7. A NEW BIOSTRATIGRAPHIC INTERPRETATION OF THE SEDIMENTARY RECORD RECOVERED AT SITE 462, LEG 61, NAURU BASIN, WESTERN EQUATORIAL PACIFIC[1]

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ABSTRACT

Reinterpretation of the biostratigraphic record from Hole 462, drilled in the Nauru Basin during Leg 61, emphasizes the importance of larger foraminifers in dating heavily redeposited sequences. Younger ages derived from larger foraminifers are supported by the occurrence of some planktonic marker species (foraminifers and radiolarians) previously interpreted as downhole contaminants. A major implication of the new younger ages is that the main erosional events previously dated at 37 Ma, 32 Ma, 26 Ma, and 13 Ma now have an age of 30 Ma, 28 Ma, 26 Ma or younger, and 12 Ma, respectively. Erosional events at the end of the Eocene and within the early Oligocene can no longer be documented.

INTRODUCTION

Two holes were drilled at Site 462 in the Nauru Basin during Leg 61 in 1978 by the *Glomar Challenger*. Hole 462A was reentered four years later in 1982 during Leg 89 in order to reach deeper horizons within the basaltic complex. The aim of this chapter is to reinterpret the biostratigraphic record from Hole 462, which was strongly biased by severe reworking and displacements of almost all the age-diagnostic fossil groups (Larson, Schlanger, et al., 1981), in light of a synthesis of the available data from both holes.

DISCUSSION

The sedimentary sequence recovered at Site 462 (Holes 462 and 462A) overlying the basaltic complex is characterized by pelagic clay and more rarely by radiolarian ooze, the autochthonous sediments, which alternate with carbonate-rich layers. Pelagic clay is dominant in the lower portion of the sequence from 550 to 450 m sub-bottom (Cores 462-59 to 462-48), then it decreases upwards. In the Cenozoic, from 370 m to the top of the hole (Cores 462-39 to 462-1), the amount of pelagic clay and/or radiolarian ooze is about 10% of the total thickness.

All the fossiliferous components, except the deep-dwelling agglutinated benthic foraminifers and possibly some radiolarians, have been transported. As a result, chronostratigraphy was jeopardized by reworking (Premoli Silva and Sliter, 1981; Premoli Silva and Violanti, 1981; Sanfilippo et al., 1981; Thierstein and Manivit, 1981). In the absence of age-diagnostic fossils from the autochthonous layers, the sediments were dated on the basis of the youngest components occurring in the various resedimented layers. However, under such conditions it is possible that even the youngest elements of a given fauna and/or flora could be not only displaced but also reworked. Consequently, the resulting dates could be much older than the actual age of deposition.

Ages reported in the Site 462 report for Hole 462 samples and in several other chapters as well (Larson, Schlanger, et al., 1981) were based mainly on planktonic foraminifers and calcareous nannofossils. Discrepancies in the ages inferred from the different fossil groups are striking (see tables 4 and 5 in Larson, Schlanger, et al., 1981, pp. 52–53). Further discrepancies are evident if one compares the age inferred from the planktonics to those ages suggested by the shallow-water larger foraminifers (Premoli Silva and Brusa, 1981).
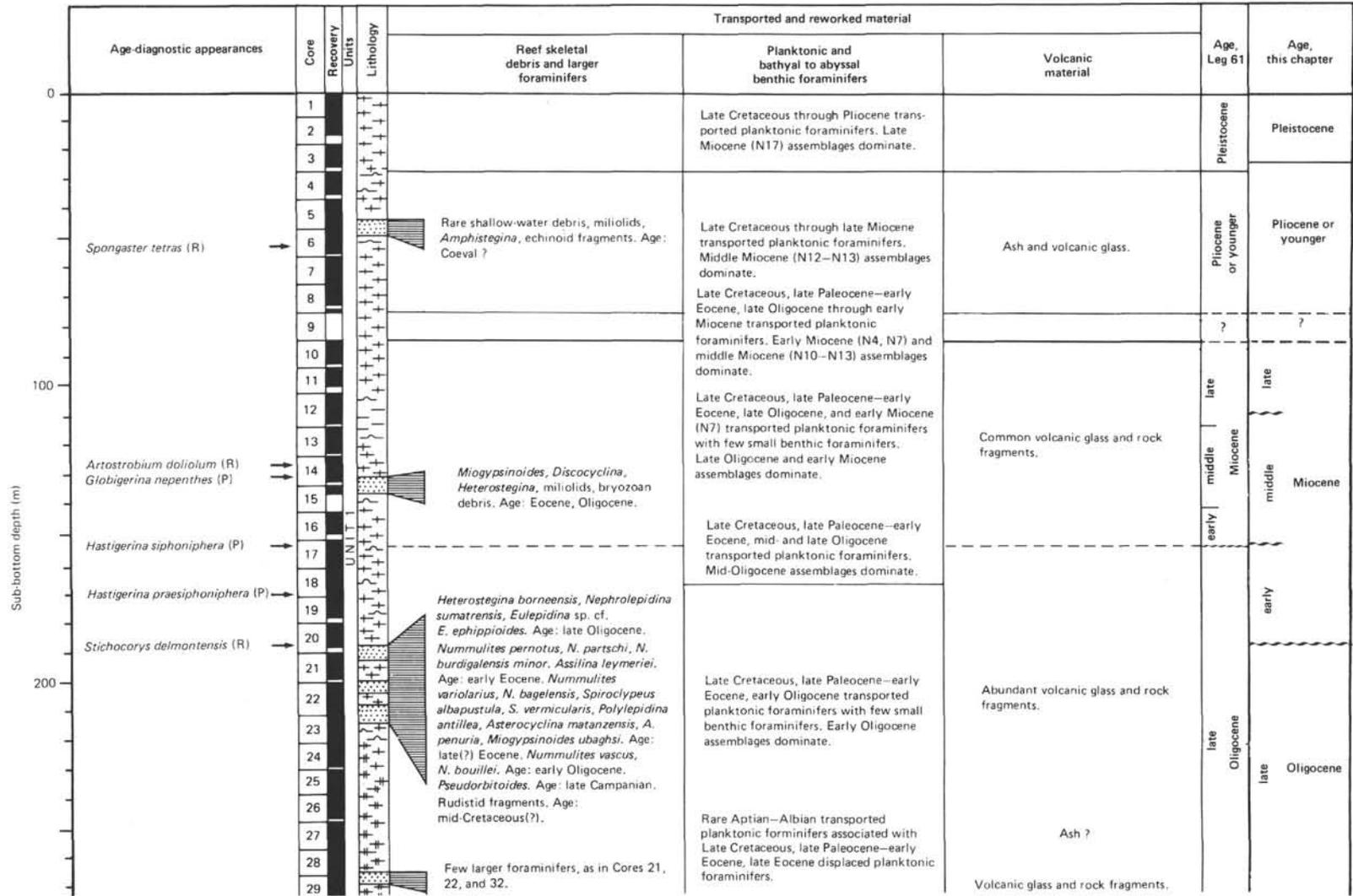
Most of the larger foraminifers are known to possess a high level of biostratigraphic resolution. Evolutionary lineages have been recognized within numerous, rapidly evolving genera. Moreover, each step within a lineage is identified as a species. Lineages are well dated by detailed quantitative studies and calibrated against stratotypes (i. e., the *Lepidorbitoides* lineage). In some cases, their occurrence could be correlated with the planktonic foraminiferal zonation schemes (van Gorsel, 1978; Adams, 1967; Schaub, 1951, 1981; Brönnimann, 1954; Haak and Postuma, 1975). Most of the species have a short stratigraphic range, and are diagnostic of specific time intervals. Furthermore, correctly identified specimens of a given evolutionary stage are age-diagnostic, even when recovered from a noncontinuous sequence. Thus the ages inferred from most of the larger foraminifers are as reliable as those based on planktonic foraminifers, once the calibration of a lineage is established.

At Site 462, although the shallow-water larger foraminifers are displaced in deeper water as are the calcareous plankton and most of the radiolarians, the taxa found give younger minimum ages than did previous age assignments that used planktonic organisms. The younger ages, based on the occurrence of some larger foraminifers from Hole 462, are as follows (from bottom to top) (see Fig. 1):

• Cores 462-52 and 462-51 contain numerous specimens of *Vaughanina cubensis*, which is Maestrichtian species according to Brönnimann (1954). Following Brönnimann's interpretation, *Pseudorbitoides israelskyi* among

Sub-bottom depth (m)

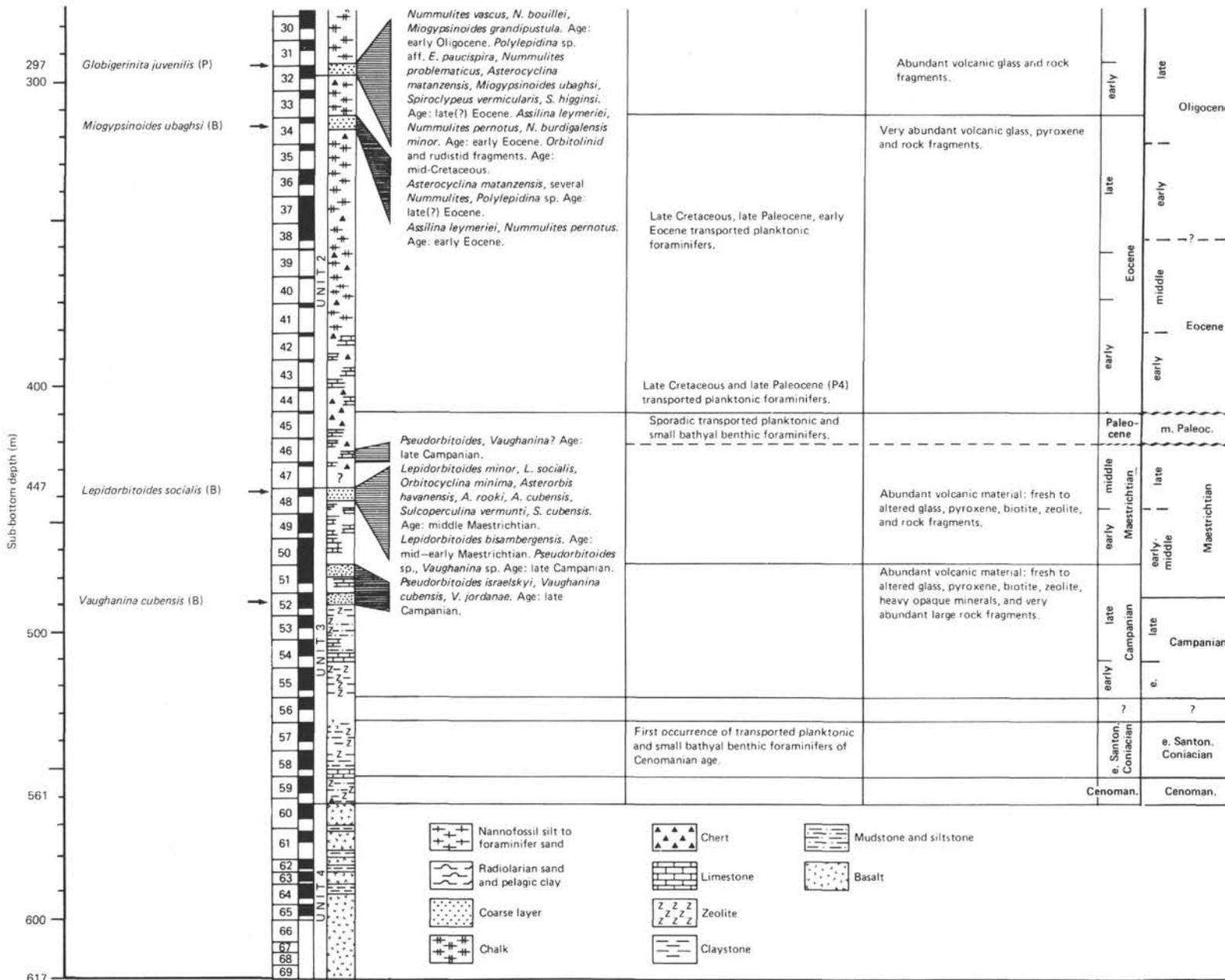| Age-diagnostic appearances	Core	Recovery	Units	Lithology	Transported and reworked material			Age, Leg 61	Age, this chapter
					Reef skeletal debris and larger foraminifers	Planktonic and bathyal to abyssal benthic foraminifers	Volcanic material		
	1					Late Cretaceous through Pliocene transported planktonic foraminifers. Late Miocene (N17) assemblages dominate.		Pleistocene	Pleistocene
	2								
	3								
	4								
	5				Rare shallow-water debris, miliolids, *Amphistegina*, echinoid fragments. Age: Coeval ?	Late Cretaceous through late Miocene transported planktonic foraminifers. Middle Miocene (N12–N13) assemblages dominate.	Ash and volcanic glass.	Pliocene or younger	Pliocene or younger
Spongaster tetras (R) →	6								
	7								
	8					Late Cretaceous, late Paleocene–early Eocene, late Oligocene through early Miocene transported planktonic foraminifers. Early Miocene (N4, N7) and middle Miocene (N10–N13) assemblages dominate.		?	?
	9								
	10							late	late
	11								
	12					Late Cretaceous, late Paleocene–early Eocene, late Oligocene, and early Miocene (N7) transported planktonic foraminifers with few small benthic foraminifers. Late Oligocene and early Miocene assemblages dominate.	Common volcanic glass and rock fragments.	middle Miocene	middle Miocene
	13								
Artostrobium doliolum (R) →	14				*Miogypsinoides, Discocyclina, Heterostegina*, miliolids, bryozoan debris. Age: Eocene, Oligocene.				
Globigerina nepenthes (P) →	15								
	16		UNIT 1			Late Cretaceous, late Paleocene–early Eocene, mid- and late Oligocene transported planktonic foraminifers. Mid-Oligocene assemblages dominate.		early	
Hastigerina siphoniphera (P) →	17								
	18				*Heterostegina borneensis, Nephrolepidina sumatrensis, Eulepidina* sp. cf. *E. ephippioides*. Age: late Oligocene.			early	
Hastigerina praesiphoniphera (P) →	19								
Stichocorys delmontensis (R) →	20				*Nummulites pernotus, N. partschi, N. burdigalensis minor. Assilina leymeriei.* Age: early Eocene. *Nummulites variolarius, N. bagelensis, Spiroclypeus albapustula, S. vermicularis, Polylepidina antillea, Asterocyclina matanzensis, A. penuria, Miogypsinoides ubaghsi.* Age: late(?) Eocene. *Nummulites vascus, N. bouillei.* Age: early Oligocene. *Pseudorbitoides.* Age: late Campanian. Rudistid fragments. Age: mid-Cretaceous(?).	Late Cretaceous, late Paleocene–early Eocene, early Oligocene transported planktonic foraminifers with few small benthic foraminifers. Early Oligocene assemblages dominate.	Abundant volcanic glass and rock fragments.	late Oligocene	late Oligocene
	21								
	22								
	23								
	24								
	25								
	26								
	27					Rare Aptian–Albian transported planktonic forminifers associated with Late Cretaceous, late Paleocene–early Eocene, late Eocene displaced planktonic foraminifers.	Ash ?		
	28				Few larger foraminifers, as in Cores 21, 22, and 32.				
	29						Volcanic glass and rock fragments.		

Figure 1. Distribution in DSDP Hole 462, Leg 61, of transported and reworked material after Premoli Silva and Brusa (1981) plotted against the new Leg 89 age interpretations, complemented by some age-diagnostic fossil appearances (in the first column, P = planktonic foraminifers, B = larger benthic foraminifers, and R = radiolarians).

the larger foraminifers, and the planktonic foraminifers attributed to the *Globotruncana subspinosa* and *Globotruncana calcarata* Zones, all diagnostic for the late Campanian, are reworked. The above-mentioned cores are thus dated as Maestrichtian and not late Campanian, as previously reported (Larson, Schlanger, et al., 1981).

• Core 462-48 must be dated as late Maestrichtian based on the occurrence of *Lepidorbitoides socialis*, the end member of the *Lepidorbitoides* lineage (van Gorsel, 1978), and not as middle Maestrichtian, as inferred from the planktonic foraminifers attributed to the *Globotruncana gansseri* Zone. It is worth mentioning that the biostratigraphic signal from the calcareous nannofossils speaks in favor of an even older age (Thierstein and Manivit, 1981).

• Core 462-34 contains a few specimens positively identified as *Miogypsinoides ubaghsi* (Premoli Silva and Brusa, 1981). This genus is known to appear in the late Oligocene (Zone P21a = *Globorotalia opima opima*). Thus all the planktonic components that are diagnostic of the late Eocene are reworked.

• Section 462-32-1, again, contains representatives of *Miogypsinoides*. It must be dated at least to Zone P21a of the late Oligocene as was Core 462-34, or even younger. The planktonic foraminiferal assemblage of Zone P20 (= *Globigerina ampliapertura* Zone) is considered reworked.

On the basis of this age reinterpretation, some planktonic foraminifers that had been interpreted by Premoli Silva and Violanti (1981) as downhole contaminants may in fact represent a correct record. The previously interpreted contaminants that have now been reinstated as markers are (from bottom to top, see Fig. 1):

• *Globorotalia opima opima, G. siakensis*, well developed globoquadrinids, *Globigerina ciperoensis*, and large *Globoquadrina tripartita* occur in several samples from Core 462-34. Their presence is consistent with the late Oligocene of Core 462-34 inferred from the occurrence of *Miogypsinoides*. Moreover, some specimens of *Globorotalia kugleri* also occur in the same samples: if these forms are also proved to belong to the host fauna, then Core 462-34 should be dated as latest Oligocene. Because of its abundance in the upper part of the sequence, *G. kugleri* is still interpreted as a downhole contaminant.

• Some specimens of *Globigerinita juvenilis* occur in Sample 462-32-1, 73–75 cm. In the Atlantic this species appears within the range of *Globigerina angulisuturalis* (Zones P21b through P22) (author's personal observation, 1984; Bolli, 1957). This occurrence would confirm not only the late Oligocene age based on the presence of *Miogypsinoides* (see above), but would also indicate that Core 462-32 is younger than Core 462-34, as expected.

• Rare specimens of *Hastigerina praesiphonipera* are recorded in Sample 462-18-6, 25–27 cm. According to Blow (1969), this species appears within the early Miocene Zone N7. Consequently, the Oligocene/Miocene boundary does not fall within Core 462-17, as stated in the Site 462 report (Larson, Schlanger, et al., 1981) and in Premoli Silva and Violanti (1981).

• The subsequently recorded occurrences of *Hastigerina siphonipera* in Sample 462-17-1, 6–8 cm, of *Streptochilus pristinum* in Sample 462-16-5, 40–41 cm, of *Sphaeroidinellopsis subdehiscens*, of evolutionary forms transitional to *Globigerina nepenthes* in Sample 462-15,CC, and finally of true *Globigerina nepenthes* in Sample 462-14-4, 86–87 cm allow us to state that the middle Miocene interval from the top of Zone N12 to Zone N14 is fully represented by Section 462-17-1 through Core 462-14. In particular, Cores 462-17 and 462-16 are younger than the early Miocene previously reported.

Besides the abundant reworking of the radiolarian faunas, Sanfilippo et al. (1981, p. 495) reported anomalous first appearances of some radiolarian species within the Cenozoic sequence from Hole 462; in particular, these authors stated:

(1) The first appearance of *Podocyrtis ampla ampla* and *P. ampla fasciolata* is abnormally late in the Cenozoic sequence.

(2) The first appearance of *Thyrsocyrtis bromia* and *Calocyclas turris* is abnormally early in relation to the first appearance of *Theocampe pirum*, the *Lithocyclia aristotelis* group, *Thyrsocyrtis tetracantha*, and *Carpocanistrum azyx*.

(3) The first appearance of *Stichocorys delmontensis* and *Artostrobium doliolum* is abnormally early.

(4) The isolated, abnormally early appearance of *Siphocampe corbula, Dictyocoryne ontongensis*, and *Spongaster tetras* in Sample 462-15,CC can be explained only by downhole contamination.

In view of the new foraminiferal data some anomalous occurrences can be reinterpreted as follows (see Riedel and Sanfilippo, 1978) (Fig. 1):

• *S. delmontensis* from Core 462-20-4, 25–27 cm may belong to the autochthonous assemblage that results in an early Miocene date for Core 462-20. The Oligocene/ Miocene boundary, then, would be placed between Cores 462-20 and 462-21.

• The occurrence of *A. doliolum* in Sample 462-14-2, 86–88 cm is in agreement with the middle Miocene age inferred for this core from planktonic foraminifers.

• Finally, if occurrence of *S. tetras* in Sample 462-15,CC is the result of downhole contamination, then the appearance of *S. tetras* in Sample 462-6-3, 65–67 cm is in agreement with the Pliocene age (or younger) inferred from the appearance of *Globorotalia margaritae* in Core 462-7, the index species for the early Pliocene (Premoli Silva and Violanti, 1981).

The other anomalous occurrences mentioned by Sanfilippo et al. (1981) may be related to reworking similar to that of planktonic foraminifers.

Figure 2 shows the new age interpretations plotted against those reported in Larson, Schlanger, et al. (1981). It appears that ages derived from calcareous nannofossils are consistently older than those based on planktonic foraminifers and radiolarians.

The reinterpretation of the planktonic foraminiferal faunas emphasizes the importance of larger foraminifers as biostratigraphic indicators. In particular, at Hole 462 they are more reliable than planktonic foraminifers

in dating heavily redeposited sequences. A possible explanation is that the age-diagnostic planktonic faunas are too diluted by reworked faunas to be perceived during a routine biostratigraphic observation. In contrast, the shallow-water components, being displaced suddenly by exceptional events, were not significantly contaminated.

The main consequences of the younger ages now reported from the interval from Cores 462-34 to 462-14 are that (1) the accumulation rates plotted in table 1 by Premoli Silva and Violanti (1981) must be recalculated as reported in Table 1, and (2) the erosional events previously dated at 37 Ma, 32 Ma, 26 Ma, and 13 Ma now have an age of 30 Ma, 28 Ma, 26 Ma or younger, and 12 Ma, respectively. The erosional event at the end of the Eocene and within the early Oligocene can no longer be documented.

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Table 1. Recalculated accumulation rates of the Cenozoic sequence from Hole 462, Leg 61, according to the new age interpretations reported in Figures 1 and 2.

| Core-section		Age	Duration (m.y.)	Thickness (m)	Clay thickness (m)	Total accumulation rate (m/m.y.)	Transported material accumulation rate (m/m.y.)
1 to 3		Pleistocene	1.8	28.5	10.65	15.83	24.28
4 to 8		Pliocene?	2.2	38.0	14.15	17.30	30.38
10 to 12-5	Miocene	N16/N17	3.0	26.5	2.36	8.84	8.74
12-6 to 14-4		N14	0.8	17.5	0.08	21.87	22.00
14-5 to 16-5		N13 (top)	0.5	11.0	0.10	22.00	22.24
16,CC to 17-1		N12 (top)	0.3	3.5	1.78	11.70	14.10
17-2 to 18,CC		N7	1.0	17.0	3.15	17.00	20.22
19 to 20		N5	1.5	19.0	5.38	12.67	14.16
21 to 23-2	Oligocene	P22	1.0	22.0	0.25	22.00	22.30
23-3 to 32-1		P21b	2.0	84.0	0.17	42.00	42.27
32-2 to 34,CC		P21a	2.0	27.0	—	13.50	13.50
35 to 38,CC		P20/P18?	7.0	38.0	4.83	5.43	15.28

A.
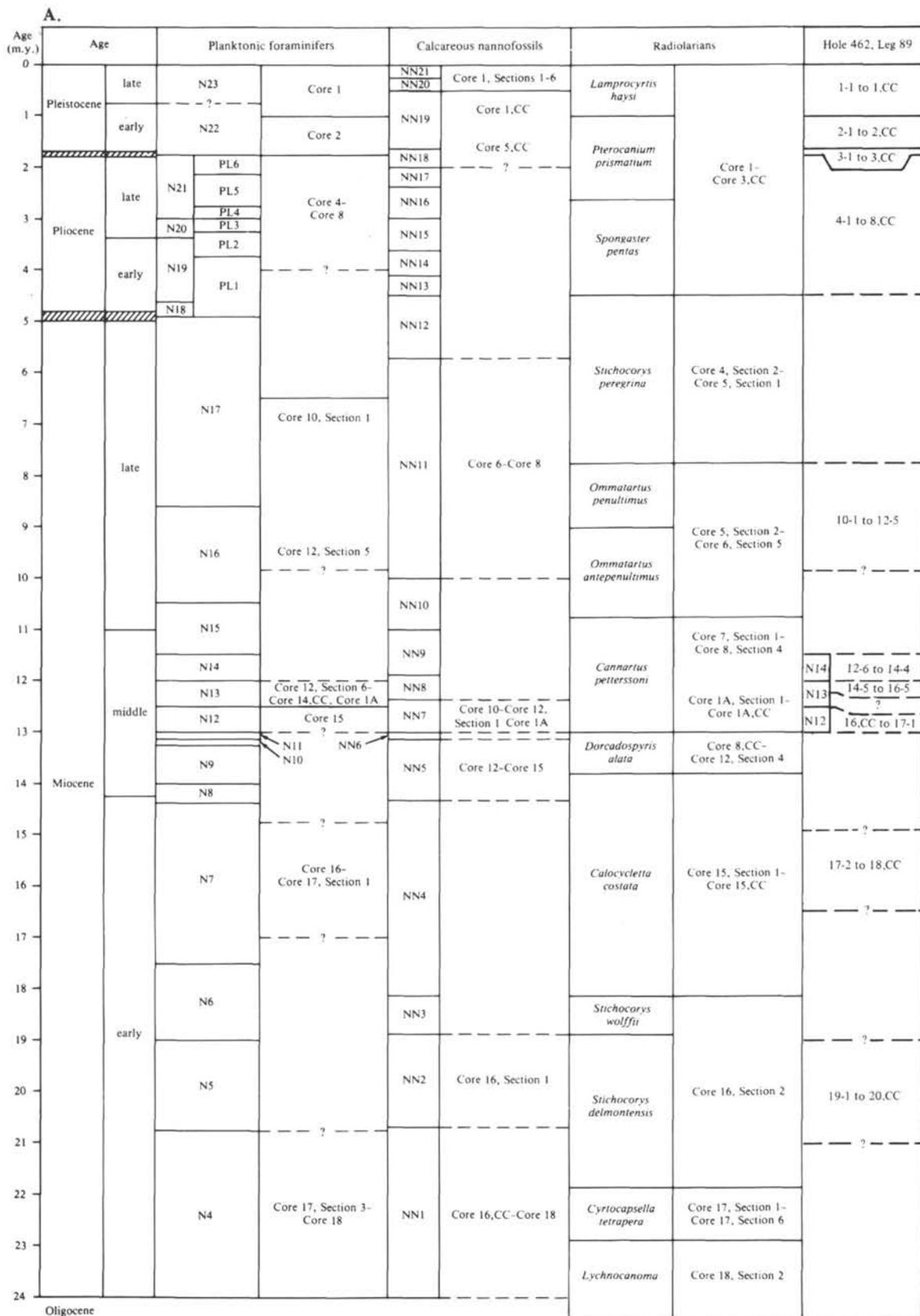
Figure 2. A–C. Neogene through Cretaceous biostratigraphy of Hole 462, Leg 61. Note the new age interpretations (last column) compared with those reported in Larson, Schlanger, et al. (1981). Hachured areas = uncertain boundaries.

B.

Figure 2 (continued).

C.

| Age (m.y.)	Age		Planktonic foraminifers	Calcareous nannoplankton	Radiolarians	Hole 462	Hole 462A	Hole 462, Leg 89
65	Maestrichtian		A. mayaroensis	M. mura	Theocapsoma comys		.	46,CC to 48,CC
			G. contusa	L. quadratus			7-1-7,CC	49-1 to 52-1
			Globotruncana gansseri					
				A. cymbiformis		46,CC–48,CC		
70			G. tricarinata			49-1–50,CC	H3-1–H3-3	
	Campanian		G. calcarata	T. trifidus	?	51-1-52-2	H3,CC-8-1	?
			G. subspinosa			52-2–52,CC		
			Globotruncana elevata	T. gothicus	Amphipyndax enesseffi	53-1-54-3		52-2 to 55,CC
75				T. aculeus		54-3-54,CC	8-1-9,CC	
				B. parca	?	55-1-55,CC		
	Santonian		Dicarinella asymetrica					
80					Artostrobium urna			57-1 to 57,CC
			Dicarinella concavata	M. furcatus		57-1-57,CC		
	Coniacian							
85								
	Turonian		Marginotruncana schneegansi	M. staurophora				
			Praeglobotruncana helvetica					
90			Whiteinella aprica	G. obliquum				
			Whiteinella baltica					
95	Cenomanian		Rotalipora cushmani	L. alatus	Dictyomitra somphedia	59-1	12-1-13-1	59-1
			R. reicheli					
			Rotalipora brotzeni					
100	Albian	VRAC	Planomalina buxtorfi	E. turriseiffeli				
		Sup.	Ticinella breggiensis					
105		M	Ticinella primula	P. cretacea				
			Hedbergella planispira					
		in	Ticinella bejaouensis					
110	Aptian		Hedbergella trocoidea	P. angustus	Acaeniotyle umbilicata			
			G. lloides algerianus					
			G. lloides ferreolensis					
			Schackoina cabri					
			Globigerinelloides maridalensis/G. blowi	C. litterarius				
			G. lloides gottisi/G. lloides duboisi					
115			Hedbergella similis		?			
	Barremian		Hedbergella sigali	M. hoschulzii	Eucyrtis tenuis		43-1-43-3 80-1	
120								

Figure 2 (continued).
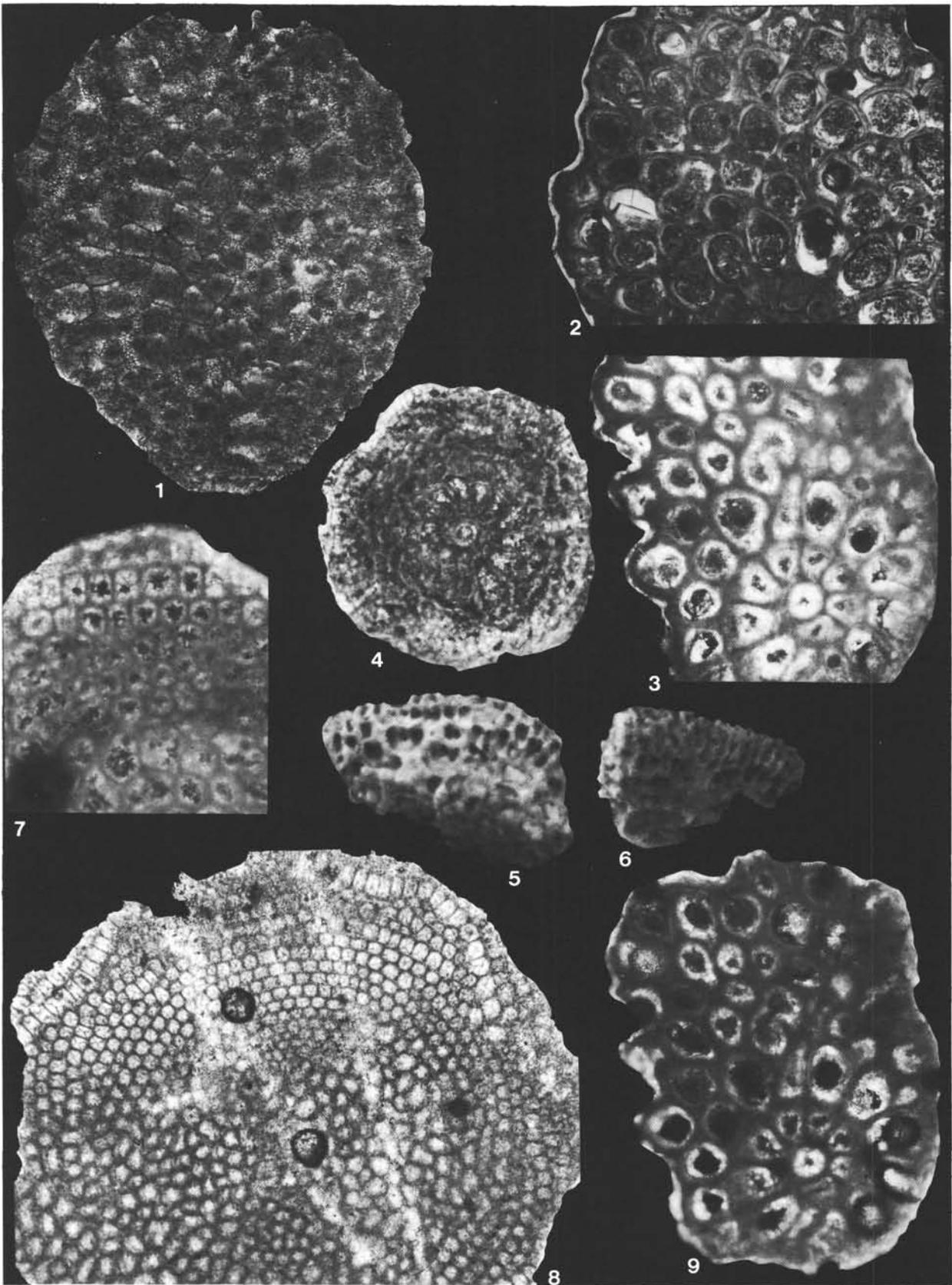
Plate 1.   **1-3, 9.** *Miogypsinoides ubaghsi* Tan. Sample 462-32-1, 5-10 cm, late Oligocene, (1) tangential section, × 75, (2) equatorial section, marginal portion, × 62, (3) equatorial section, × 60, (9) equatorial section, × 55.   **4-6.** *Vaughanina cubensis* Palmer. Sample 462-52-1, 98-101 cm, Maestrichtian, (4) equatorial section, × 50, (5-6) fragments of the marginal portion, external view, × 60.   **7-8.** *Lepidorbitoides socialis* (Leymerie). Sample 462-48 soup, late Maestrichtian, (7) detail of the marginal portion, equatorial section, × 190, (8) equatorial section, × 95.