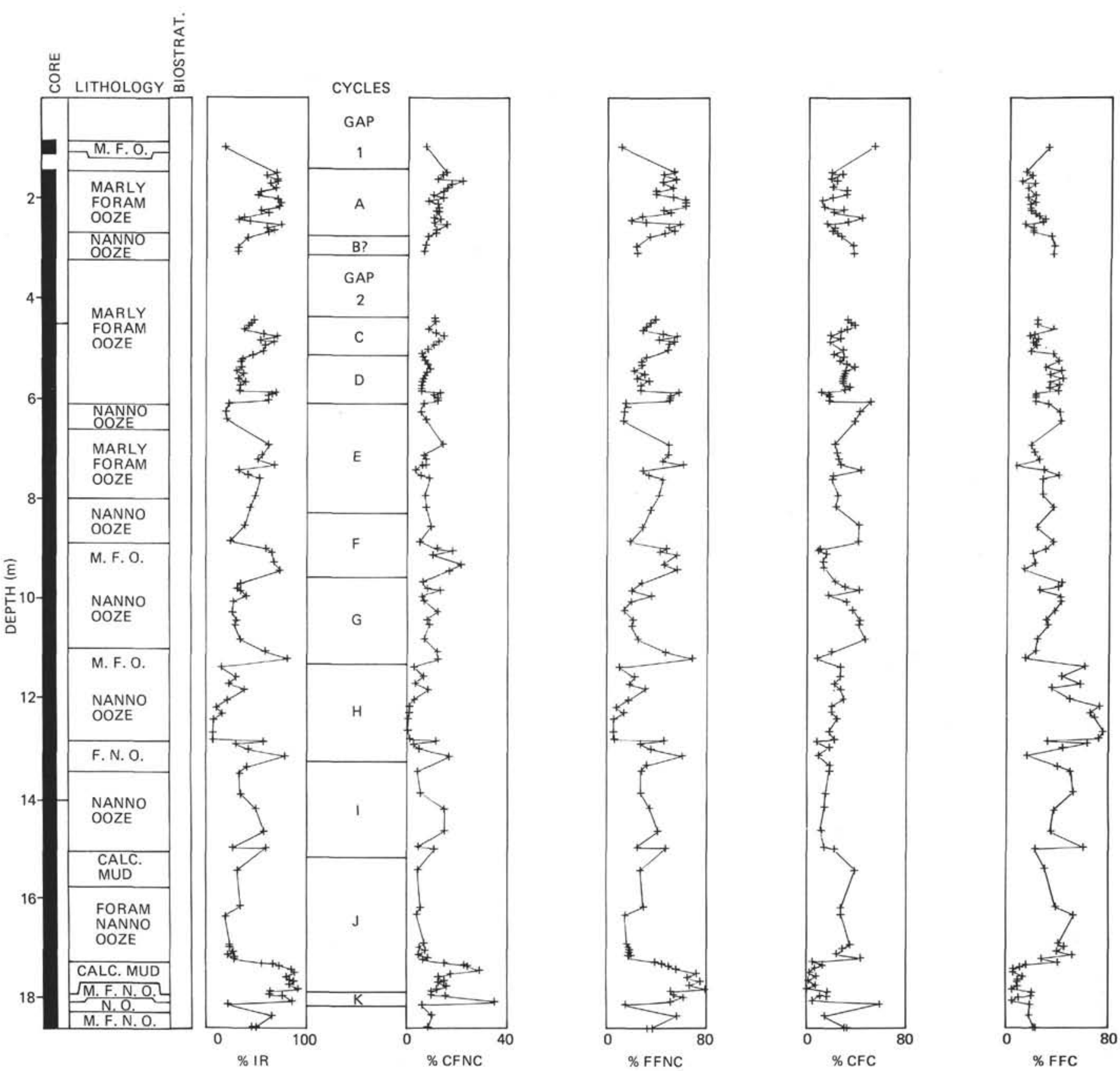

Figure 3. *Plots of per cent total insoluble, coarse fraction non-carbonate (CFNC), fine fraction non-carbonate (FFNC), coarse fraction carbonate (CFC), and fine fraction carbonate (FFC) at Site 403. Cycles, peaks, and gaps are labeled for ease of reference in the text.*

plagioclase with a minor clay component, i.e., the sediment is mineralogically immature. Because the abundance and southern extent of Northern Hemisphere icebergs is controlled by global climatic cycles, it is reasonable to postulate a relationship between variations in the proportion of ice-rafted sediment and glacial cycles. However, many complex secondary controls cloud this simple picture (Ruddiman and McIntyre, 1976; Keany et al., 1976).

Broecker (1971) points out that accurate correlation of insoluble residue data is only possible where absolute input rates are known, not just percentage variation. Absolute input cannot be determined without accurate and abundant time data. At present the only firm time mark in these cores is at the base of the Quaternary (1.8 m.y. B.P.; Berggren, 1972). Nevertheless a tentative interpretation is possible because of the inverse relationship between deposition of terrigenous sediment and biogenous carbonate in the North Atlantic (Ruddiman, 1976). This tends to exaggerate the climatic signal and saves percentage data from meaninglessness. Terminations I and II of Broecker and van Donk (1970) are tentatively indicated on Figure 2. Termination I (11,000 years B.P.) can be identified with fair confidence. If its position is correct then the sedimentation rate in the top interval is about 10 cm/1000 years. The location of termination II (127,000 years B.P.) is speculative. The position indicated gives a sedimentation rate of 7.9 cm/1000 years.

CONCLUSIONS

The availability of two cores that penetrate the whole of the Quaternary (albeit with gaps) permits analysis of the percentage of insoluble residue in the North Atlantic to 1.8 m.y. B.P., almost three times the span of most previously published data.

The proportion of acid-insoluble and acid-soluble coarse and fine fraction components at DSDP Sites 403 and 405 varies downhole. These cycles of high and low input indicate pulsating sediment supply, possibly due to variations in the southern extent of icebergs during the Quaternary period. At Site 405 the uppermost low input phase may correspond to modern interglacial events and the preceding interval of high input may be the result of the most recent glacial age. Below this topmost cycle the amplitude of the major cycles is reasonably uniform suggesting that the climatic variations were of approximately the same magnitude.

Until further age data are available it is impossible to firmly correlate the curves for Sites 403 and 405 with each other or with other published data. Work currently underway may identify the dated ash zones of Ruddiman and Glover (1972) and permit firm correlation.

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