11. QUATERNARY DINOFLAGELLATE CYSTS FROM HOLE 552A, ROCKALL PLATEAU, DEEP SEA DRILLING PROJECT LEG 81[1]

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ABSTRACT

Detailed dinoflagellate cyst analysis of the Quaternary sediments recovered from Hole 552A, on the Rockall Plateau, by hydraulic piston corer (HPC), especially from Cores 1 and 2, has revealed three major "events" in the dinoflagellate record. The oldest "event" separates a younger dinoflagellate-rich unit from the remainder of the older Quaternary sequence, which for the most part either is entirely barren or contains only poor dinoflagellate floras. The second "event" marks the change at the top of the rich dinoflagellate unit to samples above that are again barren of cysts. The rich and diverse dinoflagellate assemblages recovered from the unit delimited by these two "events" are characterized in general by the species *Operculodinium centrocarpum* (Deflandre and Cookson) Wall, but with certain horizons dominated by *Spiniferites* spp. and *Nematosphaeropsis labyrinthea* (Ostenfeld) Reid. This unit is thought to be the dinoflagellate cyst record of an interglacial environment at this latitude. The youngest "event" marks, in samples containing increasingly richer dinoflagellate assemblages, a significant change from a *Bitectatodinium tepikiense* Wilson dominated assemblage to one dominated by *O. centrocarpum*, as the climatic/environmental conditions ameliorated into the Flandrian. It is thought that this youngest "event" in the dinoflagellate record can be correlated from the Goban Spur area (DSDP Leg 80) through Rockall and possibly into the North and Norwegian seas. Unfortunately samples from the Quaternary sediments in the remaining holes (i.e., Holes 553B, 554, and 555) contained such poor floras as to preclude useful discussion.

INTRODUCTION

During 1981 eight holes were drilled at four sites in a transect across the southwestern margin of the Rockall Plateau as part of Leg 81 of the International Phase of Ocean Drilling (IPOD). (See Fig. 1.) The Rockall Plateau lies to the west of the British Isles, approximately midway between the British Isles and the Reykjanes Ridge. The island of Rockall is the only subaerial expression of the plateau and, indeed, only Rockall Bank, Hatton Bank, and the Hatton Rockall Basin are above 1000 m depth. The purpose of Leg 81 was to document the structural evolution of the western margin of the Rockall Plateau and to attempt to elucidate the record of changing climate and the oceanic environments through the Palaeogene, Neogene, and Quaternary.

Hole 552A was drilled into a relatively thin sediment cover and penetrated a 44.0-m Pleistocene section, which was cored with a hydraulic piston corer (HPC). The sediments recovered represent the first virtually complete record of the preglacial and glacial history of the northern hemisphere. Sediments from this hole and particularly from Cores 1 and 2 were analyzed in detail for their dinoflagellate cyst content. This work augments other studies on Quaternary environments of the area and should supplement work completed upon Leg 48 of IPOD (Harland, 1979) and most recently Leg 80 (Harland, in press).

Drilled at 52°0.256′N, 23°13.88′W, in some 2301 m of water, Hole 552A recovered an excellent sediment sequence by use of the HPC. The lithology of the sediment consisted of alternating beds of foraminiferal-nannofossil ooze and calcareous mud. The calcareous oozes usually have a sharp base and then grade upwards into the marl and calcareous mud. This cyclicity was also recognized in Quaternary sediments recovered in Leg 80 (Harland, in press) and reflects climatic fluctuations, with the more terrigenous layers having been deposited during glacial periods. The Plio-Pleistocene sediments are thought to have been deposited with an average rate of sedimentation of some 2.1 cm/1000 yr.

Although the study of Quaternary dinoflagellate cysts is in its infancy, it is apparent that these fossils can be easily recovered from Quaternary marine sequences and used to assist in the environmental interpretation of such sediments (Wall and Dale, 1968; Harland, 1977; Reid and Harland, 1977; Gregory and Harland, 1978; Harland, in press). The potential for using this fossil group to link events in both the oceanic and neritic realms is particularly exciting, and it is only now that the patterns of occurrence are becoming clear enough to enable the correlation of the two types of sequences at times of great environmental change. This work should assist in the interpretation of the differing water mass configurations throughout the North Atlantic area and hence will assist in interpreting the climatic history.

The present study gives data for the Quaternary sequence recovered in Hole 552A, which is dated by nannofossil means as encompassing NN19 to 21. Together with the studies reported upon in Leg 80 (Harland, in press) this sequence should allow some initial thoughts

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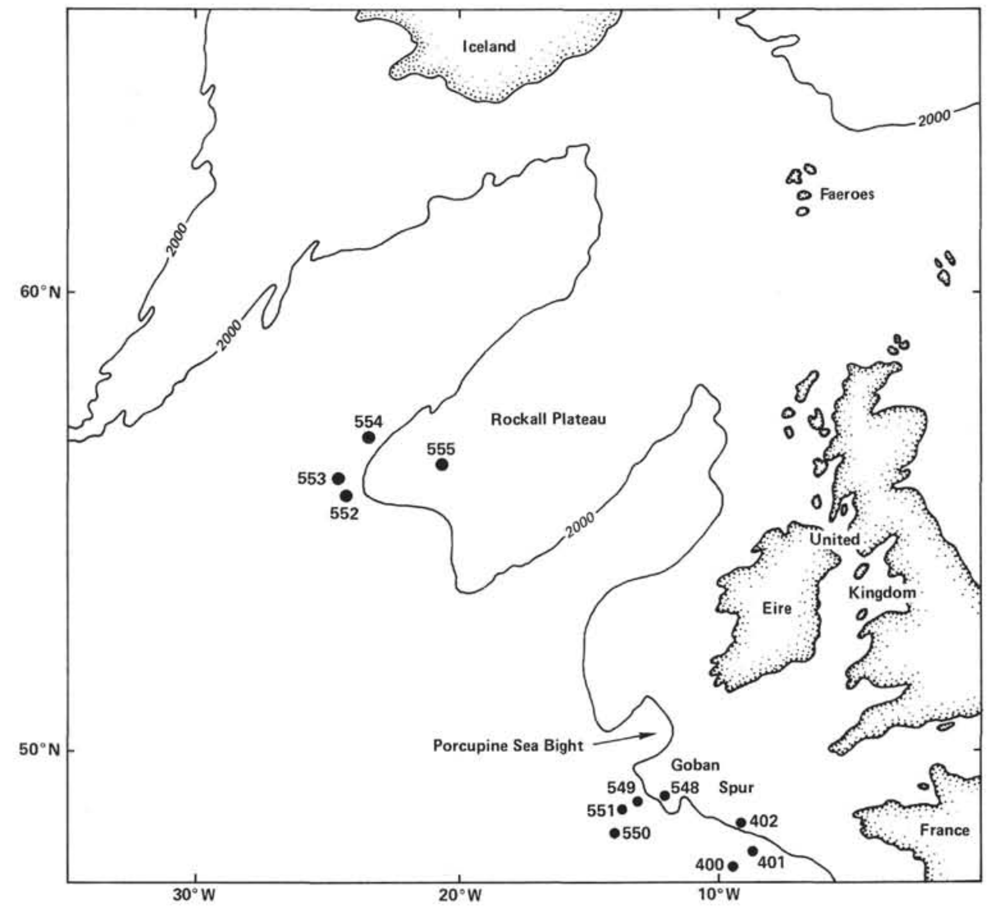

Figure 1. Northeastern part of the North Atlantic showing the Rockall Plateau and the locations of the Leg 81 holes. Also shown are the Goban Spur (Leg 80) and Bay of Biscay (Leg 48) sites.

on dinoflagellate cyst climatostratigraphy to be formulated for the North Atlantic.

MATERIAL AND METHODS

A full list of the samples analyzed from Holes 552A, 553B, 554, and 555 is given in the appendix to this chapter. All the samples were subjected to a standard palynological preparation technique with care being taken not to oxidize the material and thus risk losing certain of the dinoflagellate cyst taxa that appear to be sensitive to this treatment, e.g., peridiniacean cysts (Dale, 1976). After digetion with hydrofluoric acid the samples were handled using the sintered glass funnel technique of Neves and Dale (1963). One slide from each sample was examined and counted until, in the case of rich assemblages, one species, at least, was represented by 120 specimens. The graph of specimens per slide, as given in Fig. 2, is therefore only a guide to dinoflagellate productivity, but it does indicate the number of specimens on which the proportions were calculated, and provides an indication of the richness of the sample. In order, however, to maintain some internal consistency in the results, samples of similar size were used, and subjected to the same palynological technique. There was insufficient time available to complete full quantitative analysis, although such an analysis would have been most beneficial.

It should be pointed out that a minimum count of 120 specimens in rich samples, where never more than a dozen species are present, means that at two standard deviations (2σ) the real proportion will occur between 3% and 9% at either side of the estimated pcertange value depending upon the actual number of specimens counted (Van der Plas and Tobi, 1965). A count of 400 specimens would lower this figure at 2σ to between 2% and 4%. For such a preliminary study the first figures are considered to be accurate enough to give a reasonable idea of the proportions of the cysts present.

Although these proportions are given as a guide to dinoflagellate cyst productivity they are themselves not at all accurate for such a parameter, for a better indication such data as the number of specimens/gram would need to be calculated together with a more accurate measure of sedimentation rates and the amount of bioturbation. However, as a rough rule of thumb they may serve some useful purpose.

RESULTS

The samples analyzed and reported upon here for Hole 552A contained either rich dinoflagellate assemblages or were virtually barren. The variations in productivity are shown (Fig. 2) together with the results of the analyses, which portray the proportions of the various species, or species groups recovered, as well as the numbers of specimens on which the proportions were calculated. The data for all the samples are held in the Palaeontology Unit, Institute of Geological Sciences (IGS), Leeds. The results given here, however, appertain to Hole 552A only.

Unlike the results for Holes 548 and 549A (Leg 80—Goban Spur, Harland, in press) all the samples did not contain well-preserved rich dinoflagellate cyst assemblages. Indeed for the most part the samples from Hole 552A proved to be barren or virtually barren of dinoflagellate cysts, indicating poor environmental/climatic conditions. Two periods of good dinoflagellate recovery were recognized, however, and these are described later

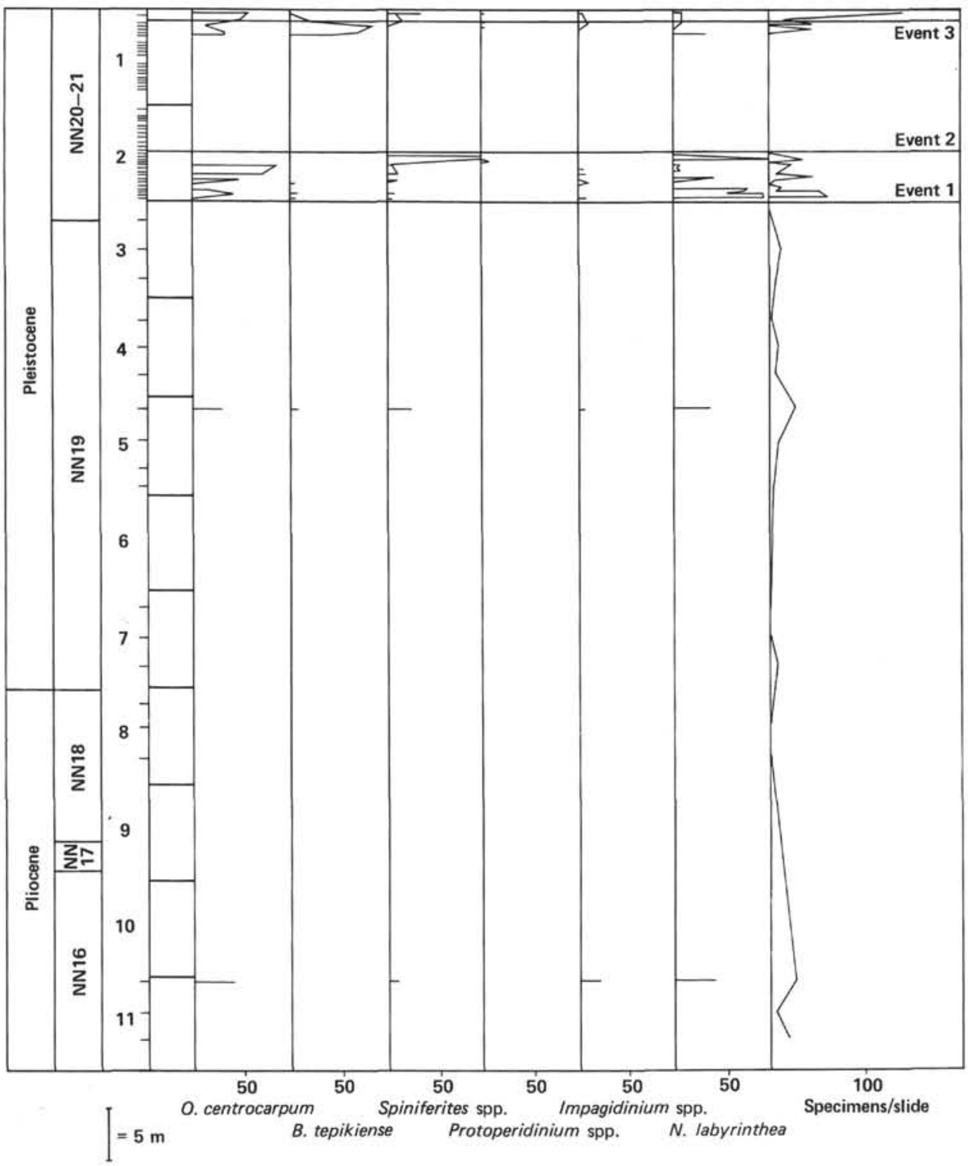

Figure 2. Dinoflagellate cyst biostratigraphy of the Plio/Pleistocene of Hole 552A showing the proportions of the various cyst species or groups and the number of specimens recorded per slide. Numbers 1 to 11 indicate the cores sampled, with ticks indicating sample positions.

in terms of the "events" that circumscribe them. An "event" in this chapter is taken to mean an identifiable horizon at which there is a significant change in the assemblages of dinoflagellate cysts, i.e., either in species composition or in productivity.

The first uphole "event" occurs at Core 2, Section 4, where samples that had been virtually barren of dinoflagellate cysts suddenly give way to samples rich in cysts. The assemblages recovered from samples above this event are variously dominated by *Operculodinium centrocarpum* (Deflandre and Cookson) Wall and *Nematosphaeropsis labyrinthea* (Ostenfeld) Reid and are indicative of North Atlantic conditions somewhat similar to those of today. Samples encompassing the uppermost portion of this productive unit in the sequence are a little different in being dominated by *Spiniferites* spp., including *Spiniferites mirabilis* (Rossignol). Productivity, indicated by the number of specimens per slide, is quite variable, demonstrating that this productive unit is probably quite complex in itself. An "event" at Core 2, Section 2 marks the return of samples virtually barren, and in most cases completely barren, of dinoflagellate cysts and an interpreted return to adverse environmental/climatic conditions. This first uphole ameliorative episode may be dated, using the nannofossil zonation as occurring during early NN20 time.

The third "event" recognized in the sequence of sediments from Hole 552A occurs in Core 1, Section 1 and marks both a second incoming of rich and diverse dinoflagellate cyst assemblages and a changeover of the dominant species. These assemblages are at first dominated by *Bitectatodinium tepikiense* Wilson and then gradually become dominated by *O. centrocarpum*. *Spiniferites* spp. and *N. labyrinthea* are also important components of the assemblages. This productive unit is recognized as marking the onset of the present ameliorated climate, and the changeover in dominance from *B. tepikiense* to *O. centrocarpum* appears to be an important marker during this time. These assemblages are, of course, very comparable to the cyst thanatocoenosis of the area (see Harland, 1983).

Summary

The dinoflagellate cyst record from Hole 552A has clearly indicated two periods of climatic amelioration that have allowed the flourishing of dinoflagellate populations in the area, and hence the production of cysts in oceanographical configurations very similar to that seen today. The first amelioration occurs during the early part of nannofossil Zone NN20 and the second in the Flandrian/post-Glacial half of nannofossil Zone NN21—our present "interglacial." The cyst assemblages in both cases are very similar to those occurring today and indicate comparable conditions. It is, however, not possible to discuss this aspect more fully since the environmental preferences of the various dinoflagellate species are still not clearly understood; we have very little knowledge of dinoflagellate autecology.

COMPARISONS

Comparisons are best made, for the time being, with the Goban Spur area (Harland, in press), DSDP Leg 80, and with work recently completed in the Rockall area by Turen (1980, 1981). An attempt has been made (see Fig. 3) to correlate the Goban Spur work with that at Rockall. Certainly the changeover of dominance between *B. tepikiense* and *O. centrocarpum* may be recognized in both areas, and this is clearly shown in Fig. 3 and is used to correlate the two areas. What is not so clear, however, is which of the two major, but complex, ameliorative periods seen in sediments dated NN20/21, recognized from the Goban Spur area, is represented in the Rockall Plateau area. The presence at Rockall of an assemblage very like that of today would appear to be a good guideline for the Goban Spur area, in which case the earlier of the two ameliorations would appear to compare more closely with the present day, with its high incidence of *S. mirabilis, O. centrocarpum*, and *Protoperidinium* spp. and the rather poorer influence of *B. tepikiense*. However, it is also clear that the situation in the Goban Spur area, like Rockall, is very complex, and there is a great danger of oversimplifying the situation. Nevertheless this earlier amelioration, in NN20, between the "events" at the early/middle Pleistocene boundary and at Core 5, Section 1 in Hole 548 (Harland, in press) is thought to correlate with the amelioration recorded between "events" at Core 2, Section 4 and Core 2, Section 2 in Hole 552A on the Rockall Plateau. This may also prove to correlate with the warm faunal pulse between Coccolith Carbonate Minima 2 and 3 (McIntyre et al., 1971; Kellogg, 1976), which has been regarded as representing the Ipswichian (Eemian) Interglacial. Backman (pers. comm.) is of the opinion that the NN19/20 nannofossil boundary is somewhat higher in the sequence, at Core 2, Section 3, 60–70 cm, than previously thought. This would indicate a correlation at a slightly older horizon that I have indicated, but the dinoflagellate cyst evidence, especially the general lack of *B. tepikiense*, supports the former correlation.

CONCLUSIONS

Three "events" have been recognized within the dinoflagellate cyst biostratigraphy of the upper Quaternary sediments recovered from Hole 552A on the Rockall Plateau. Two of these events mark the establishment and close of an ameliorative episode, whereas the third event marks the establishment of our present ameliorative climate. Within our present "interglacial" there occurs a subsidiary "event" which marks a significant change in the composition of the dinoflagellate assemblages and which has been noted as an "event" in studies of the Quaternary from the Goban Spur (Harland, in press). The "event" stratigraphy, based upon the dinoflagellate cyst record, has allowed an initial correlation of the Leg 80 and 81 Quaternary sequences and holds out much promise for correlating Quaternary sequences throughout the north and northeastern Atlantic and into the North and Norwegian seas.

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APPENDIX
Samples Prepared and Examined for Quaternary Dinoflagellate Cysts

Core-Section (interval in cm)	Core-Section (interval in cm)
Hole 552A	Hole 552A (Cont.)
1-1, 17-18	3-2, 107-108
1-1, 37-38	3-3, 108-109
1-1, 55-56	4-1, 118-119
1-1, 77-78	4-2, 108-109
1-1, 80-81	4-3, 107-108
1-1, 97-98	5-1, 64-65
1-1, 116-117	5-2, 71-72
1-1, 136-137	5-3, 71-72
1-2, 17-18	5-4, 12-13
1-2, 36-37	7-1, 96-97
1-2, 54-55	7-2, 97-98
1-2, 75-76	7-3, 97-98
1-2, 80-81	8-1, 107-108
1-2, 96-97	8-2, 67-68
1-2, 115-116	8-3, 69-70
1-2, 136-137	11-1, 27-28
1-2, 149-150	11-2, 27-28
1-3, 18-19	11-3, 27-28
1-3, 37-38	
1-3, 57-58	Hole 553B
1-3, 76-77	
1-3, 82-83	1-1, 49-50
1-3, 94-95	1-2, 49-50
2-1, 28-29	1-3, 49-50
2-1, 47-48	2-1, 115-116
2-1, 67-68	2-2, 115-116
2-1, 81-82	2-3, 115-116
2-1, 87-88	2-4, 115-116
2-1, 107-108	2-5, 115-116
2-1, 127-128	2-6, 115-116
2-1, 146-147	
2-2, 20-21	Hole 554
2-2, 38-39	
2-2, 59-60	1-1, 20-21
2-2, 74-75	1-5, 20-21
2-2, 78-79	2-2, 25-26
2-2, 103-104	2-4, 25-26
2-2, 119-120	2-6, 32-33
2-2, 143-144	3-2, 20-21
2-3, 17-18	3-4, 52-53
2-3, 34-36	3-6, 45-46
2-3, 47-48	5-3, 50-51
2-3, 66-67	5-6, 50-51
2-3, 88-89	
2-3, 89-90	Hole 555
2-3, 106-107	
2-3, 127-128	1-1, 50
2-3, 148-149	1-2, 50
2-4, 12-13	1-3, 50
2-4, 20-21	1-4, 50
2-4, 33-34	2-4, 33
2, CC (5-6)	2-5, 18
2, CC (23-24)	3-1, 60
3-1, 108-109	3-5, 40

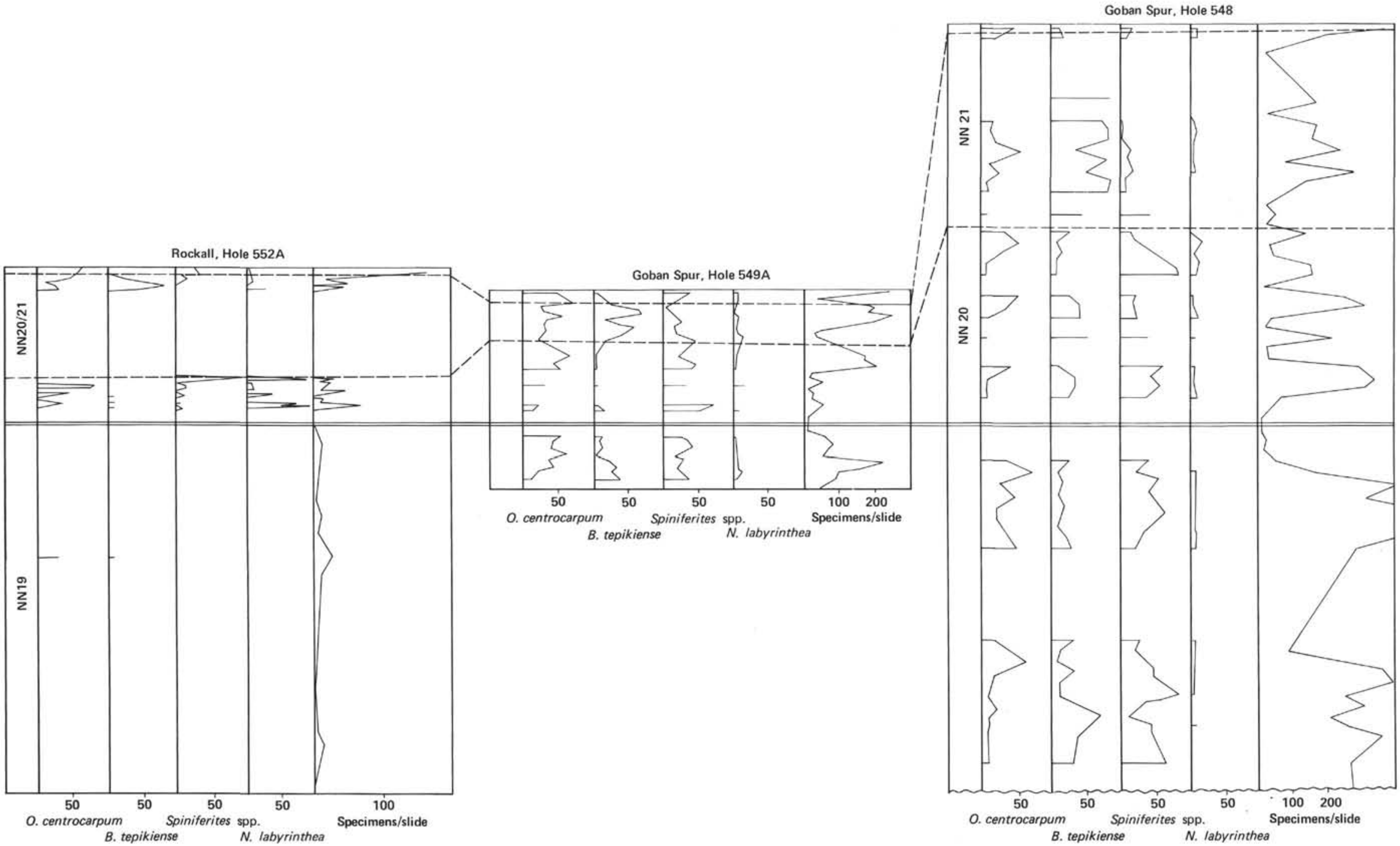

Figure 3. A tentative correlation diagram between Holes 552A (Rockall), 549A (Goban Spur), and 548 (Goban Spur), with emphasis placed upon the middle and late Pleistocene. The nannofossil boundary NN19/NN20 (double line) has been taken as datum, with the dashed lines indicating levels of correlation.