39. BIOSTRATIGRAPHIC SUMMARY OF DSDP LEG 49

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INTRODUCTION

Varied microfossil associations of the lower Oligocene to the Quaternary from the cores of North Atlantic Leg 49 are discussed. Microfossil groups described or illustrated in this volume include planktonic foraminifers, calcareous nannofossils, diatoms, radiolarians, silicoflagellates, siliceous sponge spicules, and opal phytoliths. Calcareous foraminifers and nannofossils provide the most consistent means for preliminary correlations. This chapter summarizes the correlations from Leg 49 and highlights some local problems of cross-correlation between fossil groups.

Nine holes were drilled at eight sites in three areas of the North Atlantic during DSDP Leg 49 (Figure 1, Table 1).

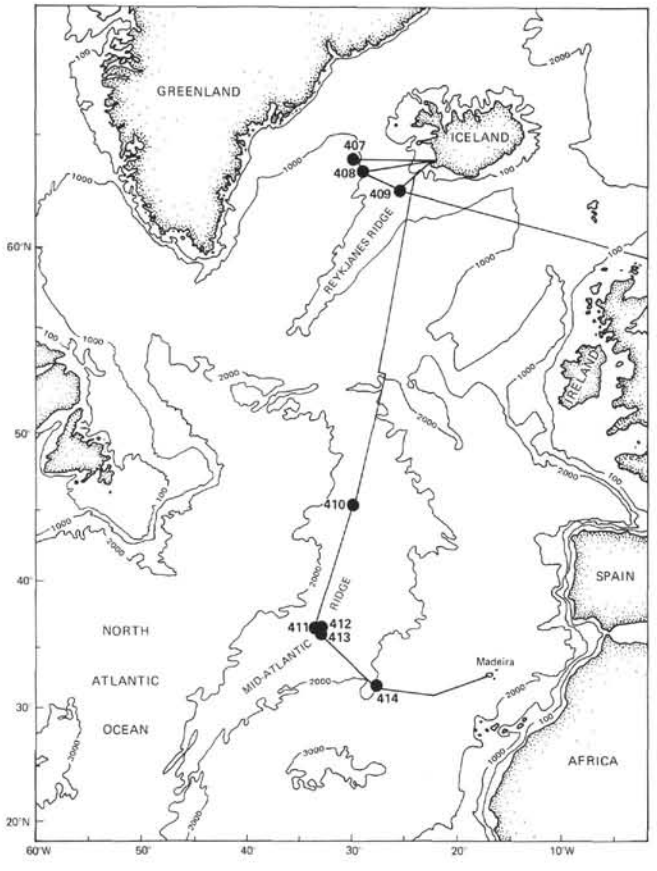

Figure 1. *Sketch map showing sites occupied and cruise track of DSDP Leg 49. Solid dots indicate sites where sediment was recovered.*

TABLE 1
Location and Water Depth (Corrected m) of Sites Where Sediment was Recovered During Leg 49

Site	Latitude	Longitude	Water Depth (m)
407	63°56.32'N	30°34.56'W	2472
408	63°22.63'N	28°54.71'W	1624
409	62°36.98'N	25°57.17'W	832
410	45°30.51'N	29°28.56'W	2975
411	36°45.97'N	33°23.30'W	1935
412	36°33.74'N	33°09.96'W	2609
413	36°32.59'N	33°10.50'W	2598

Sites 407 through 409 constitute a west-to-east transect on the west flank of the Reykjanes Ridge. Site 410 is on the west side of the Mid-Atlantic Ridge at 45° N, and Sites 411 through 413 are in the FAMOUS area at 37° N. Site 414 was located but not drilled.

Sites 407, 408, and 410 are of particular interest because they represent fairly long sedimentary records from what have been, until Leg 49, poorly sampled areas of the North Atlantic. In the following sections, a short discussion and generalized summary chart of biostratigraphic determinations derived from various microfossil groups are given for Sites 407, 408, and 410. In addition, we include a brief summary of observations made at the other sites. For all sites, planktonic foraminifer assemblages are reported in terms of the zonation of Blow (1969), and calcareous nannofossil assemblages are reported in terms of the zonation of Martini (1971). See Bukry (this volume) for zonation used for silicoflagellates and for additional calcareous nannofossil zonation. See Schrader (this volume) for lists of selected diatom taxa used for age interpretations at Site 407 and Site 408. A radiolarian report (Ling, this volume) was in preparation at the time of this summation.

Details upon which this summary is based can be found in the individual paleontologic reports in Part 2 of this volume.

REYKJANES RIDGE TRAVERSE: SITES 407 THROUGH 409

Site 407

Site 407 is on anomaly 13 on the west flank of the Reykjanes Ridge (Figure 1, Table 1), and forms the west end of the west-east transect drilled on the Reykjanes Ridge. Expected age for basement at this location is 36 to 38 m.y. (Berggren and Van Couvering, 1974).

Hole 407 was continuously cored to 458.5 meters sub-bottom, and basalt was first encountered at approximately 304 meters. At least three thin (?) layers of sediment are present below the top of the basalt section. The deepest (Sample 43, CC: 405 m sub-bottom) is about 100 meters below the first basalt. Oligocene microfossil assemblages from Sample 43, CC are referable to planktonic foraminiferal zonal interval P 19-P 20 and calcareous nannofossil Zone NP 22. These determinations suggest an age younger than, and thus compatible with, the expected age for basement at this site. Assemblages from sediments interlayered with basalt in Cores 35 and 36 (about 320 m and 330 m sub-bottom, respectively) are referable to upper Oligocene Zones P 21 and NP 25.

Biostratigraphic determinations derived from various microfossil groups in the sedimentary section above basalt in Hole 407 are summarized in Figure 2. Planktonic foraminifers are common in samples from just above basalt (Cores 32 through 39), but preservation, in general, is poor. Planktonic foraminifers are moderately well preserved in samples from Cores 28 through 19, but are not very abundant. With few exceptions, planktonic foraminifers are common to abundant and well preserved in samples above Core 19. Calcareous nannofossils are common and well preserved throughout Hole 407, and siliceous microfossils (radiolarians and diatoms) are common in Cores 32 through 22 and 11 through 6. Microfossil assemblages from Hole 407 are temperate in character, and primary tropical zone markers are usually absent or sparse. Some zone assignments, therefore, are made on secondary indicators or the general nature of the assemblage. Keeping in mind the scarcity of primary zone indicators, correlation of planktonic foraminifer zone assignments with calcareous nannofossil zone assignments and resultant age estimates are, nevertheless, similar to the expected correlation of these zones proposed by Ryan, et al. (1975) (Figure 3).

A noteworthy exception to the general correspondence in age estimates derived from different microfossil groups occurs in Cores 20 through 18. Poore (this volume), Steinmetz (this volume), and Schrader (this volume) assign all or part of this interval to zones of the middle Miocene, whereas Bukry (this volume) assigns this interval to the *Helicosphaera ampliaperta* Zone, which spans the Burdigalian Stage/Langhian Stage boundary and thus the lower Miocene/middle Miocene boundary (see Ryan et al., 1975, for summary). Some workers recognize the base of the middle Miocene by the first evolutionary occurrence of the foraminifer genus *Orbulina* (the *Orbulina* Datum), which occurs within the Langhian stratotype. Use of this convention results in a correlation that places the lower Miocene/middle Miocene boundary at the foraminifer Zone N 8/N 9 boundary and within the nannofossil Zone NN 5 (see Berggren, 1972, fig. 7).

The discrepancy in Hole 407, however, is too large to be explained by the use of different conventions by different workers. Reworking and use of secondary guide species at high latitude could contribute to the discrepancy. Since there is fairly close agreement on identification and detection of limits of middle Miocene assemblages in the adjacent Hole 408 (see below), reworking seems to be the most likely cause of the different age estimates for Cores 20 through 18 of Hole 407.

Regardless of the interpretation that one accepts for Hole 407, it is clear that an unconformity occurs between Cores 18 and 17 or within Core 18. Additional work is necessary to corroborate the occurrence of an unconformity between Cores 20 and 19, suggested by the interpretations of Poore (this volume).

An unexpected feature of Hole 407 is the absence of a significant Pliocene glacial section. Previous drilling in this area of the North Atlantic (Laughton, Berggren, et al., 1972) detected thick sequences of upper Pliocene sediments containing ice-rafted mineral grains. In Hole 407, the lowest occurrence of mineral grains ($\geq$ 63 μm) interpreted as ice-rafted is in Core 7. The thin Pliocene glacial section in Hole 407 suggests an unconformity in the upper Pliocene to Quaternary of Hole 407.

Site 408

Site 408, the middle site of the west-east transect of the Reykjanes Ridge, is on magnetic anomaly 6 (Figure 1, Table 1). Expected age for basement at this location is about 20 to 21 m.y. (Ryan et al., 1975).

Hole 408 was continuously cored to 361 meters sub-bottom; basalt was first encountered at 321.5 meters. Minor amounts of sediment intercalated with basalt were recovered from Hole 408 (Cores 35 and 37) at about 333 meters and 352.5 meters sub-bottom. These sediments contain lower Miocene calcareous nannofossils, but could not be assigned to a specific zone. Calcareous microfossil assemblages from sediments directly above basalt (Core 34) are referable to Zone N 7 and Zone NN 4 or NN 3. The paleontologic age estimate for basement at Site 408 is somewhat younger (18 $\pm$ m.y.), but still compatible with the expected age of basement (see Figure 3).

Biostratigraphic determinations derived from various microfossil groups in the sedimentary section above basalt in Hole 408 are summarized in Figure 4. Calcareous nannofossils are common and well preserved throughout the section. Planktonic foraminifers are sparse to common and moderately well to poorly preserved in Core 34. Planktonic foraminifers are more abundant and better preserved uphole. Siliceous microfossils (radiolarians and diatoms) occur in Cores 33 through 4, and are especially abundant in Cores 29 and 28.

The microfossil assemblages of Hole 408 are similar to those of Hole 407, in that they are temperate in character and tropical zone markers are usually absent. However, the correspondence of age estimates derived from planktonic foraminifers and calcareous nannofossils is good. For example, Poore (this volume) places the lower/middle Miocene boundary between Cores 32 and 31, whereas Steinmetz (this volume) places this boundary between Cores 33 and 32. Bukry (this volume) assigns Section 31-2 to the *Sphenolithus heteromorphus* Zone and Section 32-6 to the *Helicosphaera ampliaperta* Zone. Thus all three workers basically agree on placement of the lower/middle Miocene boundary. Similarly, Poore (this volume) places the middle/upper Miocene boundary between Cores 25 and 24, and Bukry (this volume) assigns Section 24-2 to the middle Miocene *Catinaster coalitus* Zone or *Discoaster kugleri* Subzone. The next higher section examined by Bukry (21-4) is assigned to the upper Miocene (*Discoaster neohamatus* Zone). Steinmetz (this volume) places the

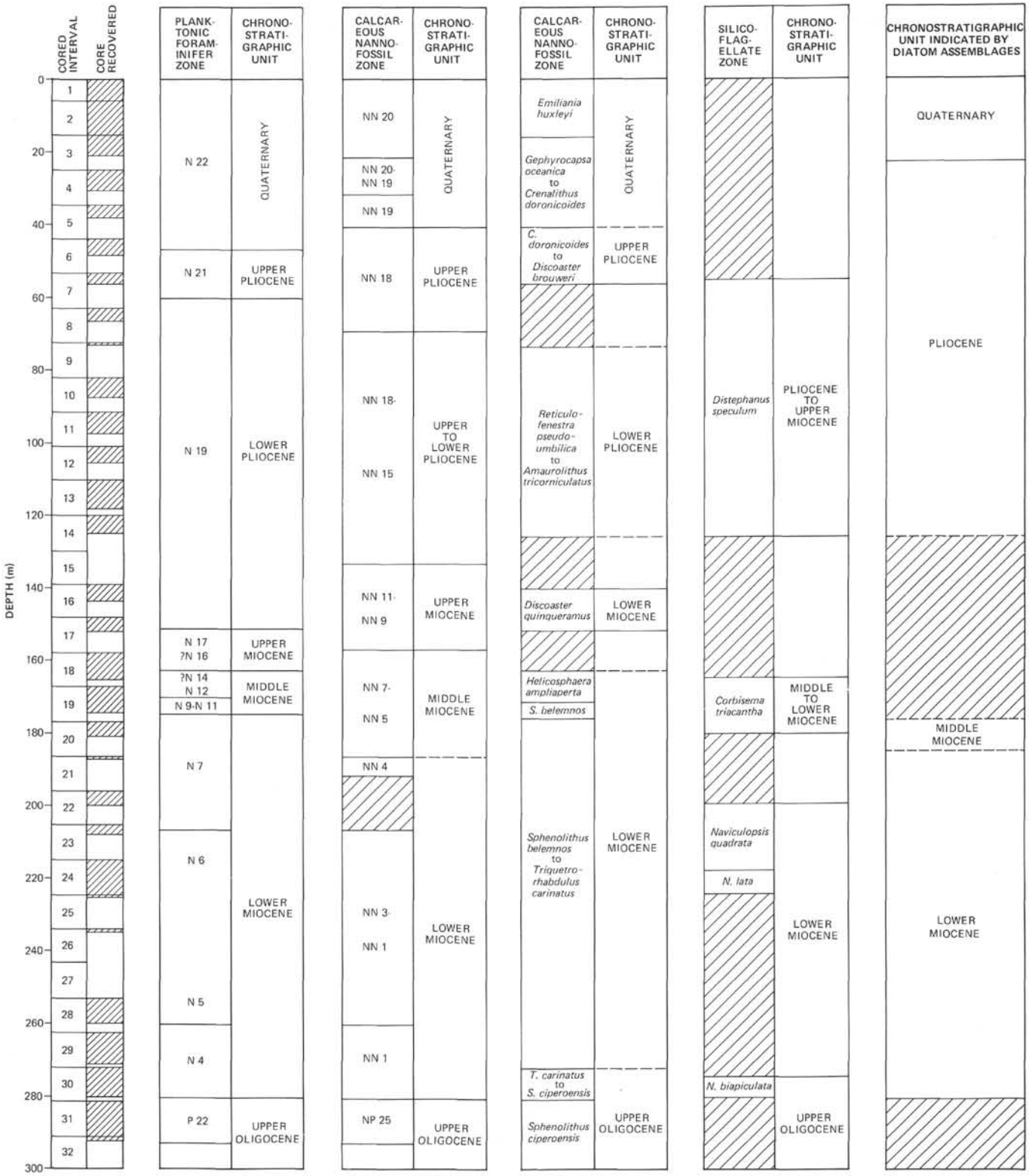

Figure 2. *Generalized summary of biostratigraphic determinations for DSDP Hole 407. Data on planktonic foraminifers taken from Poore (this volume, table 2). Data on calcareous nannofossils taken from Steinmetz (this volume, table 4). Data on calcareous nannofossils (column 3) and silicoflagellates taken from Bukry (this volume, fig. 2 and 3). Age interpretations derived from diatoms are taken from Schrader (this volume). Cross-hatched lines indicate areas that were not sampled, yield nondiagnostic assemblages, or are barren.*

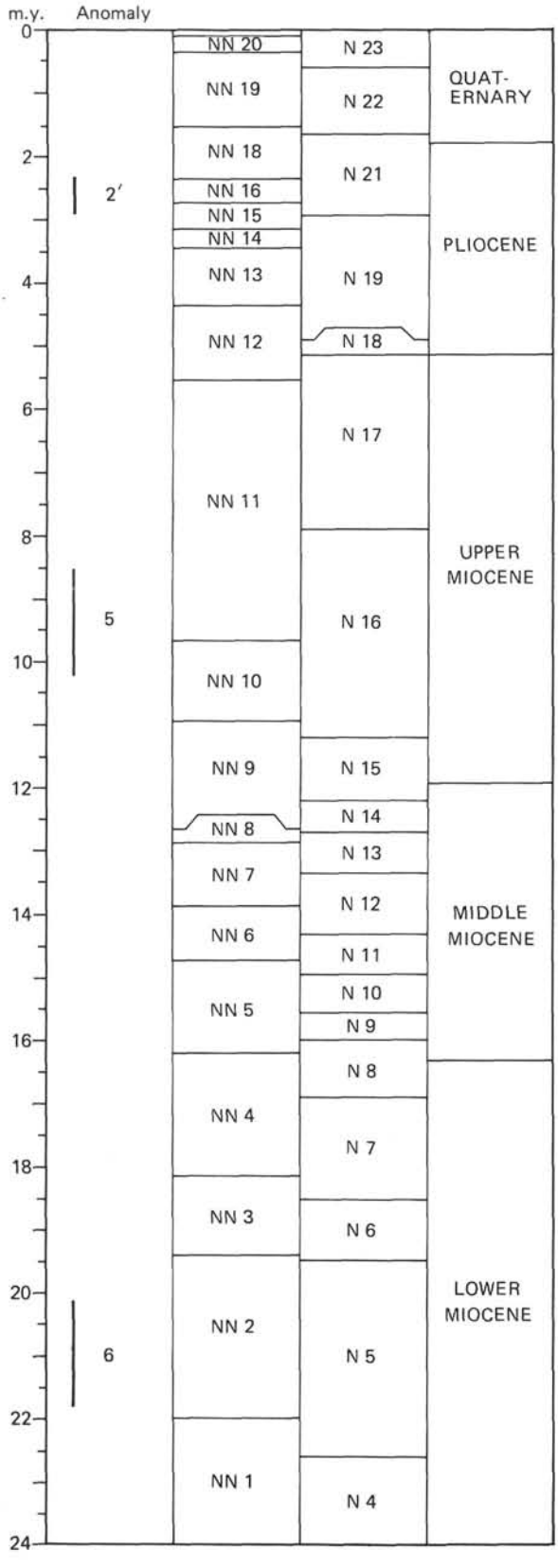

Figure 3. *Neogene time scale and presumed correlation between standard planktonic foraminifer zonation of Blow (1969) with standard calcareous nannofossil zonation of Martini (1971). Modified from Ryan* et al. *(1975).*

middle/upper Miocene boundary somewhat lower (between Cores 27 and 26), but notes that calcareous nannofossil assemblages in this interval are transitional.

The glacial Pliocene section of Hole 408 is thin (1 to 2 m), and as in Hole 407, we interpret the thin Pliocene glacial section as evidence of an unconformity in the upper Pliocene-Quaternary of Hole 408.

Although paleontologic studies of Holes 407 and 408 for the *Initial Reports* are in large part preliminary, it is evident that these holes will be extremely important in future detailed work concering Miocene and Pliocene biogeography and biostratigraphy of the Atlantic Basin. Moreover, the association of calcareous and siliceous microfossils in the sediments of Hole 407 and 408 will allow direct correlation of extra-tropical biostratigrapic zonations developed for the different correlation of extra-tropical biostratigraphic zonations developed for the different microfossil groups, and will help establish better correlations between extra-tropical and tropical zonations.

Site 409

Site 409, on magnetic anomaly 2′ near the crest of the Reykjanes Ridge, is the east point of the west-east transect (Figure 1, Table 1). Expected age for basement is 2.3 m.y. (Ryan et al., 1975).

After a nominal amount of sediment was recovered while trying to spud-in, Hole 409 was washed to 24.5 meters sub-bottom, and then continuously cored to 319 meters sub-bottom. Basalt was encountered at 80 meters sub-bottom (within Core 7).

Calcareous microfossil assemblages from Cores 1 through 6 are referable to the Quaternary, and assemblages are compatible with the expected age of 2.3 m.y. for basement at this site. Because of poor recovery, discontinuous coring, occurrence of turbidites, and highly disturbed nature of most cores, only a limited number of samples was examined from Hole 409 for the *Initial Reports*.

45° N

Site 410

Site 410 is in a sediment pond on the west side of the Mid-Atlantic Ridge at the older western edge of magnetic anomaly 5 (Figure 1, Table 1). Expected age of basement is approximately 10 m.y. (Ryan et al., 1975).

Hole 410 was continuously cored to 387.5 meters sub-bottom, and basement, consisting of basalt limestone breccia, was encountered at 340 meters sub-bottom. Recovery of the mainly nannofossil ooze and chalk above basement was relatively high, albeit spotty. Except for samples adjacent to basalt (Core 36), calcareous microfossils are abundant and well preserved throughout the nannofossil- and foraminifer-rich sedimentary section.

Biostratigraphic determinations derived from planktonic foraminifers, calcareous nannofossils, and silicoflagellates for Hole 410 are summarized in Figure 5.

A disagreement exists in age assignments for Cores 23 through 18. Poore (this volume) assigns the foraminiferal assemblages from this interval to lower Pliocene Zones N 18 and N 19, whereas Steinmetz (this volume) correlates the calcareous nannofossil assemblages from this interval with upper Miocene Zone NN 11. Study of calcareous nannofos-

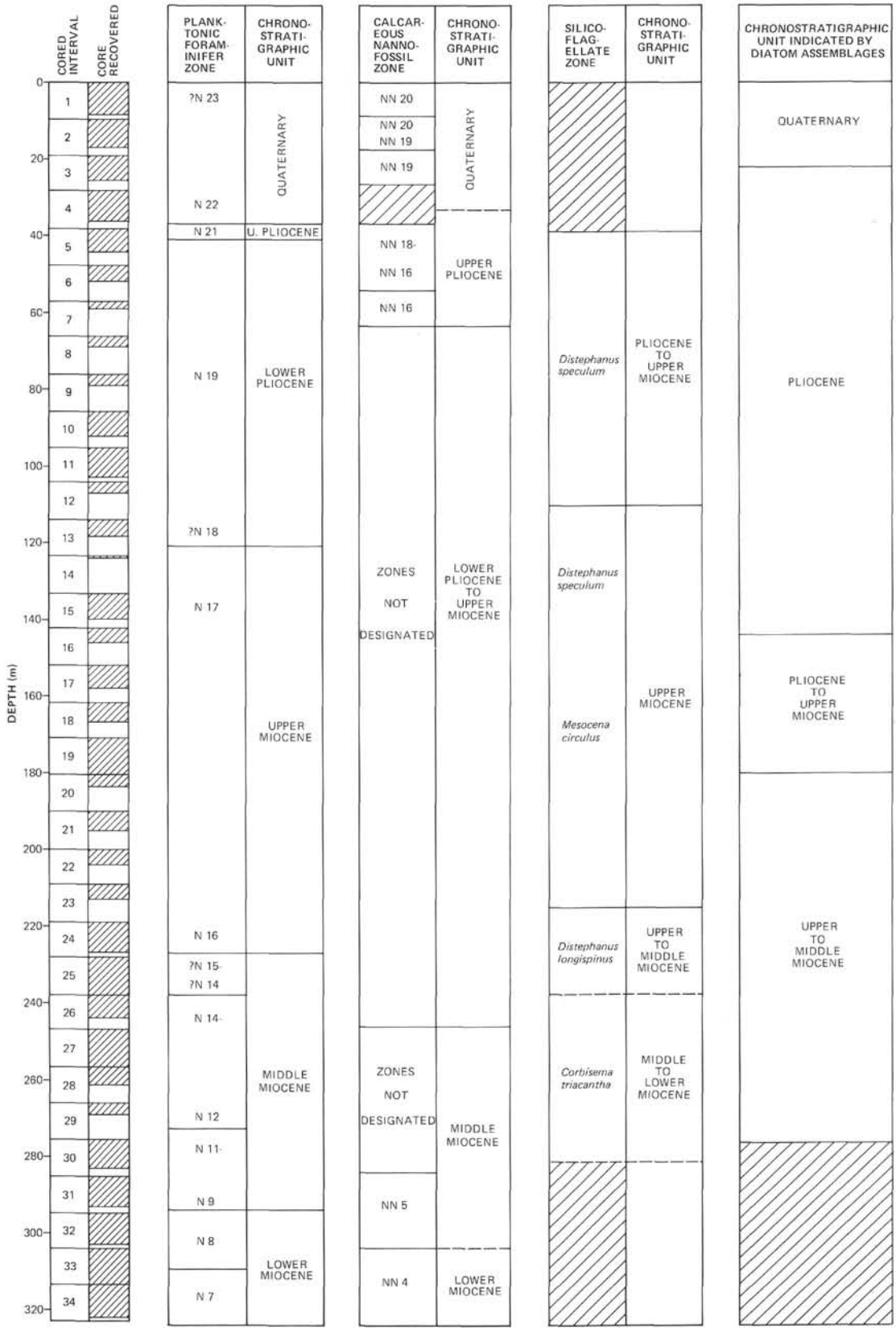

Figure 4. *Generalized summary of biostratigraphic determinations for DSDP Hole 408. Data on planktonic foraminifers taken from Poore (this volume, table 3). Data on calcareous nannofossils taken from Steinmetz (this volume, table 5). Data on silicoflagellates taken from Bukry (this volume, fig. 3). Age interpretations derived from diatoms are taken from Schrader (this volume). Cross-hatched lines indicate areas that were not sampled, yield nondiagnostic assemblages, or are barren.*

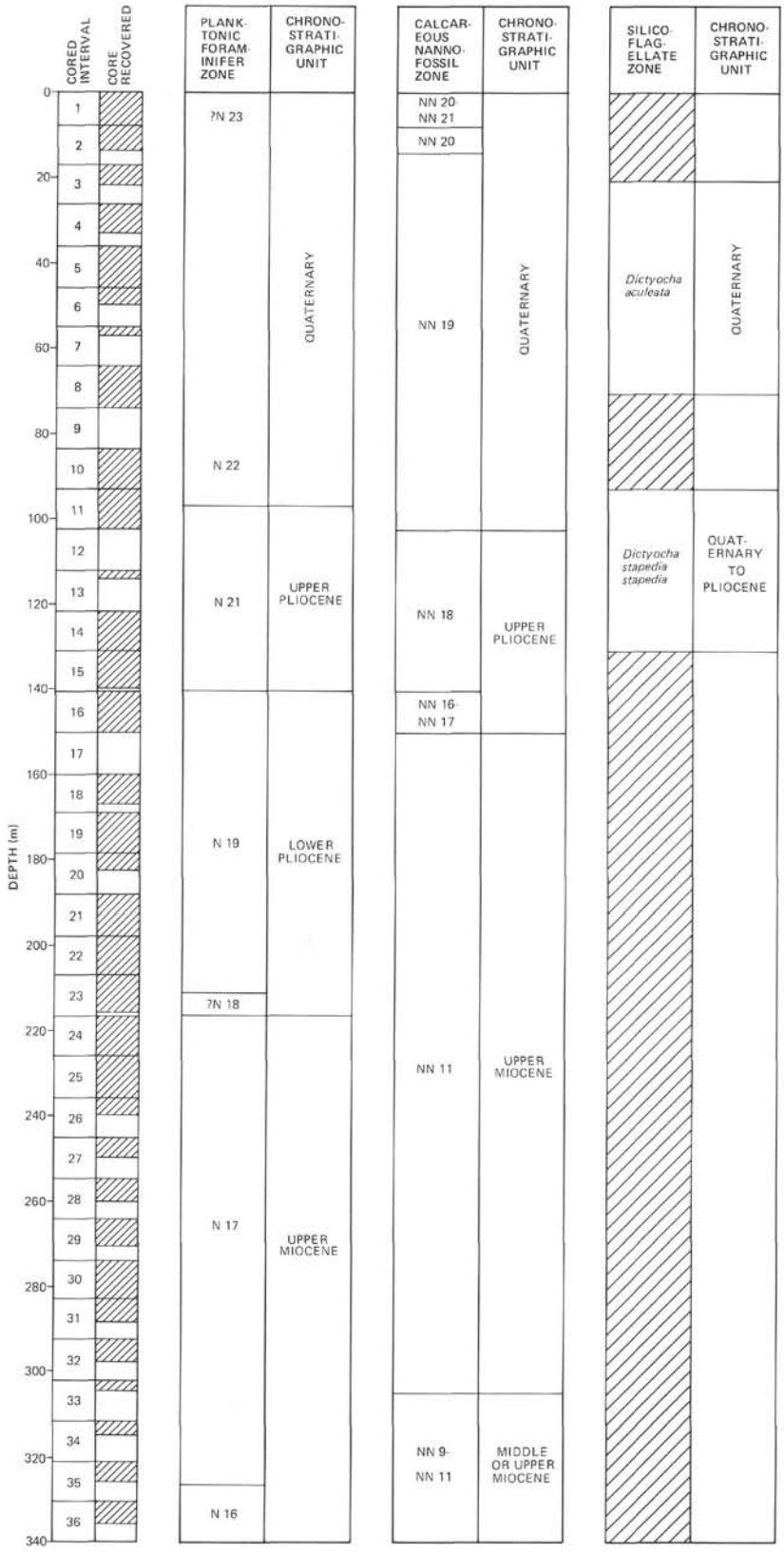

Figure 5. *Generalized summary of biostratigraphic determinations for DSDP Hole 410. Data on planktonic foraminifers taken from Poore (this volume, table 5). Data on calcareous nannofossils taken from Steinmetz (this volume, table 7). Data on silicoflagellates taken from Bukry (this volume, fig. 3). Cross-hatched lines indicate areas that were not sampled, yield nondiagnostic assemblages, or are barren.*

sils from Hole 410 by Bukry (this volume) also results in assignment of this interval to the upper Miocene *Discoaster quinqueramus* Zone, because of the presence of small *Discoaster quinqueramus*.

In an attempt to resolve this discrepancy, nannofossils from sediment infilling specimens of *Globorotalia margaritae* and *G. tumida* (primitive form) from Cores 23 and 22 were examined, as Poore (this volume) used occurrences of these species as Pliocene indicators. Unfortunately, nannofossil assemblages recovered from this procedure were not definitive in resolving the upper Miocene or lower Pliocene assignment.

Acceptance of the interpretation derived from calcareous nannofossil assemblages requires an unconformity between Cores 18 and 16 (only a trace of sediment was recovered in Core 17) representing 2 to 3 m.y. Alternatively, acceptance of the interpretation derived from planktonic foraminifer assemblages precludes the presence of a significant break in the sedimentary record. Sediments recovered in Cores 18 and 16 are very similar, and provide no physical evidence for a break or change in sedimentation.

At the present time, no clear choice can be made between the two interpretations, and resolution of this discrepancy must await future work.

The lowest occurrence of ice-rafted mineral grains in Hole 410 is in Core 15. Poore (this volume) found the first evolutionary occurrence of *Globorotalia inflata* in Core 15, and correlates the base of Core 15 with the Zone N 19/Zone N 21 boundary. Steinmetz (this volume) assigns Core 15 to Zone NN 18, and Bukry (this volume) assigns Core 15 to his *Discoaster tamalis* Subzone, which correlates with Zone NN 16. Interpretations of Poore and Bukry suggest an age of about 3.0 m.y., Steinmetz about 2.0 m.y., for the lowest occurrence of ice-rafted mineral grains in Hole 410.

As noted earlier, expected age for basement at Site 410 is about 10 m.y. — the base of magnetic anomaly 5. According to the time scale and correlations of Ryan et al., (1975), one would expect microfossil assemblages from the basal sediments of Hole 410 to correlate with nannofossil Zone NN 10 and the lower part of foraminiferal Zone N 16. The observed nannofossil assemblages agree well with this prediction, but the foraminifer assemblages, which are correlated with upper Zone N 16, suggest a somewhat younger age. This difference is not considered significant, and may simply reflect problems in the presumed "true" correlation of planktonic foraminifer and calcareous nannofossil zones.

FAMOUS AREA: SITES 411 THROUGH 413

Site 411

Two holes were drilled at Site 411 in a small sediment pond 10 km to the west of the median valley of the Mid-Atlantic Ridge. The age of basement at this locality is about 1 m.y. — base of Jaramillo polarity event.

The small amount of Quaternary sediment recovered in Hole 411 could not be assigned to any particular depth in the hole. In fact, it could have been cored during anyone of the 11 attempts to spud in (see Site Report for summary of operations). Hole 411 was terminated in a sequence of basalt flows and rubble zones, because of unstable hole conditions. After offsetting 50 meters, three discontinuous sediment cores were cut to basement (Hole 411A), and again hole conditions were highly unstable. Sediment recovered from Hole 411A was an orange-tinged foraminifer sand containing relatively minor amounts of material ≤ 63 μm. This winnowed deposit appears to have been the cause of the unstable hole conditions. Only preliminary examination was made of microfossil assemblages from this hole. Nannofossils present in Sample 2, CC (82.7 m sub-bottom) are assigned to the lower Pleistocene (Zone NN 19) by Steinmetz (this volume).

Site 412

Site 412 is on the north side of the valley of fracture zone B, FAMOUS area. Magnetic surveys of this region indicate that crust immediately north of Site 412 is just younger than the Olduvai polarity event. Expected age for basement at Site 412 is thus about 1.6 m.y.

Hole 412 was discontinuously cored to 171.5 meters sub-bottom. Destruction of the drill bit soon after basalt was encountered at 165.5 meters forced termination of Hole 412. Microfossil assemblages from the bottom of Hole 412 are referable to the lower Quaternary (nannofossi Zone NN 19), and agree with the magnetic data. Silicoflagellates are common throughout Hole 412; the Quaternary *Dictyocha aculeata* Zone and *Mesocena quadrangula* Zone are well represented (Bukry, this volume). Calcareous microfossil assemblages are diverse and well preserved.

Upon termination of Hole 412, Hole 412A was washed to basement and coring in basalt resumed. Pieces of chalk intercalated with basalt in Cores 3, 11, 12, and 14 yielded sparse lower Quaternary nannofossil assemblages.

Site 413

Site 413 is on the south side of the valley of fracture zone B. Hole 413 was washed to basement prior to cutting of the first core. Quaternary microfossils were obtained from "sediment" surrounding basalt pieces in Core 1. This "sediment" is interpreted as drill cuttings mixed with up-hole contaminants. Calcareous nannofossil assemblages recovered from a limestone and basalt breccia in Cores 2 and 3 are referable to the Quaternary, but no specific zonal assignment is possible.

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