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Ichthyolith age determinations of otherwise unfossiliferous Deep Sea Drilling Project cores

ABSTRACT

Examination of microscopic fish skeletal debris in some DSDP cores from the Pacific and the Caribbean regions permits the following approximate age assignments: In Hole 27A, cores 1-5 are probably Early to Middle Miocene. In Hole 29A, cores 2-5 are Middle to Late Miocene. At Site 38, core 2 is probably Middle Miocene, core 4 Late Oligocene or Early Miocene, and core 5 Middle Eocene to Late Oligocene. At Site 39, core 1 and the top of core 2 may be Late Oligocene or Early Miocene, with Eocene admixture. In Hole 50.1, the lower part of core 2 to the upper part of core 4 is approximately Middle Miocene. In Hole 51.1, ichthyoliths in core 2 are predominantly Eocene with some younger forms. At Site 52, cores 5 and 6 are Middle Miocene, and core 7 between Paleocene and Middle Eocene. In Hole 66.0, ichthyoliths in cores 6-9 are Campanian or Maestrichtian.

INTRODUCTION

During the last few years, studies of the stratigraphy of microscopic fish skeletal debris in pelagic sediments have resulted in the possibility of using these "ichthyoliths" for approximate age assignments of otherwise unfossiliferous samples (Doyle *et al.*, 1974; Dengler *et al.*, 1975; Dunsworth *et al.*, 1975; Doyle *et al.*, MS.*a*). In the cited papers this capability has been applied to cores collected by some recent legs of the Deep Sea Drilling Project, but earlier legs also collected a considerable number of cores which lack the better understood calcareous and siliceous microfossils, and in which the ichthyolith stratigraphy has not yet been studied. The present paper is the first in a projected series, on the stratigraphic interpretation of ichthyoliths in hitherto undated DSDP cores.

The samples investigated are from the following DSDP sites (locations indicated on text-figure 1):

27: 15°51.39'N., 56°52.76'W.; water depth 5251 m.
29: 14°47.11'N., 69°19.36'W.; water depth 4247 m.
35: 40°40.42'N., 127°28.48'W.; water depth 3273 m.
38: 38°42.12'N., 140°21.27'W.; water depth 5137 m.
39: 32°48.28'N., 139°34.29'W.; water depth 4929 m.
50: 32°24.20'N., 156°34.40'E.; water depth 4487 m.
51: 33°28.50'N., 153°24.30'E.; water depth 5981 m.
52: 27°46.30'N., 147°07.80'E.; water depth 5744 m.
66: 02°23.61'N., 166°07.31'W.; water depth 5310 m.

The relationships of the ichthyolith samples to cored intervals containing other microfossil groups useful for age determination are summarized in the site paragraphs under the heading Results and Discussion, and also in text-figure 2.

METHODS

Sediment samples were oven-dried in pre-weighed glass beakers at a temperature of 105–110°C for 24 hours, cooled and weighed. A smear slide was prepared from each sample, and the sample was disaggregated by hydrogen peroxide, usually in a 10% solution. The sediment was sieved through a 62-μ screen, first with water, followed by a Calgon solution, and finally with water again. The fraction coarser than 62 μ resulting from this treatment was mounted on glass slides in Canada balsam. Most samples yielded from 10 to 25 slides, the extremes being as few as two or three and as many as 60. In cases of extremely large yields of more than 40 slides, the coarse residues were

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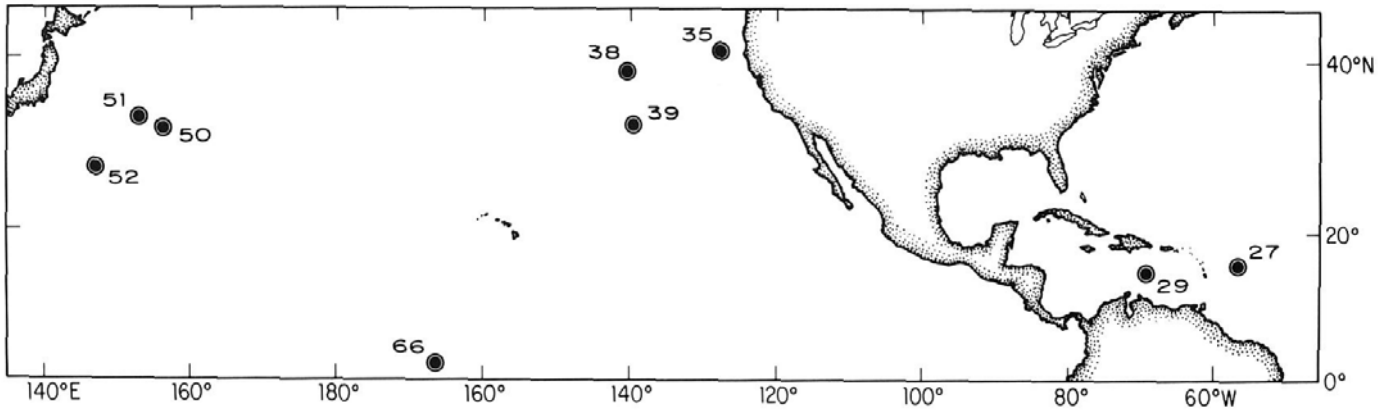


TEXT-FIGURE 1
Locations of DSDP sites sampled for this investigation.

split by a microsplitter such as is used for reducing foraminiferal samples, or by examining every third slide of the batch.

RESULTS AND DISCUSSION

The occurrence of ichthyoliths in the samples examined is shown in table 1. Sites and cores are ordered numerically. Ichthyolith subtypes are ordered according to their earliest occurrence (as determined by Doyle *et al.*, 1974; Dengler *et al.*, 1975; Dunsworth *et al.*, 1975; Doyle *et al.*, MS.*a*, MS.*b*, and some unpublished information), their ranges summarized at the top of the table. In the body of the table is shown the number of specimens of each ichthyolith form encountered in each sample. In the column on the far right are given numbers of tooth-shaped ichthyoliths per gram of dried sediment, in samples for which this information is available, and in the neighboring column is the total number of tooth-shaped ichthyoliths encountered (the majority of which are undescribed forms).

The right-hand column of table 1 shows that the concentrations of ichthyoliths in the samples for which data are available varies from about one tooth-shaped ichthyolith per gram of dry sediment to about 50/gram. With the limited data at present available, it is not possible to determine whether this variation is due to changes in the rate of ichthyolith production, changes in the rate of sediment accumulation, or disturbances such as winnowing or local dilution. At four sites (29, 50, 52, and 66) the concentrations show marked increase downward in the section. To confirm and explain this tendency will require a specially designed program involving many more samples.

Site 27

The seven samples examined from Hole 27A are from about 26 to 80 m. below the sediment surface. There are no dated samples above this section, and the first sample below it with sufficient microfossils for age determination is at 235 m. in Hole 27 (Early Miocene foraminifera with reworked Eocene, according to Bolli in Bader *et al.*, 1970, p. 607).

Ichthyoliths indicate a probable Early to Middle Miocene age for the entire 26–80 m. interval, and the persistence of Miocene to 235 m. requires a rate of sediment accumulation of at least 15.7 m./million years using the time-scale of Berggren and Van Couvering (1974). This rate is high compared to the estimate of 10 m./million years by Benson *et al.* in Bader *et al.* (1970, p. 670), but seems consistent with the sandy and silty nature of the sometimes turbiditic sediments encountered (Bader *et al.*, 1970, pp. 119–123).

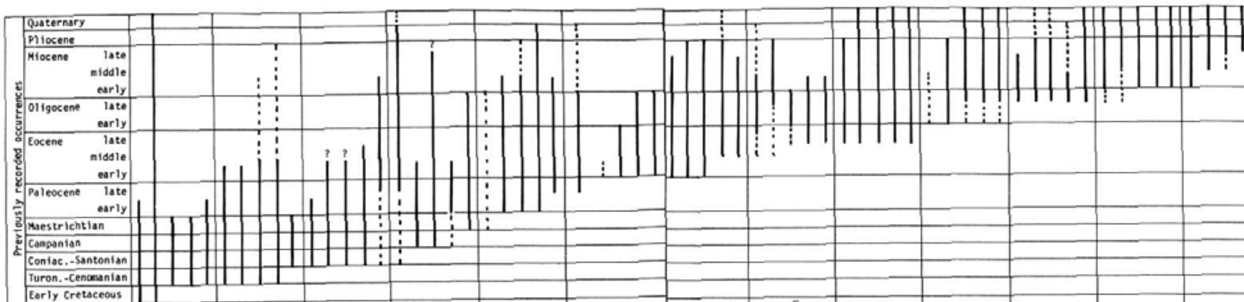
Site 29

The three samples examined from Hole 29A are from about 50 to 78 m. below the sediment surface. The oldest fossil assemblages above this section are late Miocene foraminifera at about 47 m. in Hole 29 (according to Bolli in Bader *et al.*, 1970, p. 609). Foraminifera and calcareous nannofossils in Cores 1–3 (from 57–87 m.) in Hole 29B indicate Late Miocene (according to both Hay and Bolli in Bader *et al.*, 1970, pp. 486 and 609, respectively). Ichthyoliths at corresponding depths in Hole 29A indicate an approximately conformable age of Middle to Late Miocene.

Site 35

Five samples from Hole 35.0 were examined for ichthyoliths: 35.0–12–6, 42–50 cm.; 35.0–13–4, 100–108 cm.; 35.0–14–4, 70–78 cm.; 35.0–15–4, 120–128 cm.; 35.0–16–2, 130–138 cm. In the Initial Report (McManus *et al.*, 1970, pp. 170–172), this section was suspected of being Pleistocene, and it was thought that the ichthyoliths might provide additional

TABLE 1
Numbers of ichthyoliths in the DSDP samples examined. The ranges of subtypes shown at the top of the table represent a synthesis of previously reported results, together with some hitherto unpublished information (Doyle *et al.*, MS.*a*, MS.*b*; Doyle and Riedel, in preparation). In the body of the table is shown the number of specimens of each ichthyolith form encountered in each sample. A number followed by a question mark is used to indicate that all specimens found are broken so as to render identification doubtful. For further explanation, see first paragraph under the heading "Results and Discussion."



DSDP Samples \ Subtypes	Triangular toothed	Triangle complex transverse line	Striated blunt triangle	Triangle long inline	Triangle square inline	Prominent polygon	Prominence with wyeline	Plain and lined lanceolate	Asymmetrical peaks narrow depression	Blunt triangle dendritic inline	Wide triangle projection	Triangle concave base	Narrower crescent	Five peaks flared base	Triangle medium wing	Triangle with triangular projection	Pointed and skirted	Flexed triangle shallow inbase	Short triangle bowed inline	Giant lanceolate	Kite-shaped longitudinal line	Narrow triangle cross-hachured	Wide triangle	Triangle sigmoid	Triangle pointed margin ends	Triangle transverse line across	Triangle broad wing	Small triangle crenate margin	Rhombus smooth margin	Triangle short wing
27A-1-1, 80-98cm		1														2							1							
27A-1-6, 46-58cm		1														2							1							
27A-2-2, 130-140cm		3																												
27A-3-3, 60-70cm		2																					1							
27A-4-1, 110-120cm		3														1														
27A-4-5, 120-130cm		2						1										2												
27A-5-5, 40-50cm		4																1												
29A-2-1, 65-75cm		7																3					1							
29A-4-1, 50-60cm		9														3		1					1							
29A-5-1, 54-67cm		7							2							2		4					3		1					
38-2-3, 65-67cm																														
38-2-6, 140-142cm																														
38-3-1, 30-32cm															1															
38-3-6, 120-122cm																2														
38-4-2, 20-22cm		1														1														
38-4-5, 135-140cm									1																	1?/0				
38-5-1, 30-32cm		1											1?		2	3		1?								1/1?				1
38-5-3, 145-147cm		1														10						2			3					
38-6-1, 20-22cm																4														
39-1-6, 130-138cm		5												1	3	62		4				6			1	0/1				5
39-2-1, 90-98cm		4							6						1	41						51	1		1	4/0				1
39-2-6, 70-78cm		13						2	23				1			60		2				22			1			2		1
50.1-2-5, 120-128cm		9																3					1							
50.1-3-2, 30-38cm		10														1		1												
50.1-3-6, 70-78cm		5							1							6		8				1	2							
50.1-4-1, 70-78cm		16							1						3	6		7				2?	1	1		0/1?				1
51.1-2-2, 20-28cm		17						2	4					1	1	51		11				30			1		1		1	6
51.1-2-2, 120-128cm		8						1	2			2?		1?		20		2	1			3			2	0/1				
52-5-4, 80-88cm																		4												
52-6-1, 130-138cm		2											1			1		9					1							
52-7-2, 70-78cm		9			1	6	1	1	9				1	1	1	67		9	1	1		10		1	3	0/4		5		1
66-6-3, 50-54cm			2	1	1	4			1	1											1									
66-7-3, 80-88cm			3		2	1	2?	1?	9	1	1		2																	
66-8-2, 50-54cm	2	1	4	1		2			2								1				2									
66-9-3, 70-78cm	2		5	3	2	2	2	2	16								2				4									

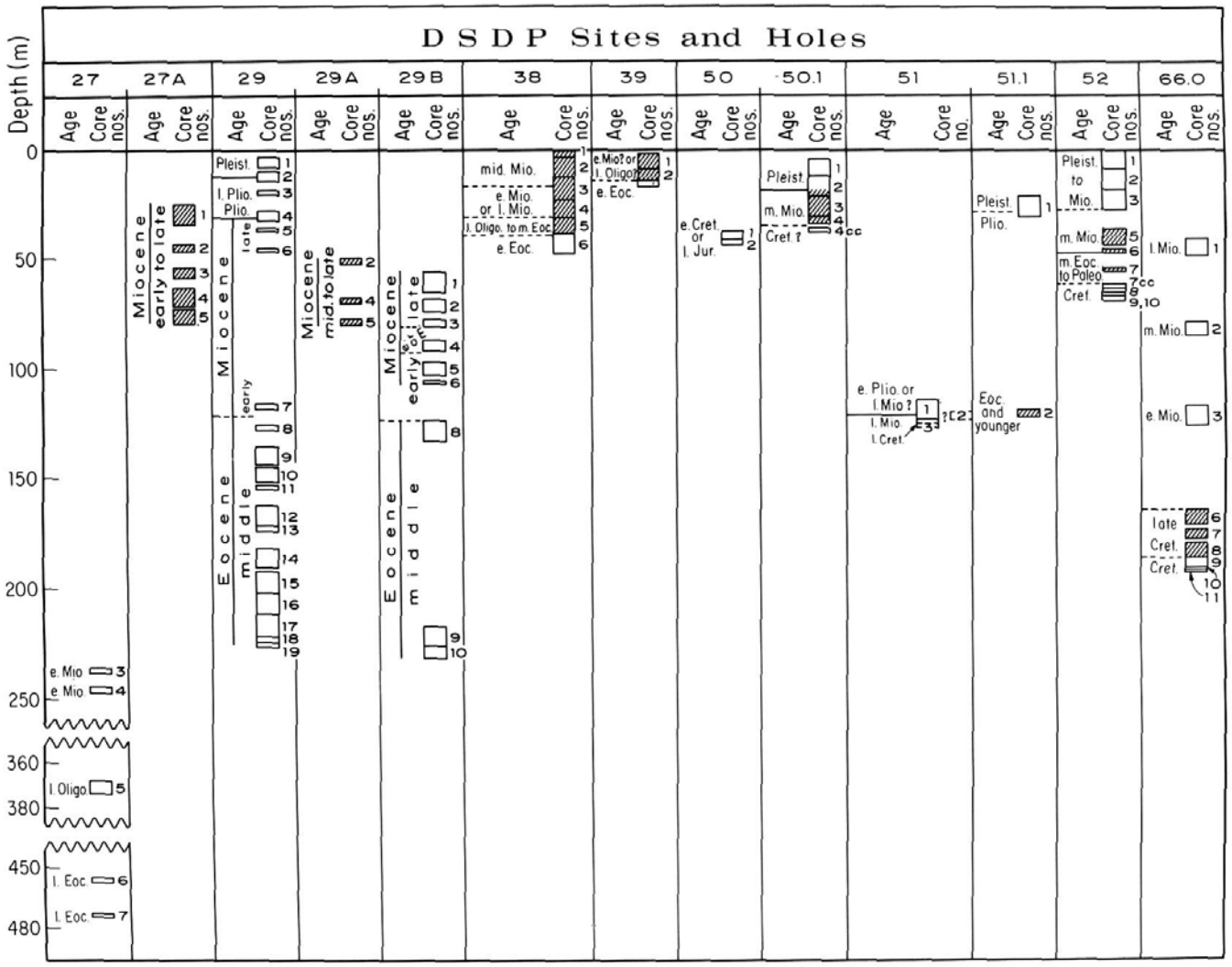
DSDP Samples \ Subtypes	Triangle one canal above	Triangle hooked margin	Wide triangle straight inbase	Triangle with canals	Triangle double flex	Triangle with base angle	Small circular center	Short side peaks differentiated margin	Curved triangle inline constricted	Flexed triangle shallow inbase ≥120	Triangle crenulate	Rectangular saw-toothed	Curved triangle pointed margin	Flexed triangle 102-112	Rounded apex triangle	Three similar peaks	Triangle crenulate with canals	Triangle with high inline apex	Narrow triangle straight inbase	Rectangular serially saw-toothed	Asymmetrical peaks wide depression	Small dendritic few radiating lines	Small dendritic many radiating lines	Flexed triangle 115-118	Large with numerous lines	Circular with line across	Short rectangular with striations	Flexed narrow triangle 120-128	Long rectangle with striations	Small triangle long striations	Short triangle stepped margin	Two triangles	Elliptical with line across	Long triangle stepped margin	Total number of tooth-shaped forms (≥8,9 / bl,5)	Number of tooth-shaped ichthyoliths per gram of dried sample
27A-1-1, 80-98cm						1								1	1			1									2				1				108	2.01
27A-1-6, 46-58cm														1	1							2		1			1	1				1		1	120	1.86
27A-2-2, 130-140cm												3								1		4			2		2			2					71	1.24
27A-3-3, 60-70cm				1?		1	1		1			4							2					1											117	1.86
27A-4-1, 110-120cm							2			1												2						3	1	1					48	0.81
27A-4-5, 120-130cm							6					2										4								1	1				77	1.25
27A-5-5, 40-50cm			1				3					1						2				4		1?	1		1			1	3				108	1.10
29A-2-1, 65-75cm				1?		1						3	1	2	1		1													3	1				203	3.63
29A-4-1, 50-60cm			2	1			2					2			1			1	2	2		1				2	5				3			3	333	5.86
29A-5-1, 54-67cm	1?	1?	6	1		2						8			3		1	6	1	1		1		1		5	4		2	9	1		6		609	11.77
38-2-3, 65-67cm		1																												1					8	
38-2-6, 140-142cm		1																		1												1			29	
38-3-1, 30-32cm																																			16	
38-3-6, 120-122cm																																			23	
38-4-2, 20-22cm									1									1																	22	
38-4-5, 135-140cm																																			13	
38-5-1, 30-32cm				1																															59	
38-5-3, 145-147cm	1																					1													67	
38-6-1, 20-22cm																																			25	
39-1-6, 130-138cm			3																			4													1162	
39-2-1, 90-98cm		1			1?																1					1		1		1					937	
39-2-6, 70-78cm							2															2													1698	
50.1-2-5, 120-128cm		1	1			1						3		1	3			1		2						4	3	1	1				7		151	5.71
50.1-3-2, 30-38cm						1						1	1	3	2			1		2				1		6			1		2		6		313	9.95
50.1-3-6, 70-78cm	1?	1	2	1			1			1		1	4	11	1			1		14		3	1?	2		9	2			3	1	1?			698	14.39
50.1-4-1, 70-78cm		1	6	1		1	6			6	1	16	1?	8	4		1	1	1			20		4	1?	11	1	14		1	1	4	2		1147	19.73
51.1-2-2, 20-28cm	1		3	3						1		5	2?		1								1												2491	46.61
51.1-2-2, 120-128cm	1?						1	1		2		3			2									1				1							724	12.25
52-5-4, 80-88cm		1?			1	2						1	2	5	4			1?		4		2		1		2	3		1	2	3		1		259	8.20
52-6-1, 130-138cm		2?	1	1		1	1			1			1	6	3			6	2	1		2		2		11	2	3	2		4	1			353	10.20
52-7-2, 70-78cm	1?	2	4		4							3				1																			1460	27.46
66-6-3, 50-54cm																																			36	1.79
66-7-3, 80-88cm																																			162	8.27
66-8-2, 50-54cm																																			389	
66-9-3, 70-78cm																																			648	

evidence. None were found, however, probably because of their dilution by rapidly accumulated hemipelagic sediment.

Site 38

The nine samples examined from Hole 38 are from about 3 to 40 m. below the sediment surface. The only paleontological age assignment previously made at this site is a determination of Early Eocene calcareous nannofossils and foraminifera at 39–48 m. (McManus *et al.*, 1970, pp. 276–278).

Ichthyoliths indicate that Core 2 is probably Middle Miocene, Core 4–2 is probably Late Oligocene or Early Miocene, and Core 5 (ignoring the single specimen of *Small dendritic few radiating lines*, which usually occurs in greater numbers when it is *in situ*) may be Middle Eocene to Late Oligocene. Thus it seems likely that no long hiatus in sedimentation occurred at this site.



TEXT-FIGURE 2
Stratigraphic relations of samples indicated by ichthyolith assemblages (hachured rectangles). Cores dated by other microfossils are shown as open rectangles. In the "Age" column, e = early, m = middle and l = late.

Site 39

The three samples examined from Hole 39 are from about 7 to 16 m. below the sediment surface. The only paleontological age assignment previously made at this site is a determination of Early Eocene calcareous nannofossils and foraminifera at 12–17 m. (McManus *et al.*, 1970, p. 299).

The ichthyolith assemblages in Core 1 and the top of Core 2 are consistent with an age determination of Late Oligocene to Early Miocene with Eocene admixture. *Small dendritic few radiating lines*, previously recorded only in sediments of Late Oligocene age and younger, here occurs in the lower part of Core 2 together with Early Eocene calcareous nannofossils and a number of ichthyoliths characteristic of the Early Eocene.

Site 50

The four samples examined from Hole 50.1 are from about 21 to 33 m. below the sediment surface. The oldest fossil assemblages determined in the upper part of this hole are Pleistocene or possibly Pliocene radiolarians and calcareous nannofossils at about 20 m. (Fischer *et al.*, 1971, p. 214), and the first samples below it with sufficient microfossils for age determination are at about 36 m. in Hole 50.1 and 38–42 m. in Hole 50.0 (probably Cretaceous radiolarians according to Kling, and earliest Cretaceous or latest Jurassic calcareous nannofossils and foraminifera according to Bukry and to Douglas, in Fischer *et al.*, 1971, pp. 221, 975, and 1035, 1036, respectively).

Ichthyoliths indicate an age of probably Middle Miocene for core-sections 2-5 and 3-2, and an age near the boundary between Early and Middle Miocene for core-sections 3-6 and 4-1. Thus there is evidently a long hiatus between Early Cretaceous and Middle Tertiary sediments at this site, and possibly another between Middle Miocene and Pliocene.

Site 51

The two samples examined from Hole 51.1 are from about 125 m. below the sediment surface. Core recovery at this site was not satisfactory, and the authors of the Initial Report were not able to interpret the section convincingly (Fishcer *et al.*, 1971, p. 277). Cretaceous microfossils were encountered at a depth of about 125–132 m. in Hole 51.0 (Fischer *et al.*, 1971, pp. 235, 237).

The ichthyolith assemblages comprise predominantly Eocene forms, but there are single specimens of the younger *Small dendritic many radiating lines, Flexed triangle 115–118*, and *Flexed narrow triangle 120–128* which may be caved from higher in the hole. None of the ichthyoliths indicate a Cretaceous component.

Site 52

The three samples examined from Hole 52 are from about 42 to 60 m. below the sediment surface. The oldest fossil assemblage above this section comprises Late Miocene to Middle Pleistocene radiolarians at about 18–27 m. (Kling in Fischer *et al.*, 1971, p. 1075). The first sample below it with sufficient microfossils for age determination is at about 61 m. (probably Cretaceous radiolarians according to Fischer *et al.*, 1971, p. 282).

The ichthyoliths in core-sections 5-4 and 6-1 indicate Middle Miocene, and those in core-section 7-2 are between Paleocene and Middle Eocene in age. Because of the short stratigraphic distance between these samples, it is evident that Late Eocene through Early Miocene sediments are either missing or extremely thin at this site.

Site 66

The four samples examined from Hole 66.0 are from about 170 to 190 m. below the sediment surface. The oldest fossil assemblages above this section are radiolarians indicating latest Oligocene at about 126 m. (Riedel and Sanfilippo in Winterer *et al.*, 1971, pp. 1533, 1561), and the first sample below it with sufficient microfossils for age determination is at about 190 m. (radiolarians indicating perhaps Turonian-Cenomanian according to Foreman in Winterer *et al.*, 1971, p. 1682).

The ichthyoliths indicate an age of Campanian or Maestrichtian for the interval examined. This raises a minor conflict with the radiolarian interpretation of Core 9, which we are not yet able to resolve.

LIST OF TAXA

Below are listed, in numerical order, ichthyolith subtypes used in the course of this study, with bibliographic references sufficient to indicate the concept associated with each name-description. Subtypes described by Ramsey *et al.* (1976) have not been used because their upper stratigraphic limits have not yet been determined. Apart from this, all described ichthyoliths have been looked for, and any omitted from the list below have not been found. Some differences between headings and their synonymy references correct earlier manuscript and typographic errors, and others result from modification of the descriptive key in successive publications.

Subtype **a2/b2/c3/d1/e1/f1/g1/h3/i1/j1** Doyle *et al.*
Three similar peaks

Subtype *a2/b2/c3/d1/e1/f1/g1/h3/i1/j1* Doyle *et al.*, 1974, p. 836, pl. 1A, fig. 1; pl. 2A, fig. 1.

Remark: The occurrence of this form in 52–7–2 evidently extends its range downward into the Eocene or earlier.

Subtype **a2/b2/c3/d1/e1/f3/g1/h3/i1/j1,2** Doyle *et al.*
Short side peaks differentiated margin

Subtype *a2/b2/c3/d1/e1/f3/g1/h3/i1/j1,2* Doyle *et al.*, 1974, p. 836, pl. 2A, figs. 2-7.

Subtype **a2/b2/c5/d3/e1/f1/g1/h4/i1/j1,2** Doyle *et al.*
Five peaks flared base

Subtype *a2/b2/c5/d3/e1/f1/g1/h4/i1/j1,2* Doyle *et al.*, 1974, p. 844, pl. 2B, figs. 6-8.

Subtype **a3,4/b1/c1,2,3/d5,(4+5)/e2/f2/g1+8/h2** Doyle *et al.*
Prominence with wye-line

Subtype *a3,4/b1/c1,2,3/d5,(4+5)/e2/f2/g1+8/h2* Doyle *et al.*, MS.*a*, pl. 1, figs. 1-4.

Subtype **a3,4/b1,2/c2,3,4/d1,2,3/e1/f2+3/g1+8/h1** Doyle *et al.*
Pointed and skirted

Subtype *a3,4/b1,2/c2,3,4/d1,2,3/e1/f2+3/g1+8/h1* Doyle *et al.* MS.*a*, pl. 1, figs. 8-11.

Subtype **a3/b1/c3/d2/e2/f2+3/g1+2** Doyle *et al.*
Kite-shaped longitudinal line

Subtype *a3/b1/c3/d2/e2/f2+3/g1+2* Doyle *et al.*, 1974, p. 844, pl. 2C, figs. 1, 2.

Subtype **a3/b1/c4/d1,3,4/e0/f1,(2+3)/g1+2** Doyle *et al.*
Rhombus smooth margin

Subtype *a3/b1/c4/d1,3,4/e0/f1,(2+3)/g1+2* Doyle *et al.*, 1974, p. 844, pl. 2D, figs. 1-3.

Subtype **a3,5/b8/c5,6,7,8/d0.70-1.0/e60-100** Doyle *et al.*
Prominent polygon

Subtype *a3.5/b8/c5,6,7,8/d0.70-1.0/e60-100* Doyle *et al.*, MS.*a*, pl. 1, figs. 5-7.

Subtype **a4/b1/c1/d3/e0/f2+3/g1+2** Doyle *et al.*
Giant lanceolate

Subtype *a4/b1/c1/d3/e0/f2+3/g1+2* Doyle *et al.*, 1974, p. 844, pl. 2E, figs. 1-7.

Subtype **a4/b1,2/c2/d1,2,3/e2/f1,(2+3)/g1+2/h1** Doyle *et al.*
Plain and lined lanceolate

Subtype *a4/b1,2/c2/d1,2,3/e2/f1,(2+3)/g1+2/h1* Doyle *et al.*, MS.*a*, pl. 1, figs. 12-15.

Subtype **a5,6/b3/c1/d1/e2** Doyle *et al.*
Small dendritic few radiating lines

Subtype *a5,6/b3/c1/d2/e2* Doyle *et al.*, 1974, p. 844, pl. 1B, figs. 1-3; pl. 2F, figs. 5, 6.

Subtype **a5,6/b3/c1/d1/e3** Doyle *et al.*
Small circular center

Subtype *a5,6/b3/c1/d3/e3* Doyle *et al.* 1974, p. 845, pl. 1B, figs. 8, 9; pl. 2F, fig. 7.

Subtype **a5,6/b3/c1/d2/e2** Doyle *et al.*
Small dendritic many radiating lines

Subtype *a5,6/b3/c1/d2/e2* Doyle *et al.*, 1974, p. 845, pl. 1B, figs. 4-7.

Subtype **a5,6/b3/c2/d1,2/e1** Doyle *et al.*
Large with numerous lines

Subtype *a5,6/b3/c2/d1,2/e1* Doyle *et al.*, 1974, p. 845, pl. 1B, figs. 10-12; pl. 2F, figs. 8, 9.

Subtype **a5/b4** Doyle *et al.*
Circular with line across
Plate 1, figures 1, 2

Subtype *a5/b4* Doyle *et al.*, 1974, p. 845, pl. 1C, figs. 1-15.

Remarks: This name is here restricted to forms in which the greatest diameter is no more than ×1.15 the length of the smallest diameter.

The illustrated specimen is closer to elliptical than most.

Subtype **a6/b4** Doyle *et al.*
Elliptical with line across
Plate 1, figure 3

Subtype *a6/b4* Doyle *et al.*, 1974, p. 845, pl. 1C, figs. 16-23.

Remarks: This name is here restricted to forms in which the major axis of the outline is more than ×1.15 the length of its minor axis, thus defining the difference between elliptical forms (a6) and subcircular ones (a5).

The illustrated form is closer to circular than most.

Subtype **a7/b1/c1/d1/e1** Doyle *et al.*
Two triangles
Plate 1, figures 4, 5

Subtype *a7/b1/c1/d1/e1* Doyle *et al.*, 1974, p. 845, pl. 1D, fig. 1.

Remarks: Some specimens from core-section 50.1-4-1 have one of the triangles curved as illustrated (plate 1, figure 5).

Another similar form, but not assignable to this subtype because of the very long base, is illustrated in plate 1, figure 6.

Subtype **a7/b1/c2/d3/e3** Doyle *et al.*
Rectangular saw-toothed

Subtype *a7/b1/c2/d3/e3* Doyle *et al.*, 1974, p. 845, pl. 1D, figs. 3-8; pl. 2G, figs. 4-8 (in part).

Subtype **a7/b1/c2/d3/e6** Dunsworth *et al.*
Rectangular serially saw-toothed
Plate 1, figure 7

Subtype *a7/b1/c2/d3/e6* Dunsworth *et al.*, 1975, p. 856, pl. 1, fig. 3.
Subtype *a7/b1/c2/d3/e3* Doyle *et al.*, 1974, p. 845, pl. 1D, figs. 3-8; pl. 2G, figs. 4-8 (in part).

Remarks: Plate 1, figure 7 illustrates the minimum angularity of projections, in forms recorded under this name.

Subtype **a7/b6/c1** Doyle *et al.*
Asymmetrical peak wide depression
Plate 1, figure 8

Subtype *a7/b6/c1* Doyle *et al.*, 1974, p. 845, pl. 1D, figs. 9, 10; pl. 2G, fig. 9.

Remarks: Although the specimen illustrated in Plate 1, figure 8 appears to be different from previously illustrated specimens, it conforms to the name-description and is therefore admitted.

Subtype **a7/b6/c3** Doyle *et al.*
Asymmetrical peaks narrow depression

Subtype *a7/b6/c3* Doyle *et al.*, 1974, p. 845, pl. 1E, figs. 1, 2; pl. 2H, figs. 1-4.

Subtype **a8/b1,5/c1/d1/e102-112/f26-36** Doyle *et al.*
Flexed triangle 102-112

Subtype *a8/b1,5/c1/d1/e102-112/f26-36* Doyle *et al.*, 1974, p. 845, pl. 1E, figs. 3, 4; pl. 2H, fig. 5.

Subtype **a8/b1,5/c1/d1/e115-118/f25-35** Doyle *et al.*
Flexed triangle 115-118

Subtype *a8/b1,5/c1/d1/e115-118/f25-35* Doyle *et al.*, 1974, p. 845, pl. 1E, fig. 5; pl. 2H, figs. 6, 7.

Subtype **a8/b1,5/c1/d1/e120-128/f20-26** Doyle *et al.*
Flexed narrow triangle 120-128

Subtype *a8/b1,5/c1/d1/e120-128/f20-26* Doyle *et al.*, 1974, p. 845, pl. 1E, figs. 6, 7; pl. 2H, figs. 8, 9.

Subtype **a8/b1,5/c1/d2/e80-140/f26-36** Doyle *et al.*
Flexed triangle shallow inbase

Subtype *a8/b1,5/c1/d2/e80-140/f26-36* Doyle *et al.*, 1974, p. 846, pl. 1E, fig. 8; pl. 2H, figs. 10-13.
cf. *Fish Tooth Type D-5*, Helms and Riedel, 1971, p. 1713, pl. 1, fig. 12.

Subtype **a8/b1,5/c1/d2,3/e≥120/f≤25 + a9/b1/c13/d1/e1/f4+[1,(9+13+15)]/g1/h2,3,4,5/i2/j2/k4,8/l0.25-0.45/m2.0-3.0/n2,3,4,6,7/o2/p1/q1** Dunsworth *et al.*, **emend.** herein
Flexed triangle shallow inbase ≥120

Subtype *a8/b1,5/c1/d2,3/e≥120/f≤25* Dunsworth *et al.*, 1975, p. 857, pl. 1, figs. 4, 5.

Remarks: The name-description is emended because in some of our specimens, as well as in one illustrated by Dunsworth *et al.* (1975, pl. 1, fig. 4), the width of the flexure is less than 20% of the maximum width of the tooth.

Subtype **a8/b1/c2/d2,3/e60-100/f20-35** Dunsworth *et al.*
Triangle double flex

Subtype *a8/b1/c2/d2,3/e60-100/f20-35* Dunsworth *et al.*, 1975, p. 857, pl. 1, fig. 6.

Subtype **a9/b1/c1/d1/e1/f1,4/g1/h1,2/i2,6,8/j2,6,8/k2,3/l<0.2/m1.5-2/n3,4/o1/p1,3** Doyle *et al.*
Triangle with high inline apex

Subtype *a9/b1/c1/d1/e1/f1,4/g1/h1,2/i2,6,8/j2,6,8/k2,3/l<0.2/m1.5-2/n3,4/o1/p1,3* Doyle *et al.*, 1974, p. 846, pl. 1F, figs. 1-3; pl. 2I, figs. 1, 2.

Remarks: In the original formulation of the system of descriptors (Doyle *et al.*, 1974, p. 831), the sketches illustrating *m0* should have included one similar to the central sketch for *l0*, and indicating that the maximum width is to be measured above any concavity of the base. That requirement is here formalized.

Subtype **a9/b1/c1/d1/e1,2/f1/g1/h1,2/i2/j2/k2/l0.2-0.4/m1.6-2.0/n4,5/o1/p1,3** Doyle *et al.*
Narrow triangle straight inbase

Subtype *a9/b1/c1/d1/e1,2/f1/g1/h1,2/i2/j2/k2/l0.2-0.4/m1.6-2.0/n4,5/o1/p1,3* Doyle *et al.*, 1974, p. 846, pl. 1F, figs. 4-6; pl. 2I, figs. 3, 4.

Subtype **a9/b1/c1/d1/e1/f1/g1/h1,2,3/i2,3/j2,3/k2/l0.25-0.45/m1-1.5/n4,5/o1/p3** Doyle *et al.*
Wide triangle straight inbase

Subtype *a9/b1/c1/d1/e1/f1/g1/h1,2,3/i2,3/j2,3/k2/l0.25-0.45/m1-1.5/n4,5/o1/p3* Doyle *et al.*, 1974, p. 846, pl. 1F, figs. 7-9; pl. 2I, figs. 5-8.

Subtype **a9/b1/c1/d1/e1/f1/g1/h2,4,5/i2,6/j2/k8/l0.2-0.3/m1.9-2.5/n6,7,8/o1,3/p1,2/q1** Doyle *et al.*
Triangle concave base

Subtype *a9/b1/c1/d1/e1/f1/g1/h2,4,5/i2,6/j2/k8/l0.2-0.3/m1.9-2.5/n6,7,8/o1,3/p1,2/q1* Doyle *et al.*, MS.*a*, pl. 1, figs. 16, 17.

Remarks: The assemblages from 39-2-1, 39-2-6, and 51.1-2-2 include a form illustrated here (plate 1, figure 9) resembling *Triangle concave base*, but too narrow to be included in this subtype and with the base of the inline squared instead of curved.

Subtype **a9/b1/c1/d1/e1/f1/g1/h3,4,5/i3/j3/k8/l0.2-0.8/m<1/n4-8/o1/p3** Dunsworth *et al.*
Wide triangle

Subtype *a9/b1/c1/d1/e1/f1/g1/h3,4,5/i3/j3/k8/l0.2-0.8/m<1/n4-8/o1/p3* Dunsworth *et al.*, 1975, p. 857, pl. 1, figs. 17, 18.

Subtype **a9/b1/c1/d1/e1/f1/g1/h5/i2,6/j2,3/k7,8/l0.5-2.0/m2.5-4.9/n2/o1/p2/q1** Doyle *et al.*
Triangle long inline

Subtype *a9/b1/c1/d1/e1/f1/g1/h5/i2,6/j2,3/k7,8/l0.5-2.0/m2.5-4.9/n2/o1/p2/q1* Doyle *et al.*, MS.*a*, pl. 2, figs. 1-3.

Subtype **a9/b1/c1/d1/e1/f1/g1/h5/i2,3/j3/k3/l0.4-0.6/m1.0-1.39/n2,6/o1/p3/q1** Doyle *et al.*
Short triangle bowed inline

Subtype *a9/b1/c1/d1/e1/f1/g1/h5/i2,3/j3/k3/l0.4-0.6/m1.0-1.39/n2,6/o1/p3/q1* Doyle *et al.*, MS.*a*, pl. 2, figs. 4-6.

Subtype **a9/b1/c1/d1/e1/f1,3/g1/h5/i9/j9/k8/l0.5-0.25/m≥2.75/n2/o1/p2 + a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k9/l9/m1,4/n1,3/o9/p3/q0.5-0.25/r≥2.75/s0/t2/u1** Dunsworth *et al.*, **emend.** herein.
Triangle sigmoid

Subtype *a9/b1/c1/d1/e1/f1,3/g1/h5/i9/j9/k8/l0.75-0.95/m≥2.75/n2/o1/p2 + a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k9/l9/m1,4/n1,3/o9/p3/q0.75-0.95/r≥2.75/s0/t2/u1* Dunsworth *et al.*, 1975, p. 857, pl. 1, figs. 11, 12; pl. 2, fig. 14.

Remarks: In the original description of this form, the extent of the inline was evidently measured from the base of the tooth rather than from the tip, giving an erroneous value for *l* and *q*.

Subtype **a9/b1/c1/d1/e1/f2/g1/h1,2,3/i6/j4/k2,4/l0.2-0.4/m1-2/n3,4,5/o2/p1** Doyle *et al.*
Curved triangle pointed margin
Plate 1, figure 10

Subtype *a9/b1/c1/d1/e1/f2/g1/h1,2,3/i6/j4/k2,4/l0.2-0.4/m1-2/n3,4,5/o2/p1* Doyle *et al.*, 1974, p. 846, pl. 1G, figs. 3, 4; pl. 2J, figs. 1-3.

Remarks: The specimen illustrated here has some basal material (missing in the examples on which the original description was based) below a straight transverse line, and thus might more appropriately be assigned to Type *a9/b5*.

Subtype **a9/b1/c1/d1/e1/f4/g1/h2,3,4,5/i2,3/j2,3/k11/l0/m0/n4,5,7,8/o1/p3/q1 + a8/b1,5/c1/d3/e80-125/f35-60** Doyle *et al.*, **emend.** herein
Triangle square inline
Plate 1, figure 11

Subtype *a9/b1/c1/d1/e1/f4/g1/h2,3,4,5/i2,3/j2,3/k11/l0/m0/n4,5,7,8/o1/p3/q1 + a8/b1,5/c1/d3/e80-115/f35-60* Doyle *et al.*, MS.*a*, pl. 2, figs. 7-11.

Remarks: A specimen found during this investigation has an angle *e* of 122° but is otherwise identical with this subtype. Therefore the name-description is modified to accommodate it.

Subtype **a9/b1/c1/d1/e1/f6/g1/h5/i2/j2/k0,5/l0.75-1/m1.5-1.8/n2/o1/p1 + a9/b5/c1/d1/e1/f1/g1/h1/i8/j1/k2/l2/m2/n2/o2/p0,6/q0.75-1/r1.5-1.8/s0/t1/u1** Dunsworth *et al.*
Small triangle long striations

Subtype *a9/b1/c1/d1/e1/f6/g1/h5/i2/j2/k0,5/l0.75-1/m1.5-1.8/n2/o1/p1 + a9/b5/c1/d1/e1/f1/g1/h1/i8/j1/k2/l2/m2/n2/o2/p0,6/q0.75-1/r1.5-1.8/s0/t1/u1* Dunsworth *et al.*, 1975, p. 857, pl. 1, figs. 13, 14.

Remarks: The assemblages in 39-2-1 and 29A-5-1 include specimens (plate 1, figures 12, 13) similar to this subtype, but differing in being too narrow or too broad.

Subtype **a9/b1/c1/d1/e1/f9 + (12,13) + 14/g1/h4,5/i2,3/j2,3/k11/l0/m0.9-1.4/n3,4,9/o1/p3/q1** Doyle *et al.*
Striated blunt triangle

Subtype *a9/b1/c1/d1/e1/f9 + (12,13) + 14/g1/h4,5/i2,3/j2,3/k11/l0/m0.9-1.4/n3,4,9/o1/p3/q1* Doyle *et al.*, MS. *a*, pl. 2, figs. 15-18.

Subtype **a9/b1/c3/d1,3/e1,2/f1,2/g1/h1,2,3/i2,6/j2,3,6/k2/l<0.3/m1-2/n4,5/o1/p1,3** Doyle *et al.*
Triangle crenulate

Subtype *a9/b1/c3/d1,3/e1,2/f1,2/g1/h1,2,3/i2,6/j2,3,6/k2/l<0.3/m1-2/n4,5/o1/p1,3* Doyle *et al.*, 1974, p. 846, pl. 1G, figs. 1, 2; pl. 2I, figs. 9, 10.

Subtype **a9/b1/c5/d1/e1/f1,4,5/g1/h1,3/i2,3/j6/k2/l<0.4/m1.5-2/n1/o1/p1** Doyle *et al.*
Triangle short wing

Subtype *a9/b1/c5/d1/e1/f1,4,5/g1/h1,3/i2,3/j6/k2/l<0.4/m1.5-2/n1/o1/p1* Doyle *et al.*, 1974, p. 846, pl. 1G, fig. 5; pl. 2J, figs. 4-6
cf. *Fish tooth type A-2* Helms and Riedel, 1971, p. 1710, pl. 1, fig. 2.

Subtype **a9/b1/c6/d1/e1/f1,5/g1/h1,3/i2/j2,6/k2/l≥0.15/m<1.4/n1/o1/p1,2** Doyle *et al.*, **emend.** herein
Triangle broad wing

Subtype*a 9/b1/c6/d1/e1/f1,5/g1/h1,3/i2/j2,6/k2/l>0.25/m<1.4/n1/o1/p1,2* Doyle *et al.*, 1974, p. 846, pl. 2J, fig. 11.

Remarks: The name-description is here modified to admit specimens in which *l* (perpendicular length from apex of outline to apex of inline, divided by perpendicular length from apex to base of inline, or to base of outline if inline not present) is 0.15 or greater.

Subtype **a9/b1/c6,7/d1/e1/f1,4,5/g1/h1,3/i2,3/j6/k2/l<0.4/m1.5-2/n1/o1/p1** Doyle *et al.*
Triangle medium wing

Subtype *a9/b1/c6,7/d1/e1/f1,4,5/g1/h1,3/i2,3/j6/k2/l<0.4/m1.5-2/n1/o1/p1* Doyle *et al.*, 1974, p. 846, pl. 1G, fig. 6; pl. 2J, figs. 8-10.
Fish tooth type A-1 Helms and Riedel, 1971, p. 1710, pl. 1, fig. 1.

Subtype **a9/b1/c9,13/d1/e1/f4 + (6,7)/g1/h4/i2/j2/k7,8/l0.2-0.6/m1.6-2.8/n2/o1,2/p1 + a9/b5/c8,12/d1/e1/f1/g1/h1/i2+4/j1/k2/l2/m2/n2/o9/p3,8/q0.2-0.6/r1.6-2.8/s0/t1/u1** Dunsworth *et al.*
Triangle with base angle

Subtype *a9/b1/c9,13/d1/e1/f4 + (6,7)/g1/h4/i2/j2/k7,8/l0.2-0.6/m1.6-2.8/n2/o1,2/p1 + a9/b5/c8,12/d1/e1/f1/g1/h1/i2+4/j1/k2/l2/m2/n2/o9/p3,8/q0.2-0.6/r1.6-2.8/s0/t1/u1* Dunsworth *et al.*, 1975, p. 857, pl. 1, figs. 15, 16.
cf. *Fish Tooth Type D-4* Helms and Riedel, 1971, p. 1710, pl. 1, fig. 11.

Subtype **a9/b1/c13/d13/e1/f4/g1/h1/i2/j2/k2/l<0.6/m2.0-3.0/n3/o3/p2** Doyle *et al.*
Triangle pointed margin ends

Subtype *a9/b1/c13/d13/e1/f4/g1/h1/i2/j2/k2/l<0.6/m2.0-3.0/n3/o3/p2* Doyle *et al.*, 1974, p. 847, pl. 1G, fig. 7; pl. 2K, figs. 1-4.

Subtype **a9/b1/c14/d1/e1/f2+5/g1/h2/i4/j2,3/k2/l0.1-0.4/m1-2/n1/o1/p1 + a9/b5/c13/d1/e1/f1/g1/h1/i2+7/j1/k2/l4/m3/n1/o1/p3/q<0.4/r1-2/s0/t1** Doyle *et al.*
Triangle hooked margin

Subtype *a9/b1/c14/d1/e1/f2 + 5/g1/h2/i4/j2,3/k2/l0.1-0.4/m1-2/n1/o1/p1 + a9/b5/c13/d1/e1/f1/g1/h1/i2 + 7/j1/k2/l4/m3/n1/o1/p3/q<0.4/r1-2/s0/t1* Doyle *et al.*, 1974, p. 847, pl. 2H, fig. 6; pl. 2K, figs. 13-16.

Subtype **a9/b1/c15,17/d15,17/e1,2/f1/g1/h5/i2,3/j2,3/k9/l0.25-0.5/m0.5-1.4/n1/o1/p1** Dunsworth *et al.*
Small triangle crenate margin

Subtype *a9/b1/c15,17/d15,17/e1,2/f1/g1/h5/i2,3/j2,3/k9/l0.25-0.5/m0.5-1.4/n1/o1/p1* Dunsworth *et al.*, 1975, p. 857, pl. 2, figs. 4, 5.

PLATE 1

All figures are magnified X112

1–2 *a5/b4* Doyle *et al.*
Circular with line across
1, DSDP 50.1-2-5, 120–128 cm.; 2, DSDP 50.1-4-1, 70–78 cm.

3 *a6/b4* Doyle *et al.*
Elliptical with line across
DSDP 52-5-4, 80–88 cm.

4–5 *a7/b1/c1/d1/e1* Doyle *et al.*
Two triangles
DSDP 50.1-4-1, 70–78 cm.

6 Undescribed form similar to *Two triangles* Doyle *et al.*
DSDP 27A-4-1, 110–120 cm.

7 *a7/b1/c2/d3/e6* Dunsworth *et al.*
Rectangular serially saw-toothed
DSDP 50.1-2-5, 120–128 cm.

8 *a7/b6/c1* Doyle *et al.*
Asymmetrical peak wide depression
DSDP 39-2-1, 90–98 cm.

9 Undescribed form, similar to *Triangle concave base* Doyle *et al.*
DSDP 51.1-2-2, 120–128 cm.

10 *a9/b1/c1/d1/e1/f2/g1/h1,2,3/i6/j4/k2,4/l0.2-0.4/m1-2/n3,4,5/o2/p1* Doyle *et al.*
Curved triangle pointed margin
DSDP 52-6-1, 130–138 cm.

11 *a9/b1/c1/d1/e1/f4/g1/h2,3,4,5/i2,3/j2,3/k11/l0/m0/n4,5,7,8/o1/p3/q1 + a8/b1,5/c1/d3/e80-125/f35-60* Doyle *et al.*, emend.
Triangle square inline
DSDP 52-7-2, 70–78 cm.

12, 13 Undescribed form, similar to *Small triangle long striations* Doyle *et al.*
12, DSDP 29A-5-1, 54–67 cm.; 13, DSDP 39-2-1, 90–98 cm.

14 *a9/b5/c1/d1/e1/f1/g1,2/h2/i1,4/j1/k2/l2/m2/n2/o5,6/p3/q0.2-0.5/r1-1.5/s0/t1* Doyle *et al.*
Triangle with canals
DSDP 50.1-3-6, 70–78 cm.

Remarks: One specimen tabulated under this name has a transverse line, and therefore should more correctly be assigned to the Type *a9/b5*.

Subtype **a9/b5/c1/d1/e3/f1/g1/h1/i1/j1/k2,7/l2/m2,4/n3/o1,2/p2,3/q0/r>1/s>3/t2** Doyle *et al.*
Triangle with triangular projection

Subtype *a9/b5/c1/d1/e4/f1/g1/h1/i1/j1/k2,7/l2/m2,4/n3/o1,2/p2,3/q0/r>1/s>3/t2* Doyle *et al.*, 1974, p. 847, pl. 1H, figs. 16-19; pl. 2K, figs. 17-21.
cf. *Fish Tooth Type B* Helms and Riedel, 1971, p. 1710, pl. 1, fig. 3.

Subtype **a9/b5/c1/d1/e1/f1/g1/h1/i1,3,5,6/j1/k2,6/l3/m2,4/n2,3/o3/p3,8/q>0.25/r<2/s0/t2** Doyle *et al.*, **emend.** herein
Short triangle stepped margin

Subtype *a9/b5/c1/d1/e1/f1/g1/h1/i1,3,5/j1/k2,6/l3/m2,4/n2,3/o3/p3,8/q>0.4/r<2/s0/t2* Doyle *et al.*, 1974, p. 847, pl. 1I, figs. 1-4.

Remarks: The name-description is here modified to admit specimens in which *q* (perpendicular length from apex of outline to apex of inline above transverse line, divided by perpendicular length from apex to transverse line) is greater than 0.25; and to admit specimens which have a simply or complexly curved line, between inline and outline, terminating at the margins (i6).

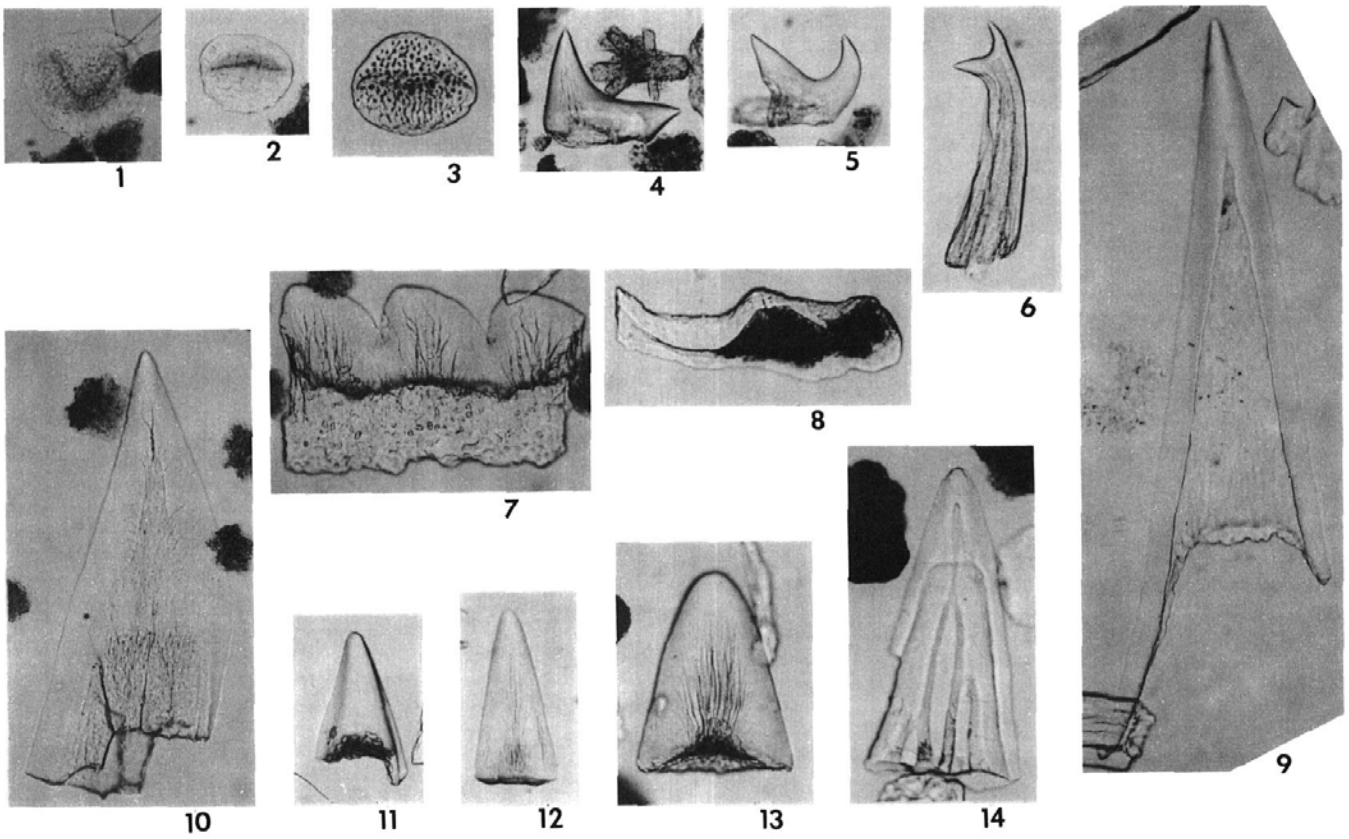
Subtype **a9/b5/c1/d1/e1/f1/g1/h1/i1,5,6/j1/k2,6/l3/m2,4/n2,3/o3/p3,8/q>0.25/r>2/s0/t2** Doyle *et al.*, **emend.** herein
Long triangle stepped margin

Subtype *a9/b5/c1/d1/e1/f1/g1/h1/i1,5/j1/k2,6/l3/m2,4/n2,3/o3/p3,8/q>0.4/r>2/s0/t2* Doyle *et al.*, 1974, p. 847, pl. 1I, figs. 5, 6.

Remarks: The name-description is here modified similarly to that of *Short triangle stepped margin*.

Subtype **a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k2,6/l3/m2,4/n3/o2/p7/q0.4-0.6/r1.5-2.6/s0/t2 + a9/b1/c1/d1/e1/f1/g1/h1/i2,6/j3/k6/l0.4-0.6/m1.5-2.6/n2/o1/p2** Doyle *et al.*
Curved triangle inline constricted

Subtype *a9/b5/c1/d1/e1/f1/g1/h1/i1/j1/k2,6/l3/m2,4/n3/o2/p7/q0.4-0.6/r1.5-2.6/s0/t2 + a9/b1/c1/d1/e1/f1/g1/h1/i2,6/j3/k6/l0.4-0.6/m1.5-2.6/n2/o1/p2* Doyle *et al.*, 1974, p. 847, pl. 1I, fig. 7; pl. 2L figs. 7, 8.
Fish Tooth Type F Helms and Riedel, 1971, p. 1713, pl. 1, fig. 10.



Subtype **a9/b5/c1/d1/e1/f1/g1/h1/i(1,5) + 4 + [1,(11 + 15 +16)]/j1/k3/l3/m2,3/n2,3/o4,7/p3+6/q0.4-0.9/r0.4-0.7/s1-1.9/t3/u1/v1 + a9/b1/c1/d1/e1/f(1,4) + [1,(9+13+14)]/g1/h4,5/i3/j3/k5+8/l0/m0.9-1.4/n7,8,9/o1/p3/q1** Doyle *et al.*
Narrower crescent

Subtype *a9/b5/c1/d1/e1/f1/g1/h1/i(1,5)+4+[1,(11+15+16)]/j1/k3/l3/m2,3/n2,3/o4,7/p3+6/q0.4-0.9/r0.4-0.7/s1-1.9/t3/u1/v1 + a9/b1/c1/d1/e1/f(1,4) + [1,(9 + 13 + 14)]/g1/h4,5/i3/j3/k5+8/l0/m0.9-1.4/n7,8,9/o1/p3/q1* Doyle *et al.* MS.*a*, pl. 3, figs. 6-11.

Subtype **a9/b5/c1/d1/e1/f1/g1/h1/i1,6/j3/k1/l1/m2,3,5/n2,3,5/o3,4/p2/q0/r0/s≤1/t2,3** Doyle *et al.*
Short rectangular with striations

Subtype *a9/b5/c1/d1/e1/f1/g1/h1/i1,6/j3/k1/l1/m2,3,5/n2,3,5/o3,4/p2/q0/r0/s≤1/t2,3* Doyle *et al.*, 1974, p. 847, pl. 1H, figs. 7-11.

Subtype **a9/b5/c1/d1/e1/f1/g1/h1/i3/j1/k6/l3/m4/n3/o8/p2,3/q0/r0.8-2.5/s1-3/t2 + a9/b5/c1/d1/e1/f1/g1/h1/i6/j1/k3/l3/m3/n3/o7/p1,2/q0/r0.8-2.5/s1-3/t3** Doyle *et al.*
Triangle complex transverse line

Subtype *a9/b5/c1/d1/e1/f1/g1/h1/i3/j1/k6/l3/m4/n3/o8/p2,3/q0/r0.8-2.5/s1-3/t2 + a9/b5/c1/d1/e1/f1/g1/h1/i6/j1/k3/l3/m3/n3/o7/p1,2/q0/r0.8-2.5/s1-3/t3* Doyle *et al.*, 1974, p. 848, pl. 1I, figs. 9-12; pl. 2L, figs. 10-12.
Fish Tooth Type C Helms and Riedel, 1971, p. 1710, pl. 1,fig. 4; pl. 2, fig. 7.

Subtype **a9/b5/c1/d1/e1/f1/g1/h1/i4+5/j1/k2,6/l2,3/m1/n1/o6,9/p8+9/q0.2-0.4/r1.1-2.0/s0/t3/u1/v1 + a9/b1/c1/d1/e1/f4/g1/h2,3,4,5/i2,6/j2,3/k(7,8)+10/l0.25-0.5/m1.1-2.2/n7,8,9/o1/p3/q1** Doyle *et al.*
Blunt triangle dendritic inline

Subtype *a9/b5/c1/d1/e1/f1/g1/h1/i4+5/j1/k2,6/l2,3/m1/n1/o6,9/p8+9/q0.2-0.4/r1.1-2.0/s0/t3/u1/v1 + a9/b1/c1/d1/e1/*

f4/g1/h2,3,4,5/i2,6/j2,3/k(7,8) + 10/l0.25-0.5/m1.1-2.2/n7,8,9/o1/p3/q1 Doyle *et al.*, MS.*a*, pl. 3, figs. 12-15.

Subtype **a9/b5/c1,4/d1/e1,3/f1/g1/h1/i5/j2/k2,7/l2/m2,4/n2,3/o1,2/p2,3,6/q0/r>0.5/s>3/t2** Doyle *et al.*
Narrow triangle cross-hachured

Subtype *a9/b5/c1,4/d1/e1,3/f1/g1/h1/i5/j2/k2,7/l2/m2,4/n2,3/o1,2/p2,3,6/q0/r>0.5/s>3/t2* Doyle *et al.*, 1974, p. 847, pl. 2L, figs. 1-6.

Subtype **a9/b5/c1/d1/e1/f1/g1/h1/i6/j3/k1/l1/m2/n2/o3,4/p2/q0/r0/s>1/t2,3** Doyle *et al.*
Long rectangular with striations

Subtype *a9/b5/c1/d1/e1/f1/g1/h1/i6/j3/k1/l1/m2/n2/o3,4/p2/q0/r0/s>1/t2,3* Doyle *et al.*, 1974, p. 848, pl. 1H, figs. 12-15.

Subtype **a9/b5/c1/d1/e1/f1/g1,2/h2/i1,4/j1/k2/l2/m2/n2/o5,6/p3/q0.2-0.5/r1-1.5/s0/t1** Doyle *et al.*
Triangle with canals
Plate 1, figure 14

Subtype *a9/b5/c1/d1/e1/f1/g1,2/h2/i1,4/j1/k2/l2/m2/n2/o5,6/p3/q0.2-0.5/r1-1.5/s0/t1* Doyle *et al.*, 1974, p. 848, pl. 1I, figs. 13, 14; pl. 2L, figs. 13-15.

Remarks: Although the specimen illustrated here conforms with the name-description of this subtype, it is relatively narrow and has sparse canals.

Subtype **a9/b5/c1/d1/e1/f1/g1/h2/i4 + (1,5)/j1/k2/l2/m2/n2/o4/p8/q0.3-0.6/r1-2/s0/t1** Doyle *et al.*
Triangle one canal above

Subtype *a9/b5/c1/d1/e1/f1/g1/h2/i4+(1,5)/j1/k2/l2/m2/n2/o4/p8/q0.3-0.6/r1-2/s0/t1* Doyle *et al.*, 1974, p. 848, pl. 1I, fig. 15; pl. 2M, figs. 1-5.

Subtype **a9/b5/c1/d1/e1/f1/g2/h2/i4/j1/k2,4,6/l2,4/m1/n1/o4/p3/q0.2-0.4/r1.5-2.5/s0/t1** Doyle *et al.*
Triangle transverse line across

Subtype *a9/b5/c1/d1/e1/f1/g2/h2/i4/j1/k2,4,6/l2,4/m1/n1/o4/p3/q0.2-0.4/r1.5-2.5/s0/t1* Doyle *et al.*, 1974, p. 848, pl. 1J, fig. 1; pl. 2M, figs. 6-9.

Remarks: In table 1, entries for this subtype are in the form "number of specimens representing the upper part only/number of complete specimens." Incomplete specimens will be formally described in Doyle and Riedel (in preparation).

Subtype **a9/b5/c1/d1/e3/f1/g1/h1/i1/j3/k2/l2/m2/n2,3/o2,4/p2/q0/r0.7-0.9/s1,2,3/t2/u1/v1 + a9/b5/c4/d1/e1/f1/g1/h1/i1/j3/k2/l2/m2/n2,3/o10/p2,6/q0/r0.7-0.9/s1,2,3/t2/u1/v1** Doyle *et al.*
Wide triangle projection

Subtype *a9/b5/c1/d1/e3/f1/g1/h1/i1/j3/k2/l2/m2/n2,3/o2,4/p2/q0/r0.7-0.9/s1,2,3/t2/u1/v1 + a9/b5/c4/d1/e1/f1/g1/h1/i1/j3/k2/l2/m2/n2,3/o10/p2,6/q0/r0.7-0.9/s1,2,3/t2/u1/v1* Doyle *et al.*, MS.*a*, pl. 3, figs. 18-26.

Subtype **a9/b5/c3/d1,3/e1/f1/g1,2/h2/i1/j1/k2/l2/m2/n2/o5/p3/q0.2-0.4/r1-1.5/s0/t1** Doyle *et al.*
Triangle crenulate with canals

Subtype *a9/b5/c3/d1,3/e1/f1/g1,2/h2/i1/j1/k2/l2/m2/n2/o5/p3/q0.2-0.4/r1-1.5/s0/t1* Doyle *et al.*, 1974, p. 848, pl. 1J, figs. 2, 3; pl. 2M, figs. 10, 11.

Subtype **a9/b6/c2-5/d2/e1** Doyle *et al.*
Triangular toothed

Subtype *a9/b6/c2-5/d2/e1* Doyle *et al.*, MS.*a*, pl. 4, figs. 1-4.

Type **a9/b7** Doyle *et al.*
Rounded apex triangle

Type *a9/b7* Doyle *et al.*, 1974, p. 848, pl. 1J, figs. 7-10; pl. 2M, figs. 12-15.

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