PALYNOLOGY AND BIOSTRATIGRAPHY OF THE LOWER CRETACEOUS SEDIMENTS IN THE SOUTH BARROW TEST WELL NO. 1, POINT BARROW, ALASKA

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Abstract

Twenty-two species of dinoflagellates and acritarchs, and thirty species of spores and pollen are reported from twenty Lower Cretaceous core samples of shale and siltstone from the South Barrow Test Well No.1 in Point Barrow, Alaska. The stratigraphic distribution of the fifty-two species is summarized, and four stratigraphic intervals are established. Based on diagnostic dinoflagellate cysts, the geologic age for the Torok Formation is suggested to be Aptian–Albian, and the age of the "Pebble Shale" unit is suggested to be Barremian–Aptian. The depositional environment is considered to be marine.

INTRODUCTION

In 1923, an area of 95,830 sq km (37,000 sq mi) in the Arctic Coastal Plain Province of Alaska was secured as Naval Petroleum Reserve No. 4 (N. P. R.-4). During the years from 1944–1953 the United States Navy drilled and completed thirty-six test wells and forty-five core tests, including the test well described in this investigation. In 1964, the exploration and drilling again resumed and the U.S. Navy drilled an additional seventeen test wells in the area. The test wells and the core tests were drilled to determine the geology, stratigraphy, and petroleum potential in the area. On June 1, 1977, the jurisdiction of the N.P.R.-4 was transferred from the Navy to the Department of Interior (The U.S. Geological Survey) and the Reserve was officially named the National Petroleum Reserve in Alaska (N.P.R.A.). The core samples from the test wells were processed for palynological investigation by the subcontractors with the U. S. Geological Survey techniques — using hydrochloric, hydrofluoric and nitric acids and sieving with a 10 μm mesh. Cellosize was used to mount the unstained palynomorphs onto coverslides. All microscope slides from the test wells have been transferred to the Smithsonian Institution in Washington, D. C., and are available for loan and examination.

In 1992, the author studied the slides prepared from the sediments of one of the test wells, the Fish Creek Test Well No. 1, and the results were published *in Revista Espanola Micropaleontologia* (Kimyai, 1992).

The present investigation involves the palynological study of the slides prepared from core samples from another test well, the South Barrow Test Well No. 1, located at the Point Barrow on northern Arctic Coastal Plain, Alaska (Text-Figure 1).

The South Barrow Test Well No. 1 was chosen for this investigation because the sediments contained both well-preserved marine dinoflagellates and terrestrial palynomorphs from core samples in the Lower Cretaceous Torok Formation and the "Pebble Shale" unit (Text-Figure 2).

Although a very few palynological publications other than May (1979), May and Stein (1979), and Kimyai (1992) have been published dealing with Cretaceous sediments from the Arctic Coastal Plain, Alaska, several studies (Pocock, 1962, 1976; Singh, 1964, 1971; Norris, 1967; Brideaux, 1971, 1977; Brideaux and McIntyre, 1975; Nøhr-Hansen and McIntyre, 1998) dealing with the biostratigraphy of ajacent areas in Canada have appeared in the palynological literature.

The objectives of this investigation are to compile and illustrate both marine and non-marine palynological assemblages present in the South Barrow Test Well No. 1, and to establish the age of the core samples from the Torok Formation and "Pebble Shale" unit. No attempt has been made to describe new taxa.

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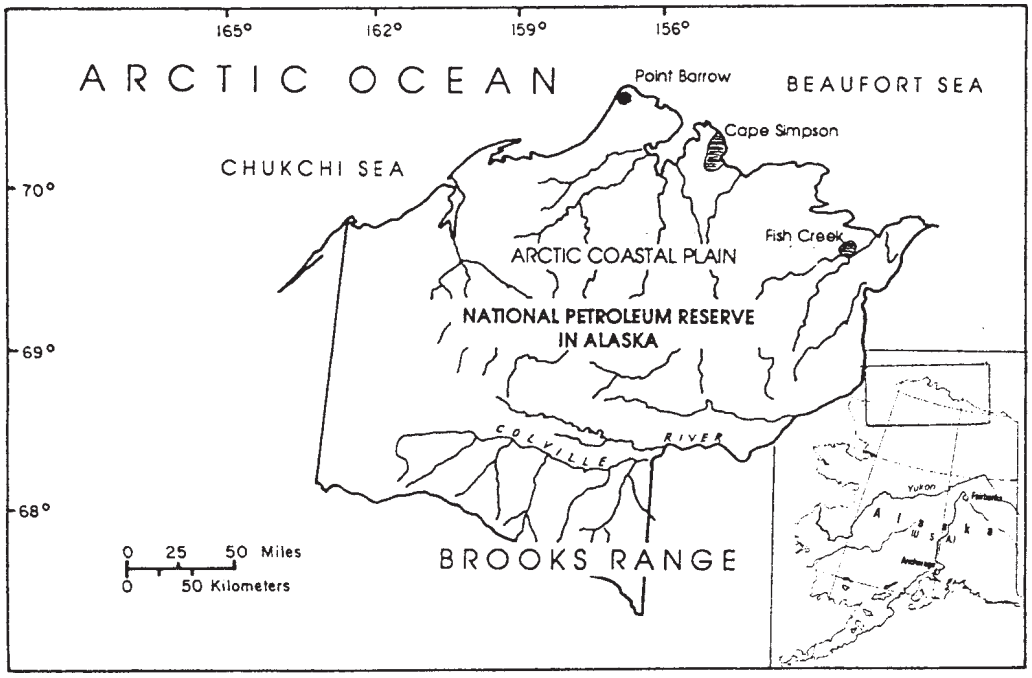


Text-Figure 1. Geographic map showing the location of Point Barrow on the Arctic Coastal Plain, Alaska.

PLATE 1

1 *Acanthotriletes levidensis* Balme 1957. Slide D4032-13, length 59μm.

2 *Baculatisporites comaumensis* (Cookson) Potonié 1956. Slide D4032-3, length 58 μm.

3 *Couperisporites complexus* (Couper) Pocock 1962. Slide D4032-7, length 53 μm.

4, 5 *Policingulatisporites reduncus* (Bolkhovitina) Playford & Dettmann 1965. 4, Slide D4032-2, length 34 μm. 5, Slide D4032-1, length 52 μm.

6 *Streisporites antiquasporites* (Wilson & Webster) Dettmann 1963. Slide D4032-1, length 37 μm.

7 *Impardecispora crassus* (Brenner) Burden & Hill 1989. Slide D4032-1, length 36 μm.

8 *Trilobosporites apiverrucatus* Couper 1958. Slide D4032-19, length 56 μm.

9 *Dictyophyllidites equiexinus* (Couper) Dettmann 1963. Slide D4032-1, length 44 μm.

10 *Aequitriradites variabilis* Pocock 1962. Slide D4032-24b, length 50 μm.

11 *Hymenozonotriletes* sp. Slide D4032-2, length 88 μm.

12 *Cicatricosisporites australensis* (Cookson) Potonié 1956. Slide D4032-13, length 64 μm.

13 *Lycopodiumsporites ambifoveolatus* Brenner 1963. Slide D4032-1, length 43 μm.

14 *Lycopodiumsporites austraclavatidites* (Cookson) Pocock 1962. Slide D4032-24b, length 48 μm.

15 *Lycopodiumsporites marginatus* Singh 1964. Slide D4032-13, length 40 μm.

16 *Deltoidospora psilostoma* Rouse 1959. Slide D4032-13, length 50 μm.

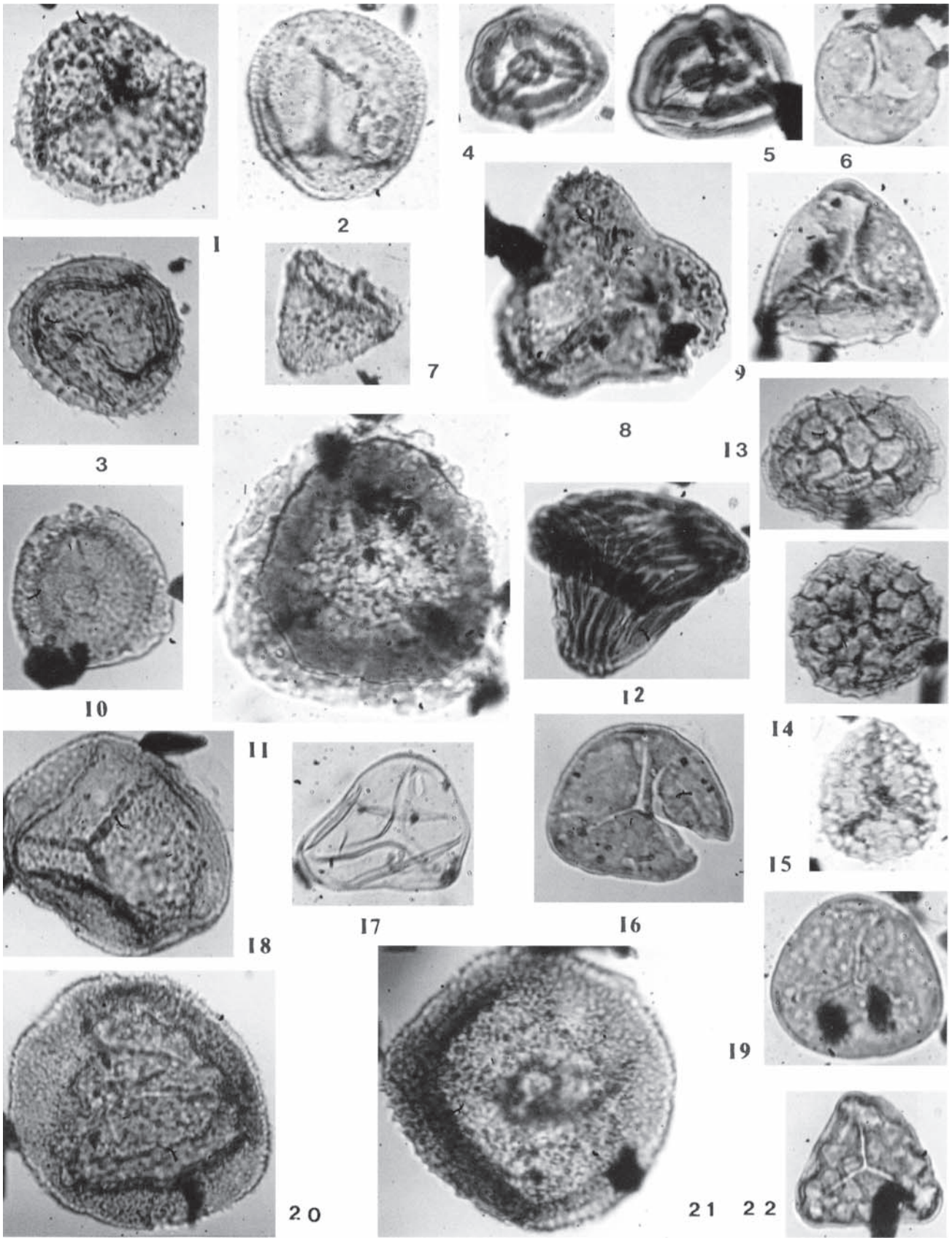
17 *Cyathidites minor* Couper 1953. Slide D4032-3, length 48 μm.

18 *Todisporites major* Couper 1958. Slide D4032-13, length 68 μm.

19 *Foveotriletes subtriangularis* Brenner 1963. Slide D4032-2, length 50 μm.

20, 21 *Osmundacidites wellmanii* Couper 1953. 20, Slide D4032-16, length 68 μm. 21, Slide D4032-28, length 82 μm.

22 *Klukisporites foveolatus* Pocock 1962. Slide D4032-30, length 48 μm.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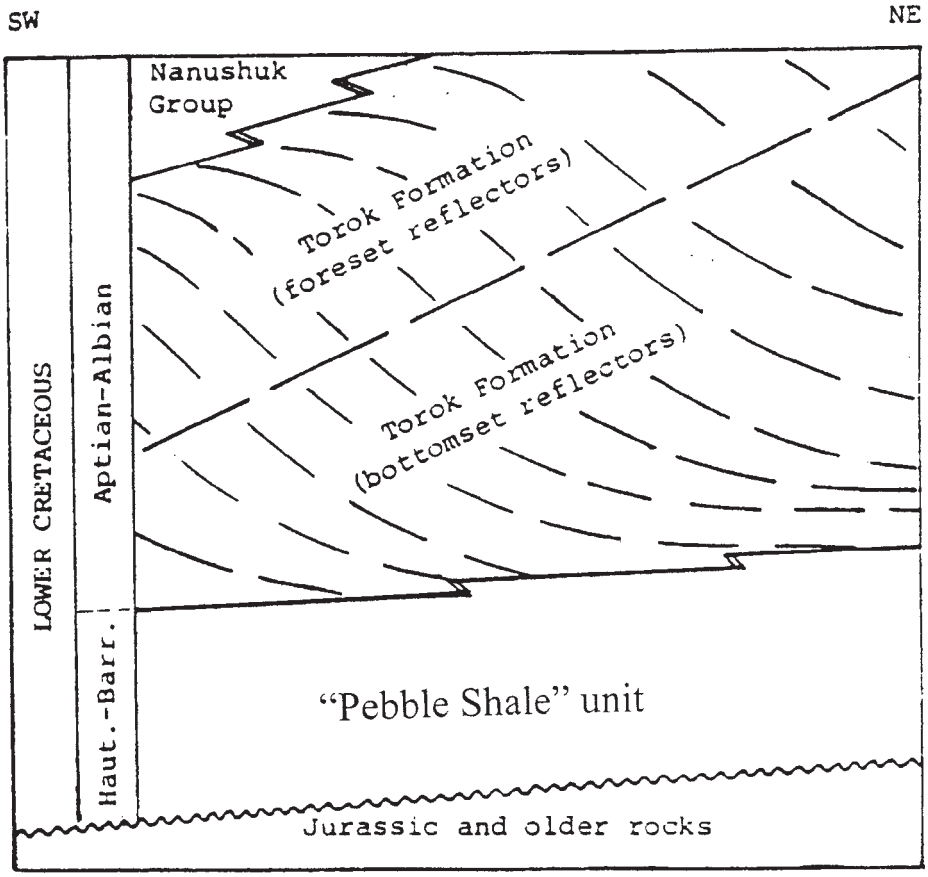
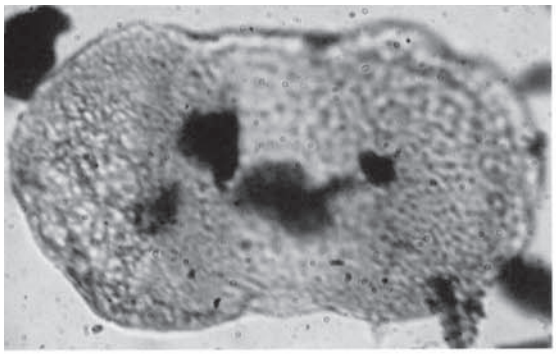


Text-Figure 2. Diagrammatic Cretaceous stratigraphic section for northern N.P.R.A., Alaska, based on paleontological and seismic data (adopted from Bird and Andrews 1979).

PLATE 2

1 *Podocarpidites herbstii* Berger 1963. Slide D4032-2, size 112 x 65 μm.
2 *Alisporites bilateralis* Rouse 1959. Slide D4032-1, size 128 x 80 μm.
3 *Podocarpidites canadensis* Pocock 1962. Slide D4032-28, size 108 x 64 μm.
4 *Podosarpidites biformis* Rouse 1956. Slide D4032-2, size 80 x 54 μm.
5 *Classopollis torosus* (Ressinger) Balme 1957. Slide D4032-16, length 34 μm.
6 *Araucariacites australis* Cookson 1947. Slide D4032-28, length 64 μm.
7 *Callialasporites dampieri* (Balme) Dev 1961. Slide D4032-5, length 66 μm.
8 *Cerebropollenites mesozoicus* (Couper) Nilssen 1958. Slide D4032-16, length 80 μm.
9 *Ginkgocycadophytus nitidus* (Balme) De Jersey 1962. Slide D4032-4, size 51 x 32 μm.
10 *Cycadopites sp*. Slide D4032-2, size 40 x 24 μm.
11 *?Tricolpites microminus* (Groot & Penny) Singh 1971. Slide D4032-9, size 26 x 18 μm.
12 *Tasmanites suevicus* (Eisenack) Wall 1965. Slide D4032-47, length 80 μm.



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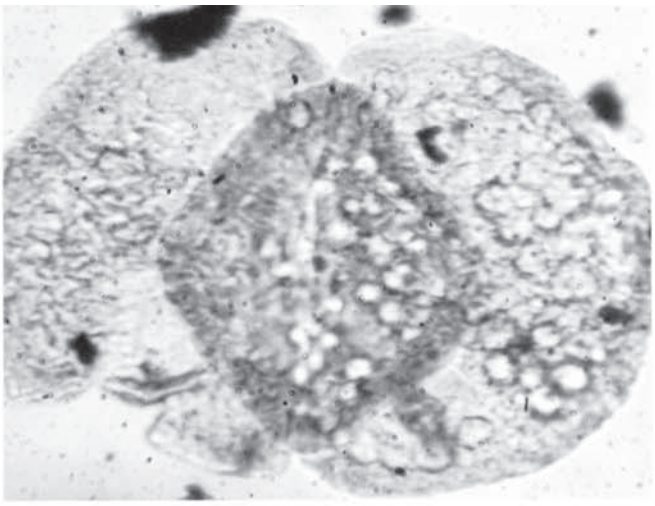

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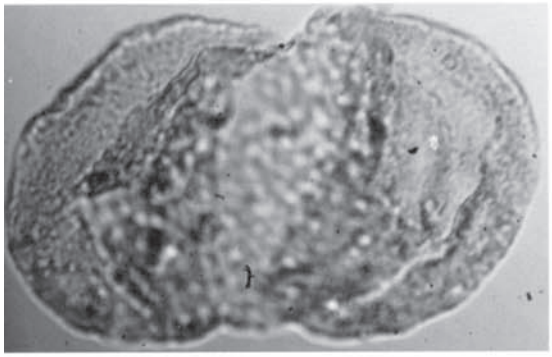

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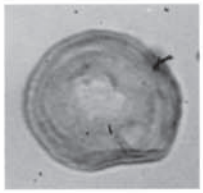

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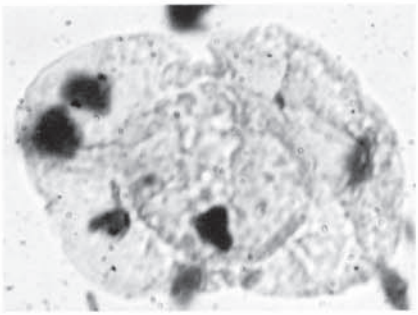

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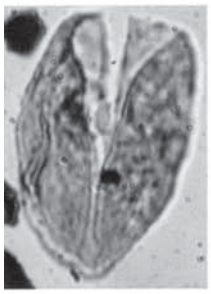

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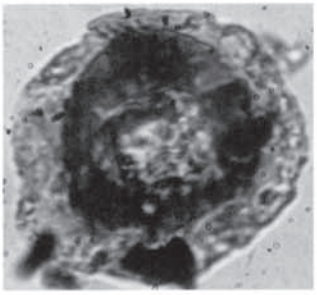

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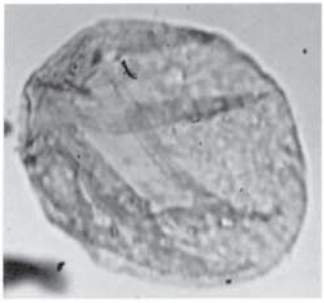

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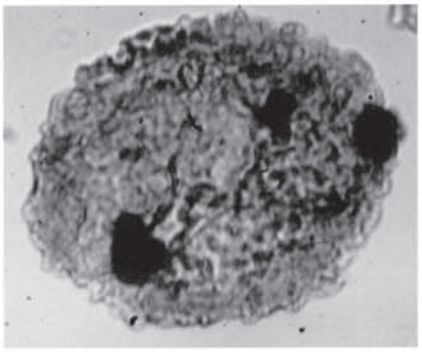

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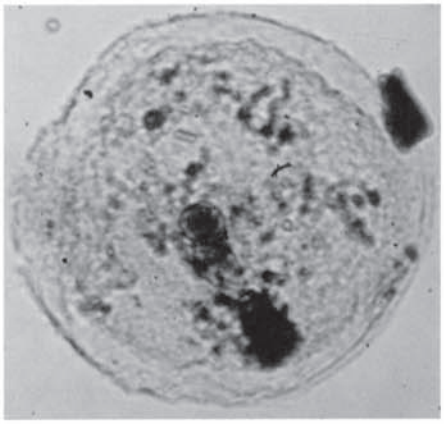

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GEOLOGICAL HISTORY

The South Barrow Test well No. 1 was drilled in Point Barrow, which is located on the shore of the northern Arctic Coastal Plain in Alaska (Text-Figure 1). The well penetrated 21 m (70 ft) of Pleistocene sediments (Gubik Formation), and approximately 1040 m (3410 ft) of sandstone, siltstone, claystone, and shale of Early Cretaceous age.

The first core sample came from 366–369 m (1200–1210 ft) depth. This core and five others between that depth and 868 m (2847 ft) are considered to represent the middle to lower parts of the Torok Formation. The interval between 868 m and 1040 m is considered to be equivalent to the "Pebble Shale" unit in age. The fossils found in samples from this test well are all considered to be of Early Cretaceous age.

Lithology of the Torok Formation

According to Pattan (Bergquist 1966), the bulk of the Torok Formation is composed of gray silt and shale interbedded with subordinate amounts of green to gray siltstone.

In the subsurface, the Torok Formation is divided into two units and described as two separate formations: (1) the Oumalik Formation with medium-gray to dark-gray shale, sandy shale and siltstone; and (2) the Topagoruk Formation with shale that is slightly softer and lighter in color.

Lithology of the "Pebble Shale" Unit

The "Pebble Shale" unit includes claystone, grayish-black color shale, detrital quartz and pyrite grains. The clear, mostly well-rounded and fine-grained quartz are distributed throughout the shale and claystone. The unit receives its name from the well-rounded gray to black chert, ranging in size from 2–6.4 mm (Collins and Robinson, 1967).

PALYNOLOGICAL INTERPRETATIONS

Thirty species of spores and pollen, and 22 species of dinoflagellates and acritarchs are encountered in this study. The preservation of the palynomorphs is fair to good. The distribution of the palynomorphs is summarized in two biostratigraphic range charts (Text-Figures 3 and 4). A histogram illustrating the relative abundance of inaperutrate and bisaccate pollen grains and diagnostic dinoflagellates is presented in Text-Figure 5.

Dinoflagellates provide the best means for dating the "Pebble Shale" unit intervals. While inaperturate and bisaccate pollen are abundant, fossils of spores and other pollen grains are few and non-diagnostic in the "Pebble Shale." Dinoflagellates are rare in the Torok Formation; only a few long-ranging Lower Cretaceous dinoflagellates were observed in this section.

Based on fossils encountered at Point Barrow, Imlay (1961) dated the Torok Formation as Early Albian. In a study of arenaceous foraminifera, Bergquist (1966) correlated the lower part of the Torok Formation with the "Pebble Shale" and considered the two units to be Early Albian. Collins and Robinson (1967), in a study of sediment from the Barrow area, suggested that the "Pebble Shale" may be as old as Early Albian. Palynological results from the South Barrow Test Well No. 2 (Timmcke, 1981) proposed a Barremian to Hauterivian age for the "Pebble Shale." Based on the presence of abundant dinoflagellates and the terrestrially-derived palynomorphs encountered from the South Barrow Test Well No. 1, this author suggests an age of Aptian to Albian for the Torok Formation, and a Barremian to Aptian age for the "Pebble Shale."

The following section details the occurrences of the palynomorphs, the paleoenvironmental interpretations, and the ages proposed for the South Barrow Well analyses.

Interval 366–803 m (1200–2635 ft): Torok Formation

This interval includes core samples 1 to 6 (Text-Figures 3–5). The strata in this interval are mostly of non-marine to

PLATE 3

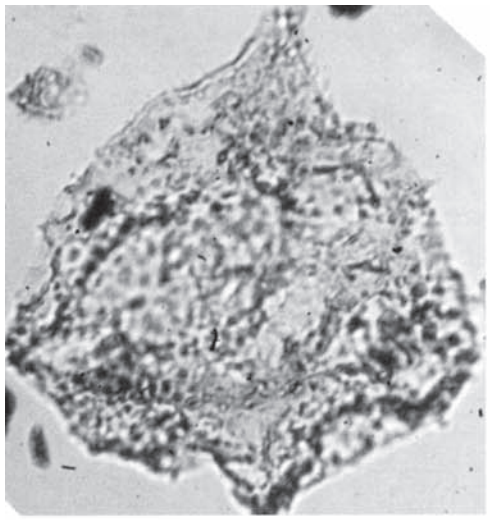
1, 2 *Canningia reticulata* Cookson & Eisenack 1960. 1, Slide D4032-37, length 112 μm. 2, Slide D4032-37, length 112 μm.

3, 4 *Cyclonephelium distinctum* Deflandre & Cookson 1955. 3, Slide D4032-35, length 114 μm. 4, Slide D4032-24b, length 104 μm.

5 *Spiniferites ramosus* subsp. *ramosus* (Ehrenberg) Loeblich & Loeblich 1966. Slide D4032-7, length 104 μm.

6 *Pterodinium cornutum* Cookson & Eisenack 1962. Slide D4032-42, length 72 μm.

7 *Turbiosphaera* aff. *T. filosa* (Wilson) Archangelsky 1969. Slide D4032-19, length 104 μm.



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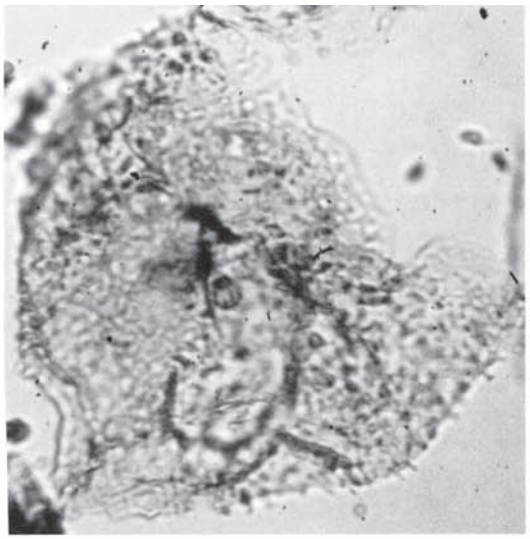

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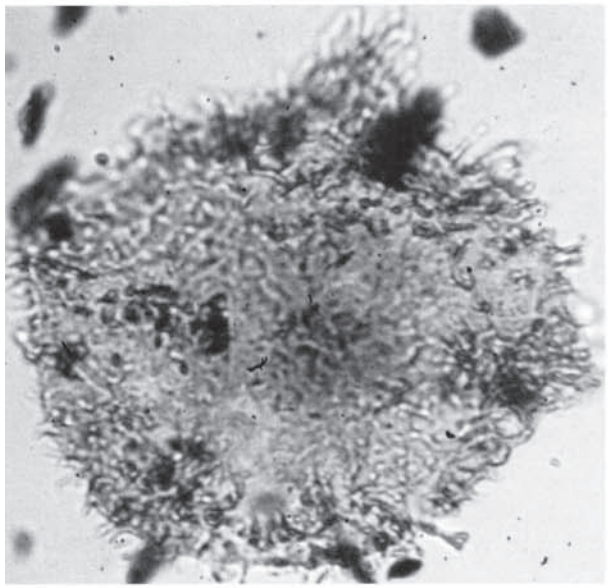

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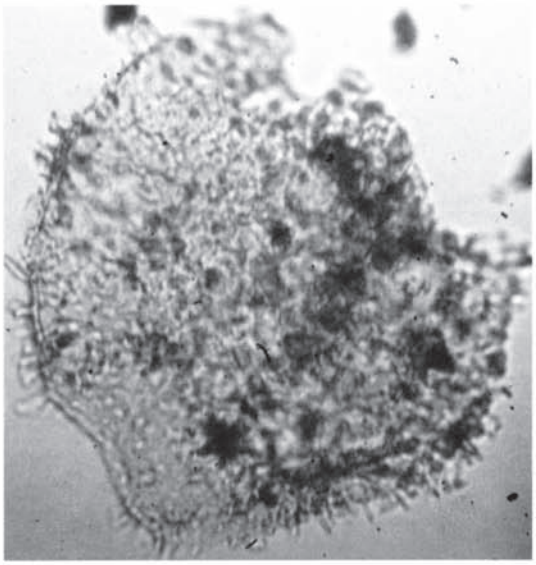

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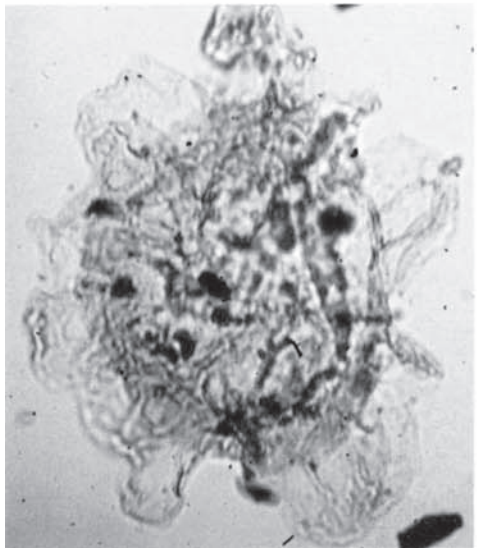

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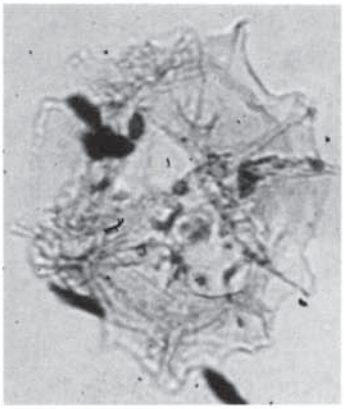

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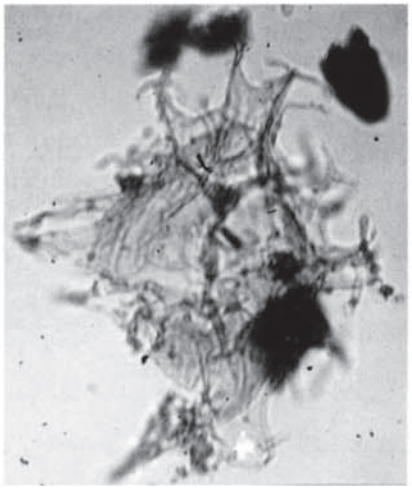

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Epoch	Early Cretaceous																			
Age	Albian - Aptian						Aptian - Barremian													
Formation	Torok Formation						"Pebble Shale" unit													
Depth (meter) / Palynomorphs / Core Samples	366 - 369	488 - 481	581 - 584	638 - 640	717 - 720	800 - 803	868 - 870	870 - 871	926 - 929	929 - 930	936 - 938	940 - 941	944 - 945	947 - 950	963 - 964	970 - 973	985 - 991	1015-1019	1023-1024	1037-1040
	1	2	3	4	5	6	7	8	9	13	16	19	24a	24b	28	30	35	37	42	47
Canningia reticulata			-															+		-
Cyclonephelium distinctum			-					-	-		+	+	+	a			+	a		-
Spiniferites ramosus subsp. ramosus							+	-			-							-		
Pterodinium cornutum															-		-		+	
Turbiosphaera aff. T. filosa												-								
Oligosphaeridium complex							a	a	+	+	+	a	a	+	a	a	a	a	a	a
Callaiosphaeridium asymmetricum								+											+	
Hytrichokolpoma stellatum							+	+	-			+	-		+	+	-		+	-
Batioladinium jaegeri													-							+
Odontochitina operculata			-				a	-	-		-	+	a	-	a	+	+	-	+	a
Gardodinium trabeculosum									-	+	-	-			-				-	
Gardodinium elongatum									-	-	-	+				-	-		-	-
Cribroperidinium orthoceras			-									-	-		-	-		+	+	
Apteodinium maculatum																		+	a	+
Palaeoperidinium cretaceum													-	-	+					+
Gonyaulacysta hyalodermopsis									-			-				+	+		-	
Gonyaulacysta aff. G. edwardsii								+	-			-			-	-	-	+	a	+
Kiokansium polypes							a		+	+							+		+	
Cleistosphaeridium multispinosum							a								+		+		+	-
Cleistosphaeridium ancoriferum							a		-			+			+					
Veryhachium reductum			-				-			-										
Tasmanites suevicus													-	-	+	+				-

'-' = Rare '+' = Common 'a' = Abundant

Text-Figure 3. Stratigraphic distribution and relative abundance of dinoflagellates in the South Barrow Test Well No.1, Point Barrow, Alaska.

Epoch	Early Cretaceous																			
Age	Albian - Aptian						Aptian - Barremian													
Formation	Torok Formation						"Pebble Shale" unit													
Depth (Meter)	366 - 369	488 - 491	581 - 584	638 - 640	717 - 720	800 - 803	867 - 870	870 - 871	926 - 929	929 - 930	936 - 938	940 - 941	944 - 945	947 - 950	963 - 964	970 - 973	985 - 991	1015-1019	1023-1024	1037-1040
Palynomorphs / Core samples	1	2	3	4	5	6	7	8	9	13	16	19	24a	24b	28	30	35	37	42	47
Streisporites antiquasporites					+					-						-				-
Polycingulatisporites reduncus	-	-				-														
Osmundacidites wellmanii			-							+	+	+	+	-	+	-	-			
Callialasporites dampieri	-				-	-														
Klukisporites foveolatus																+				
Aequitriradites variabilis	-	-				-														
Todisporites major										-										
Trilobosporites apiverrucatus												-								
Imardecispora crassus	-																			
Deltoidospora psilostoma	+		+	+	+					+	-		+			+				-
Foveotrletes subtriangularis		-				-														
Cyathidites minor	a		+	+	-				+	+	+	+		-		+				-
Lycopodiumsporites austraclavatidites	-		-											-						
Lycopodiumsporites ambifoveolatus	+																			
Lycopodiumsporites marginatus	-		-							-										
Cicatricosisporites australiensis	-				-					-		-								
Baculatisporites comaumensis			+	+	-	+				+	-	-	+		-	-	-			
Couperisporites complexus							-				+	+			+					
Dictyophyllidites equiexinus	+		-	-	+	+				+	-		-	-			+	-		
Acanthotriletes levidensis				a	+	-				a		-			-	+	-			+
Cerebropollenites mesozoicus								-				+								
Araucariacites australis	a	+	+	a	+	+	a	a	+	+	+	+	a	+	a	a	+	+	a	a
Ginkgocycadophytus nitidus	+		+	-	+	-	-			+				-	+	+				-
Cycadopites sp.	-	-	+	+	-		-			-					+		-			
Classopollis classoides	-	-	+						-		-		-							-
Podocarpidites biformis	-	+	+	+	+	+	+	+	+	-	a	a	a	+	+	a	+	-	+	a
Podocarpidites herbstii	-	+	+	a	+	+	+	+	+	+	a	a	a	-	a	a	-	+	+	a
Podocarpidites canadensis	-	-	+	+	+	+	+	+	+	+	+	+	a	-	a	a	+	+	a	a
Alisporites bilateralis	-	-	+	+	+	-	-	+	+	-	+	+	a	-	a	+	+	-	a	a
Tricolpites micrimunus									? -											

'-' = Rare '+' = Common 'a' = Abundant

Text-Figure 4. Stratigraphic distribution and relative abundance of spores and pollen grains in the South Barrow Test Well No.1, Point Barrow, Alaska.

marginal marine origin. Diversified assemblages of spores together with rich inaperturate pollen (*Araucariacites australis*) and bisaccate pollen grains (*Podocarpidites biformis, P. herbstii, P. canadensis*, and *Alisporites bilateralis*), and a few dinoflagellates distinguish this interval.

The top of this interval is represented by the occurrence of a few Lower Cretaceous dinoflagellates: *Odontochitina operculata, Cribroperidinium orthoceras, Cyclonephelium distinctum* and *Canningia reticulata*. Bird and Andrews (1979) suggested that the middle section of the Torok Formation represented the foreset reflectors consisting of slope (marine) deposits, and that the lower part of the Torok represented the bottomset reflectors consisting of basin-floor deposits (Text-Figure 2). It is possible that the folding and faulting which created the structural traps in the Barrow area could possibly cause contamination of the sediment and palynomorph assemblages. However, the abundance of diversified Lower Cretaceous spores and pollen grains, coupled with the occurrence of distinctive dinoflagellates, may suggest an Aptian–Albian age for this interval.

Interval 868–941 m (2847–3086 ft): "Pebble Shale" Unit

The top of this interval is marked by the highest abundance of *Odontochitina operculata*, *Oligosphaeridium complex, Cleistosphaeridium multispinosum, C. ancoriferum*, and *Kiokansium polypes*. *Cyclonephelium distinctum* and *Gardodinium elongatum* are also most common in this interval. The occurrence of these distinctive and diversified dinoflagellate assemblages, which has also been reported by Pocock (1962), Singh (1971), Brideaux (1971, 1977), Brideaux and McIntyre (1975), and Nøhr-Hansen and McIntyre (1998), from Aptian sediments in Canada, suggests an Aptian age for this part of the "Pebble Shale" unit.

The high frequency of dinoflagellates, along with rare spores and pollen (with the exception of inaperturate and bisaccate pollen grains) within this interval, indicate that the sediments from the upper part of the "Pebble Shale" unit were deposited in a open marine environment far away from the shoreline.

Interval 944–1019 m (3095–3341 ft): "Pebble Shale" Unit

This interval is characterized by the reappearance and dominance of *Odontochitina operculata*. Other abundant species are *Cyclonephelium distinctum* and *Oligosphaeridium complex*. *Gonyaulacysta* aff. *G. edwardsii*, *G. hyalodermopsis, Pterodinium cornutum*, and *Tubiosphaera* aff. *T. filosa* are also common in this interval.

Araucariacites australis becomes rare at the base of the interval between core samples 35 and 37, but bisaccate pollen such as *Podocarpidites canadensis* is common. This interval is considered to be Barremian to Aptian in age.

During deposition of this interval, open marine conditions prevailed in this area. This is evidenced from the abundance of dinoflagellates and rare species of spores and pollen grains.

Interval 1023–1040 m (3355–3410 ft): "Pebble Shale" Unit

This interval is selected on the appearance and abundance of *Apteodinium maculatum* and *Gonyaulacysta* aff. *G. edwardsii*. Other dinoflagellates which are abundant in this section are *Oligosphaeridium complex* and *Odontochitina operculata*. A rich assemblage of marine dinoflagellates associated with a few pollen grains and rare spores, indicates that this interval was deposited in an open marine environment. The age of this interval is also considered to be Barremian to Aptian.

PLATE 4

1, 3 *Oligosphaeridium complex* (White) Davey & Williams 1966. 1, Slide D4032-8, 20 x 23, 128 μm. 2, Slide D4032-42, length 136 μm.

2 *Callaiosphaeridium asymmetricum* (Deflandre & Courteville) Davey & Williams 1966. Slide D4032-8, length 120 μm,

4 *Hystrichokolpoma stellatum* (Maier) Truswell et al. 1983. Slide D4032-13, length 124 μm.

5 *Odontochitina operculata* (O. Wetzel) Deflandre & Cookson 1955. Slide D4032-24a, length 128 μm.

6 *Batioladinium jaegeri* (Alberti) Brideaux 1975. Slide D4032-47, length 128 μm.

7 *Gardodinium trabeculosum* (Gocht) Davey 1978. Slide D4032-28, length 120 μm.

8 *Gardodinium elongatum* Singh 1971. Slide D4032-13, length 96 μm.

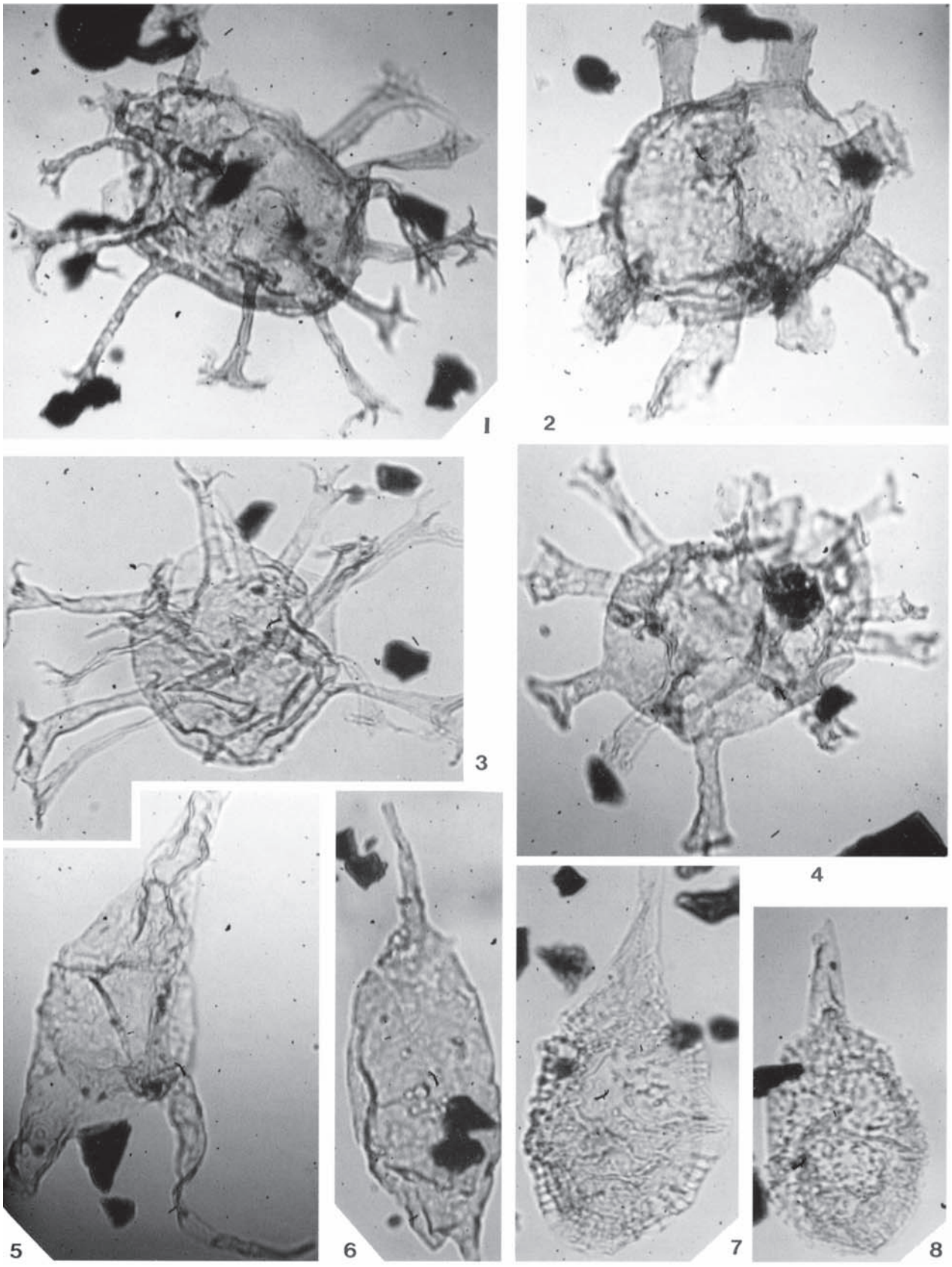
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PLATE 5

1, 2 *Cribroperidinium orthoceras* (Eisenack) Davey 1969. 1, Slide D4032-28, length 96 μm. 2, Slide D4032-37, length 112 μm.

3 *Apteodinium maculatum* Eisenack & Cookson 1960. Slide D4032-37, length 104 μm.

4 *Palaeoperidinium cretaceum* Pocock 1962. Slide D4032-24b, length 92 μm.

5 *Gonyaulacysta hyalodermopsis* (Cookson & Eisenack) Sarjeant 1966. Slide D4032-35, length 80 μm.

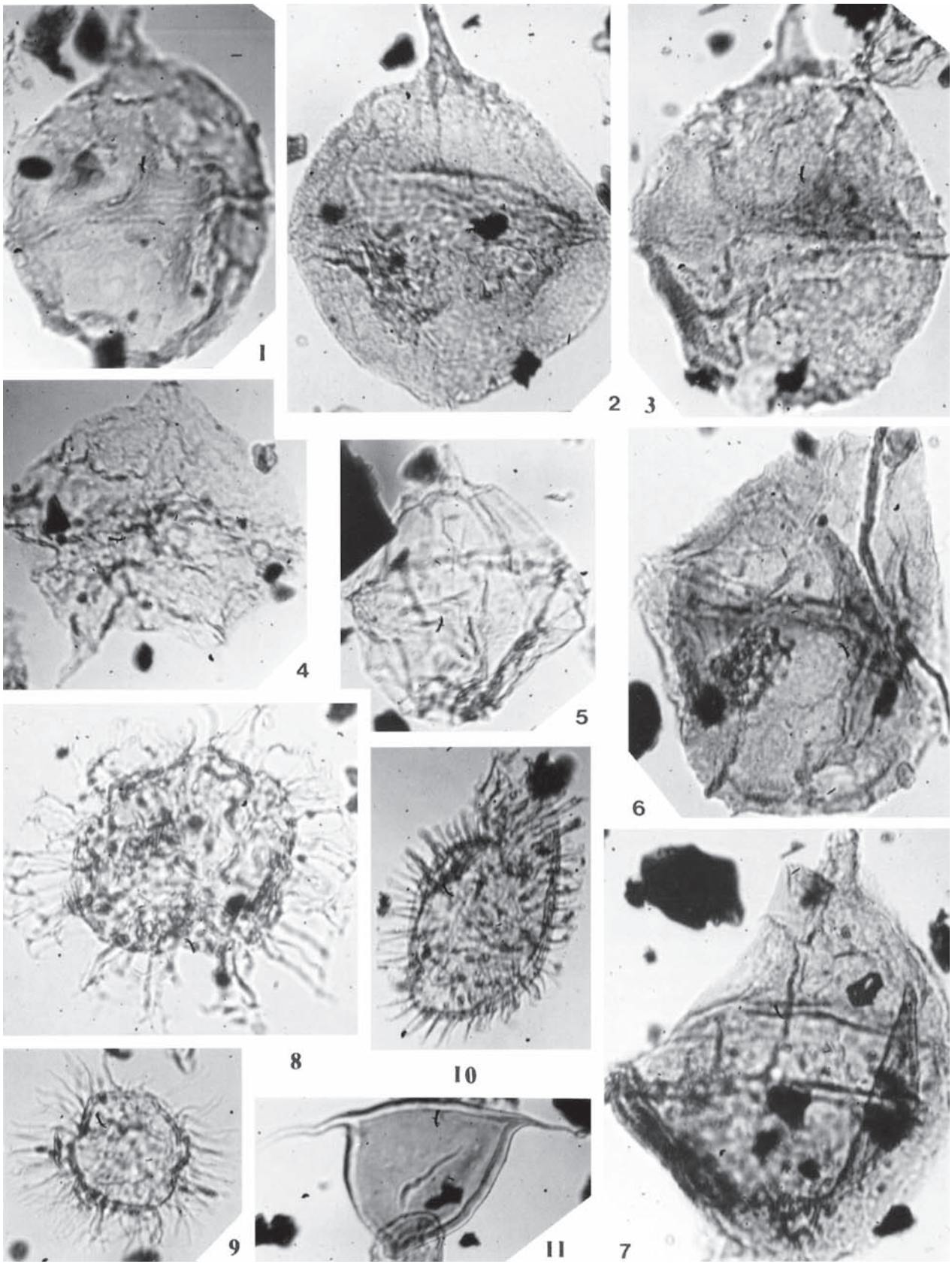
6, 7 *Gonyaulacysta* aff. *G. edwardsii* (Cookson & Eisenack) Clarke & Verdier 1967. 6, Slide D4032-35, length 104 μm. 7, Slide D4032-7, length 118 μm.

8 *Kiokansium polypes* (Cookson & Eisenack) Duxbury 1983. Slide D4032-37, length 92 μm.

9 *Cleistosphaeridium multispinosum* (Singh) Brideaux 1971. Slide D4032-42, length 56 μm.

10 *Cleistosphaeridium ancoriferum* (Cookson & Eisenack) Davey et al. 1966. Slide D4032-7, length 64 μm.

11 *Veryhachium reductum* Deflandre emend. De Jekhowsky 1961. Slide D4032-13, length 64 μm.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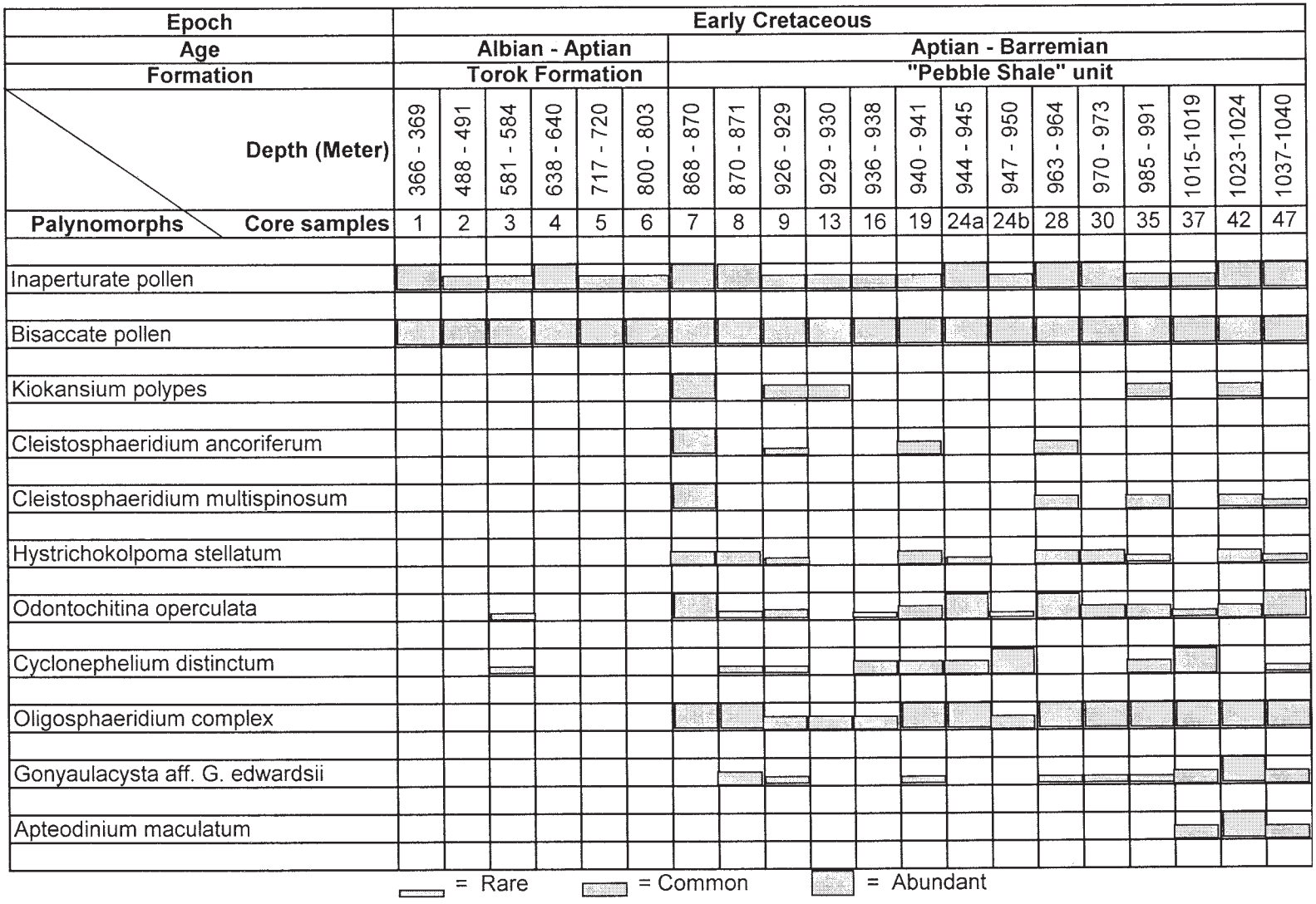

Text-Figure 5. Distribution of abundant pollen grains and dinoflagellates in the South Barrow Test Well No.1, Point Barrow, Alaska. The width of the bars in the histogram indicates the relative abundance.

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