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# Upper Cretaceous diatom biostratigraphy of the Arctic archipelago and northern continental margin, Canada

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**ABSTRACT:** Strata in the Canadian Arctic contain diverse and moderately well-preserved Late Cretaceous siliceous microfossil assemblages. One-hundred-twelve samples were analyzed from a composite stratigraphic section (1094m-thick) of the Smoking Hills, Mason River and Kanguk formations. Four sections were examined: (1) Slidre Fjord on Ellesmere Island; (2) Hoodoo Dome on Ellef Ringnes Island; (3) Cape Nares on Eglinton Island; and (4) Horton River on the Anderson Plains, Northwest Territories. Two hundred-three diatom taxa were identified in forty-nine productive samples. Four Upper Cretaceous diatom zones are proposed for the Canadian Arctic based on the biostratigraphic distribution of diatoms: (i) the Upper Cenomanian to Upper Santonian(?) *Gladius antiquus* Concurrent Range Zone, (ii) the Lower Campanian *Costopyxis antiqua* Partial Range Zone, (iii) the lower Upper Campanian *Trinacria indefinita* Interval Zone, and (iv) the upper Upper Campanian *Stephanopyxis simonseni* Partial Range Zone.

The diatom assemblages are similar to those of Alpha Ridge (Arctic Ocean), Ural Mountains (Russia), and Campbell Plateau (SW Pacific Ocean), enabling diatom-based biostratigraphical correlations within the northern high-latitudes and to the southern high-latitudes. A fifth biostratigraphic zone, *Azpeitiopsis morenoensis* Concurrent Range Zone, is also proposed, based on common and widespread distribution of the nominative taxon in lower to upper Maastrichtian sediments. Sufficient data is now available to establish the construction of a diatom-based standard zonal framework for the Upper Cretaceous.

Two new combinations, *Trochosira denticulatum* (Strelnikova) Tapia and *Trochosiropsis polychaeta* (Strelnikova) Tapia are here proposed.

## INTRODUCTION

### Diatoms in time and space

Diatoms are known from the Lower Cretaceous (Aptian-Albian) to Recent and represent useful tools as biostratigraphic, paleoenvironmental, and paleoclimatic indicators (Stoermer and Smol 1999). The Cenozoic diatom biostratigraphic record is relatively well-developed (Barron and Baldauf 1995), though many stratigraphic gaps still exist in the Paleocene and Eocene diatom record around the world. Upper Cretaceous diatom biostratigraphy, however, requires considerable further development through collection of stratigraphic data, taxonomic reorganization, morphological description, and biostratigraphical analysis such as that presented here. A compilation of known Upper Cretaceous diatom-bearing sediments (table 1, text-fig. 1) expresses the limitation of our current knowledge for this stratigraphic interval. Diatom preservation is the limiting factor on many of these deposits.

This paper is an attempt to develop an Upper Cretaceous diatom biostratigraphy for the Canadian Arctic. Our main goal is to identify the main diatom assemblages in order to apply diatom biostratigraphy to the stratigraphic sequences of the Kanguk, Smoking Hills, and Mason River formations. The moderately good preservation of diatoms from these strata enables us to investigate changes in diversity and composition of siliceous microfossil assemblages from the northern high-latitudes (text-fig. 2). Thick stratigraphic sections, like the 125m-thick continuous and moderately well-preserved diatomaceous shale of the Horton River section represent an excellent reference section for development of a biostratigraphic framework for future correlation.

### *Status of Late Cretaceous diatoms: taxonomic studies vs the stratigraphic record*

Our knowledge of Late Cretaceous diatoms is hindered by the temporal instability of opal-A and detrimental effects of silica diagenesis through time. Most published Late Cretaceous diatom studies are descriptive and taxonomic, with little or no stratigraphic control (table 1). Nevertheless, general trends in Upper Cretaceous diatom biostratigraphy and evolution can be found in Strelnikova (1974) and Harwood and Nikolaev (1995). Current knowlegde of Campanian diatom biostratigraphy was developed from high-latitude diatomaceous deposits in Russia and the S.W. Pacific Ocean. These deposits contain sufficiently well-preserved diatom floras and reliable stratigraphic control that can be compared to results presented here.

*Outcrops and industrial wells from the Ural Mountains and Western Siberian lowland plains, Russia.* The best sequence that contains Upper Cretaceous opaline diatoms is in north-central Russia. A 299m-thick composite core section along the North Sosva River (Cores 22, 82, and 19; text-fig. 3-A) and outcrop samples from the Syinja River [Sections XI(14) and IX(13)] record portions of the Campanian and Maastrichtian (Strelnikova 1974, 1975). Strelnikova divided the Campanian sequence into three diatom complexes. The First Complex (aleuritic diatomaceous clays, Lower Campanian) is characterized by diatoms *Paralia cretacea, P. ornata, Costopyxis antiqua, C. uralensis, Lepidodiscus elegans, Triceratium schulzii, Hemiaulus danicus, H. echinulatus, Pterotheca alata*, and *P. simplex*. The *Prunobrachium crassum* radiolarian complex and the foraminiferal *Spiroplectammina lata* Zone provide biostratigraphic control that indicates an Early Campanian age. The Second Complex (white diatomite, lower part of the Upper Campanian)

TABLE 1
Occurences of Upper Cretaceous bearing-diatom deposits in the world.

| Age | Reference | Location | Preservation | Remarks |
|---|---|---|---|---|
| Albian to Early Cenomanian | Foulcault et al., (1986) | Ligurian Alps, Italy | Poor | Resembles younger diatom assemblages |
| Turonian | Müller (1912) | Rielmerich, Westfalia, Germany | Poor | - |
| Turonian | Weisner (1936) | Bohême, Czechoslovakia | Poor | - |
| Turonian | Deflandre (1941) | Villers-Sur-Mer, Calvados | Poor | Taxonomic approach |
| Early Turonian to Late Campanian | Koutsoukos and Hart (1990) | Sergipe Basin, Brazil | Poor | Aracaju Member Cotiguiba Formation |
| Coniacian and Santonian | - | - | - | No reports |
| Senonian | Schulz (1935) | Gdansk, Poland | Good | Campanian. |
| Campanian | Kitchell (1980), Barron (1985), Dell'Agnese (1988), Dell'Agnese and Clark (1994) | Alpha Ridge, Arctic Ocean | Excellent | Microfossil documentation, biostratigraphic approach |
| Campanian | Riegraf (1995) | Westfalia, NW Germany | Poor | - |
| Campanian | Moshkovitz et al., (1983) | Central Negev, Israel | Moderate | Mishah Formation |
| Campanian | Gresham (1985, 1986) | DSDP Leg 22, Site 216 | Moderate | Ninetyeast Ridge, Indian Ocean |
| Campanian | Fourtanier (1991) | ODP Leg 121, Site 758 | Moderate | " |
| Campanian | Ballance et al., (1989) | Tonga Trench | Moderate | Pacific Ocean |
| Campanian | Hajós and Stradner (1975) | DSDP Leg 29, Site 275 | Excellent | Biostratigraphy, SW Pacific |
| Campanian | Given and Wall (1971); Wall (1975) | Alberta, Canada | Pyritized | - |
| Campanian to Maastrichtian | Jousé (1948, 1949, 1951, 1955); Krotov (1957a,b, 1959); Krotov and Schibkova (1961), Schibkova (1961), Strelnikova (1964, 1965a,b, 1966a,b, 1968, 1971, 1974, 1975); Vekschina (1961a,b) | Ural Mountains and western Siberian lowland, Russia | Good to excellent | Taxonomy, biostratigraphy approach |
| Campanian to Maastrichtian | Bergstresser and Krebs (1983) | Wyoming, Colorado, and Kansas | Pyritized | Pierre Shale |
| Late Campanian to early Maastrichtian | Takahashi et al., (1999) | NW Kanto Mts., Japan | Poor | Shoya Formation |
| Campanian to Danian | Martinez-Machiavello (1987); Harwood (1988) | Seymour Island, Antarctic Peninsula | Poor to moderate | Biostratigraphy, K/T boundary. Lopez de Bertodano and Sobral Formations. |
| Late Maastrichtian | Hanna (1927, 1934); Long et al. (1946); Barker & Meakin (1944, 1945, 1946, 1948, 1949); Brigger & Hanna (1965), Hasle & Syverten (1985), Ross & Sims (1985, 1997), Sims (1986, 1989, 1994a,b), Sims & Hasle (1987), Sims & Ross (1988), Nikolaev et al. (2001). | Fresno County, California | Good | Taxonomy, Moreno Formation |
| Maastrichtian | Wiedmann (1964) | de la Manche Valley, Rougemont, Swiss Alps | Pyritized | - |
| Maastrichtian | Abbott (1978) | South Carolina | Pyritized | Pee Dee Formation |
| Maastrichtian | Fenner (1982) | Emperor Canyon | Moderate | Off New Jersey coast |
| Early Maastrichtian | Shipboard Scientific Party (1989), Nikolaev & Harwood (2000) | ODP Leg 120, Site 748 | Moderate | Kerguelen Plateau, South Indian Ocean |
| Cenomanian? to Campanian | Tapia 1996,1997, and this report | Slidre Fjord, Hoodoo Dome, Cape Nares, and Horton River sections | Moderate | Arctic Canada, biostratigraphy and paleoecology |

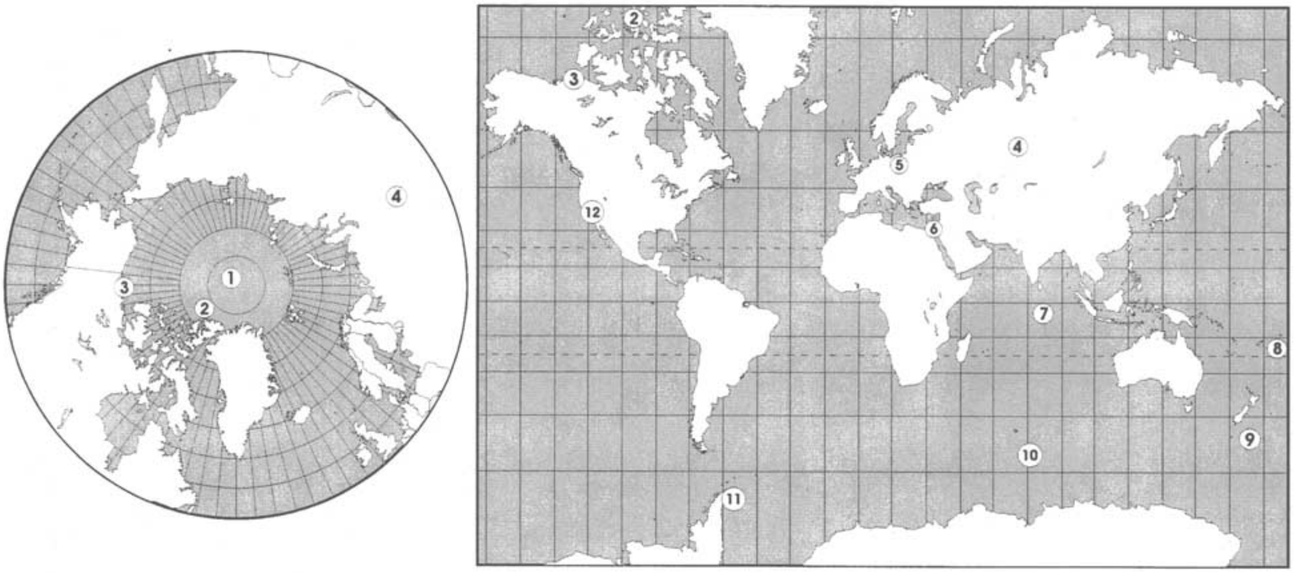
is distinguished by the presence of *Stephanopyxis turris, Triceratium anissimovae, Paralia sulcata, Pseudopodosira simplex, P. punctata, Skeletonema polychaetum, Costopyxis broschii, Aulacodiscus archangelskianus, A. bifrons, Hemiaulus antiquus, H. kittonii, Gladius speciosus* f. *speciosus, Pterotheca aculeifera*, and *P. evermannii*. The Third Complex (light gray diatomaceous clays, upper part of the Upper Campanian) is characterized by *Paralia sulcata, Pseudopodosira aspera, Stephanopyxis turris, S. lavrenkoi, Costopyxis reticulata, Aulacodiscus jouseae, Triceratium planum, T. coronatum, Gladius speciosus* f. *aculeatus* and f. *poratus*, and *Pseudopyxilla rossica*. The *Prunobrachium articulatum* radiolarian complex and the foraminiferal *Bathysiphon nodosariaformis* Zone provide biostratigraphic control that indicates a Late Campanian age for the Second and Third diatom complexes (Strelnikova 1975).

*Deep Sea Drilling Project Leg 29, Site 275, SW Pacific Ocean.* DSDP Site 275 recovered 17.5m (40.6%) of sediment from a 43m-thick cored section on the Southeast Campbell Plateau (50°26'S, 176°19'E). Two cores containing 13m of glauconite-bearing silty, radiolarian-diatomaceous ooze recorded the Late Cretaceous diatom history in the Southwest Pacific Ocean (text-fig. 3-B). A Late Campanian age was determined by correlation with the uppermost Campanian radiolarian *Patulibracchium dickinsoni* Zone of California and by palynological correlation to New Zealand and Campbell Island, which suggested a Late Campanian to Maastrichtian age (Shipboard Scientific Party 1975). The diatom record indicates a Late Campanian to Maastrichtian age, whereas silicoflagellates indicate a Late Cretaceous (probably Maastrichtian) age (Perch-Nielsen 1975). Extraordinarily well-preserved diatom and silicoflagellate assemblages were encountered in Cores 1 and 2. Hajós and Stradner (1975) examined twenty samples and proposed nine biostratigraphic zones for this 13m-thick section. In ascending order the zones are the *Horodiscus rugosus* Zone, *Chasea ornata* Zone, *Epithelium rossicum* Zone, *Anaulus subantarcticus* Zone, *Biddulphia sparsepunctata* Zone, *Kentrodiscus armatus* Zone, *Cerataulus-Odontotropis* Zone, *Acanthodiscus antarcticus* Zone, and *Pseudopyxilla jouseae* Zone.

Although many diatom taxa present at Site 275 are also noted in the Canadian Arctic sediments, other key taxa, including those used as stratigraphic markers, are not present in the Arctic diatom flora. For this reason, the zonation of Hajós and Stradner (1975) cannot be applied in the present study.

### *Geological setting of the Upper Cretaceous Canadian Arctic*

Samples examined in this study came from two different geological settings. Samples from the Arctic Islands belong to the Sverdrup Basin, whereas those from the continental margin belong to the Anderson Plain Syncline (Yorath et al. 1975, Plauchut and Jutard 1976). The Sverdrup Basin developed by rifting during the mid-Carboniferous and was filled by up to 9000m of Mesozoic sediment. Upper Cretaceous strata of the Kanguk and Expedition formations rest unconformably upon Lower Cretaceous rocks. A diachronus unconformity (Late Albian-Late Cenomanian) is present throughout the basin. A major Late Cenomanian transgression transformed the Arctic Island region in an offshore shelf. By the end of the Cretaceous, sediment supply increased and the region was occupied by pro-delta and fluvial-deltaic plains (Embry 1991). In the Anderson Plain Syncline, Mesozoic strata rest unconformably on a Paleozoic sequence and are unconformably overlain by the Up-



TEXT-FIGURE 1
Global distribution of selected Campanian-Maastrichtian diatomaceous deposits (See Table 1). 1= Alpha Ridge, Arctic Ocean; 2= Arctic Archipelago, Canada (this study); 3= Northern Continental Margin, Canada (this study); 4= Ural Mountains, Russia; 5= Gdansk, Poland; 6= Central Negev, Israel; 7= Ninetyeast Ridge, Indian Ocean; 8= Tonga Trench, Pacific Ocean; 9= Campbell Plateau, Pacific Ocean; 10= Kerguelen, Plateau, Southern Ocean; 11= Seymour Island, Antarctica; 12= Moreno Gulch, California.

per Tertiary Beaufort Formation. The Upper Cretaceous sequence is represented by the Smoking Hills and Mason River formations of the Amudsen Gulf Group (Yorath et al. 1975).

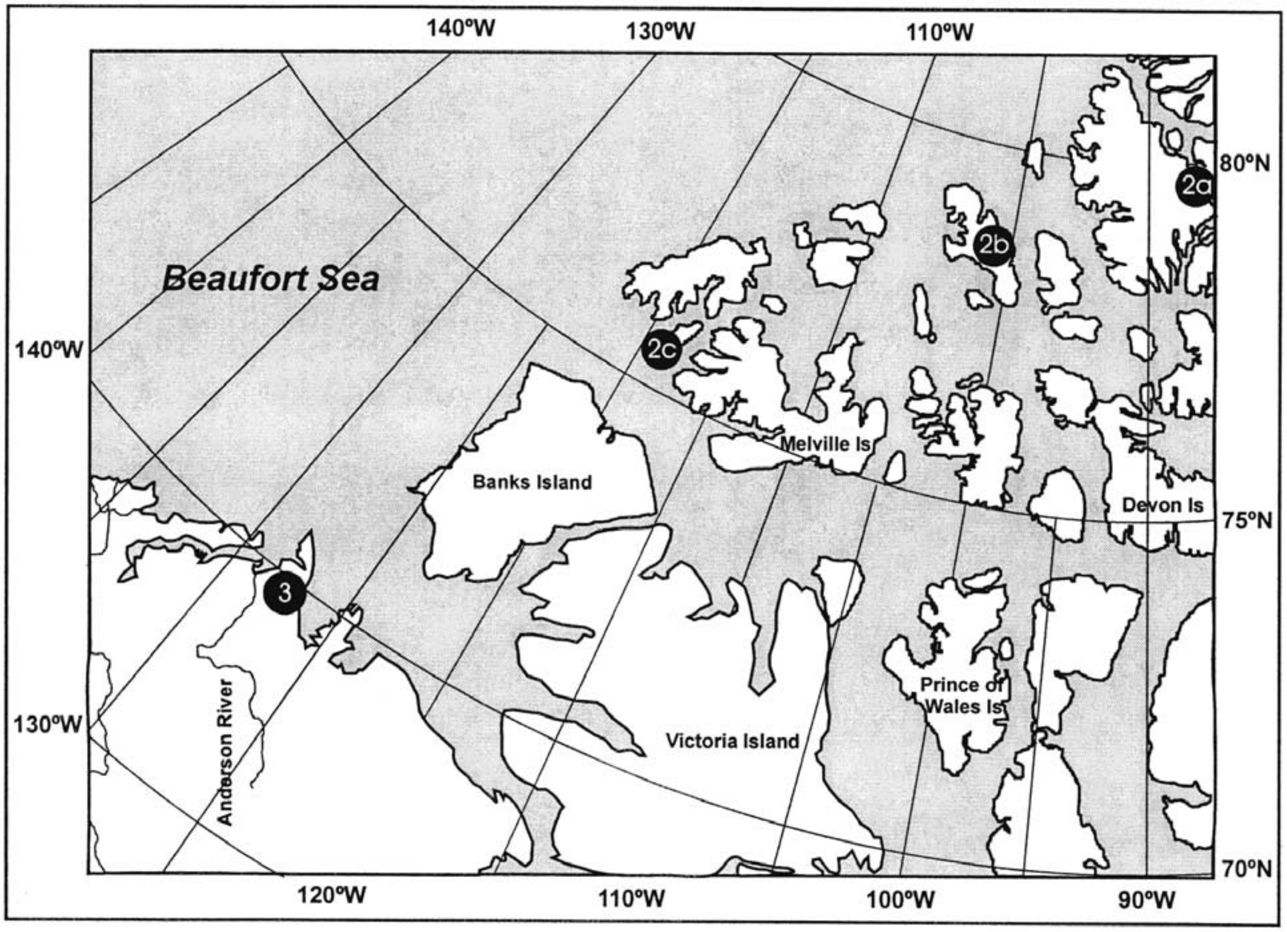
## MATERIALS AND METHODS

Cretaceous siliceous microfossils in the Canadian Arctic Archipelago (Banks Island) were first identified as reworked elements in glacial sediments (Vincent et al. 1983) from the Duck Hawk Bluff, Morgan Bluff, Nelson River, and Prince of Wales formations. That report stimulated the present study.

Four stratigraphic sections within the Canadian Arctic Archipelago and continental margin were examined (text-fig. 4, columns A-D). Samples were collected by scientists from the Geological Survey of Canada (GSC) (P. T. Chamney, A. F. Embry, J. C. Harrison, and J. H. Wall) and kindly provided by David McNeil of the GSC. From these sections, one hundred and twelve samples were analyzed to determine the presence of siliceous microfossils. Forty-nine of these contained enough siliceous microfossils to warrant a detailed diatom survey (text-fig. 4).

*Slidre Fjord, Ellesmere Island, District of Franklin*. The Slidre Fjord GSC section 74RV-38 is located at 79°47.4'N, 85°22'W (text-fig. 2, site 2a; J. H. Wall, pers. comm.). A total of 29 samples were examined from the 260.5m-thick Kanguk Formation (text-fig. 4, column A). There is no available section description or stratigraphic column from this locality. At an adjacent site (GSC locality 79 EL-3, Remus Creek, Fosheim Peninsula, Ellesmere Island), the Kanguk Formation unconformably overlies the Upper Albian to Cenomanian Hassel Formation (Wall 1983) and consists of approximately 220m of dark-gray shale with minor amounts of siltstone and sandstone. Thin bentonite seams are characteristic of the lower part of this formation. Macrofossils do not provide reliable age control at this site, but Lower Santonian ammonites are reported from this formation at the head of Slidre Fjord on Fosheim Peninsula (Jeletzky in Wall 1983). Foraminiferal data indicate an age range from Turonian to Late Campanian (Wall 1983). The depositional environment of the Kanguk Formation at Slidre Fjord is interpreted to be marine of shallow to moderate depth on the shelf (J. H. Wall, pers. comm.).

*Hoodoo Dome, Ellef Ringnes Island, District of Franklin.* Hoodoo Dome is a double-plunging anticline, cored and pierced locally by a Carboniferous halite diapir (Stott 1969). The 12 samples examined here came from the 390m-thick Kanguk Formation at Hoodoo Dome, GSC section 73BAA-10002 (text-fig. 2, site 2b; text-fig. 4, column B). Unfortunately, no section description or stratigraphic column is available from this locality. Other studies of the Kanguk Formation at Hoodoo Dome (Blakwill 1974, Blakwill and Hopkins 1976) report a thickness of about 450m, dividing this lithostratigraphic unit into two informal (lower and upper) members based on the presence of an escarpment-forming, red-brown siltstone between those units. The lower member comprises about 240m of soft, slightly silty, pyritic, black shale with abundant thin beds and laminations of yellow-gray jarositic clay. Near the base of this section, the beds are pink and brick-red due to the oxidation of iron-sulfide minerals. No macrofossils are known from this member, however the presence of mollusks *Watinoceras* sp. and the recognition of the *Mytiloides labiatus* Zone at the same stratigraphic level on the adjacent Amund Ringnes Island indicates an Early Turonian age for the lower unit (Jeletzky *in* Blakwill and Hopkins 1976). The upper member comprises *circa* 210m of dark-brown-gray shaly siltstone and silty shale, with abundant small red-brown ironstone nodules and a few jarositic clay beds. A collection of well-preserved mollusks suggests the base of the upper unit is late Early or early Late Santonian in age (Jeletzky *in* Blakwill and Hopkins 1976). The depositional environment of the Kanguk Formation at Hoodoo Dome represents a middle outer

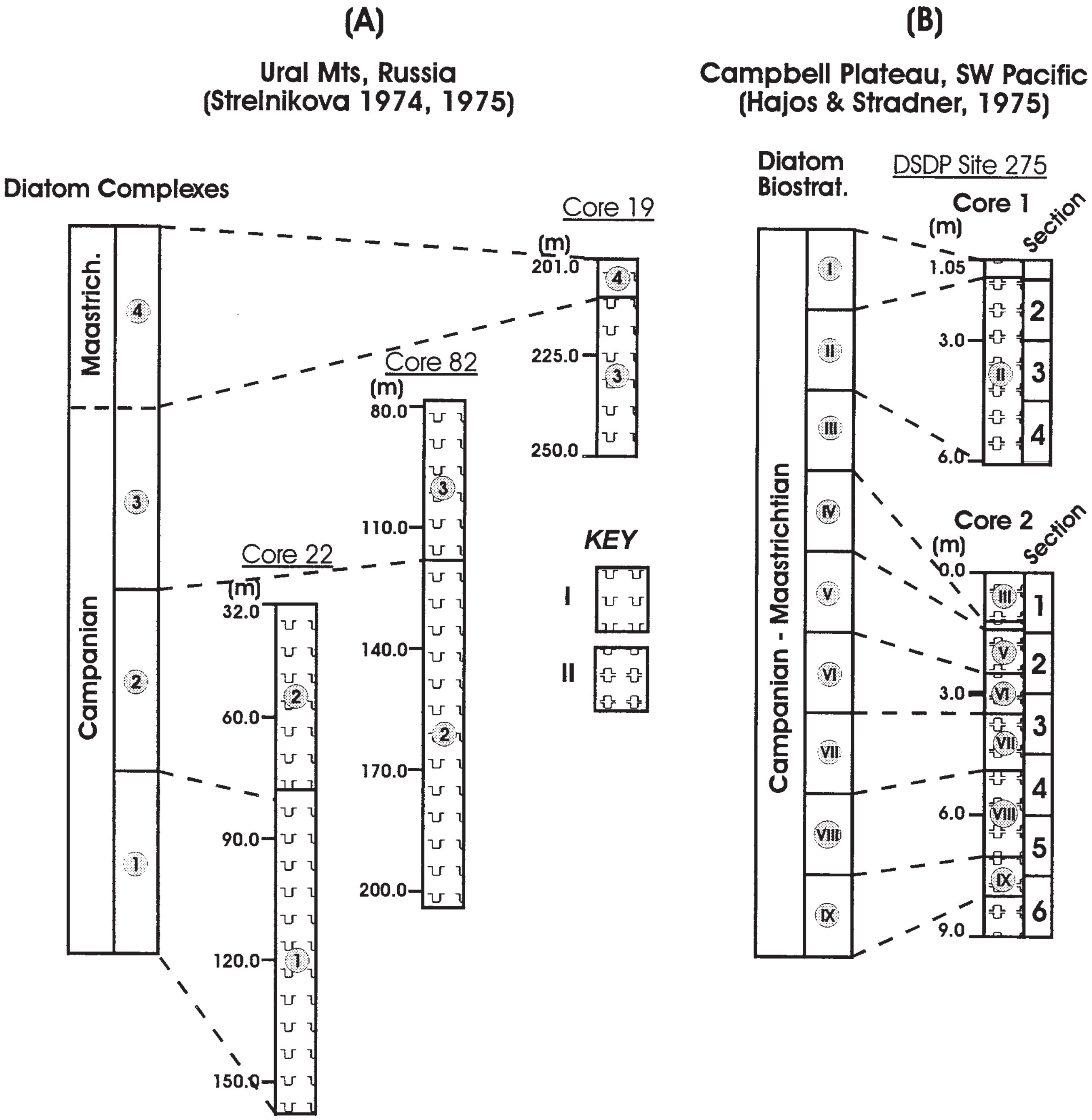


TEXT-FIGURE 2
Diatomaceous deposits in the Canadian Arctic (areas 2 and 3 in Fig. 1). 2a= Slidre Fjord, Ellesmere Island; 2b= Hoodoo Dome, Ellef Ringnes Island; 2c= Cape Nares, Eglinton Island; 3= Horton River, Northwest Territories.

shelf setting in the lower unit and an upper shelf to pro-delta setting in the upper unit (Blakwill and Hopkins 1976).

*Cape Nares, Eglinton Island, District of Franklin*. The Cape Nares section (GSC 87EL-16) is located at 75°38'N, 119°22'W (text-fig. 2, site 2c; J. H. Wall, pers. comm.). The 20 samples examined here came from a 156m measured section of the Kanguk Formation at Cape Nares (text-fig. 4, column C). No section description or stratigraphic column is available from this locality. The Kanguk Formation at Eglinton Island was studied by Plauchut and Jutard (1976), who reported a 312m-thick unit unconformably overlying the Upper Albian Hassel Formation. The Kanguk Formation is divided into three members: the Lower Shale, Eglinton Sandstone, and Upper Shale members. (1) The Lower Shale Member is 200m-thick and contains two units; the lower part (110m) comprises gray to black shale, silt and sandstone with thin bands of yellow jarosite and concretionary masses of mudstone and dark ironstone, and the upper part (90m) comprises brown to black shale and minor silt with thin bands of gray and green sand, which increase in abundance toward the top of the unit. (2) The Eglinton Sandstone Member is 50m-thick and comprises green, gray or whitish, indurated, medium to coarse quartz sandstone, gravel and conglomerate. The contact between the Eglington and Lower Shale members is transitional. (3) The Upper Shale Member is 62m-thick and comprises gray to gray-brown shale, silty shale and sandstone with a few beds of brown ferruginous sandstone. The age of the Kanguk Formation at Eglinton Island is Santonian to Campanian, based on fossil mollusks (Jeletzky *in* Plauchut and Jutard 1976) and Senonian based on fossil radiolaria and foraminifera (Fischer in Plauchut and Jutard 1976). The Lower Shale and Eglinton members are considered to be Upper Turonian to Lower Campanian based on the presence of the foraminiferal *Dorotia smokyensis* assemblage and *Trocammina ribstonensis* (J. H. Wall, pers. comm.). The depositional environment is interpreted to be nearshore to open marine for the lower part of the Lower Shale Member and a shallow to moderate depth marine shelf environment for the rest of the formation (Plauchut and Jutard 1976, J. H. Wall, pers. comm.).

*Horton River Section, District of Mackenzie, Northwest Territories*. The Horton River sequence is a composite section constructed from three adjacent outcrops on the Anderson Plains (text-fig. 2, area 3). The 51 samples examined here came from these three outcrops of the Smoking Hills and Mason River formations (text-fig. 4, column D). No section descriptions or stratigraphic columns are available from any of these 3 localities. (1) The GSC location CR 16A-N68 (69°27'30"N, 126°58'W) represents the Smoking Hills Formation (McIntyre 1974, Yorath et al. 1975). This formation disconformably overlies the mid Albian Horton River Formation, and comprises ap-



TEXT-FIGURE 3
Upper Cretaceous diatom biostratigraphy in (A) Ural Mts., Russia (from Strelnikova 1974), and (B) Campbell Plateau, SW Pacific (from Hajós & Stradner 1975). Note the different scales. Strelnikova (1974) divided Russian cores into 4 biostratigraphical divisions: 1= First Diatom Complex, 2= Second Diatom Complex, 3= Third Diatom Complex, 4= Complex with *Stephanopyxis biseriata* and *Triceratium cellulosum*; Hajós & Stradner (1975) erected 9 zones for two cores in DSDP Site 275: I= *Pseudopyxilla jouseae* Zone, II= *Acanthodiscus antarcticus* Zone, III= *Cerataulus-Odontotropis* Zone, IV= *Kentrodiscus armatus* Zone, V= *Biddulphia sparsepunctata* Zone, VI= *Anaulus subantarcticus* Zone, VII= *Epithelium rossicum* Zone, VIII= *Chasea ornata* Zone, and IX= *Horodiscus rugosus* Zone. Key: I= Diatomite and diatomaceous mudstone, II= Radiolarian and diatomaceous ooze.

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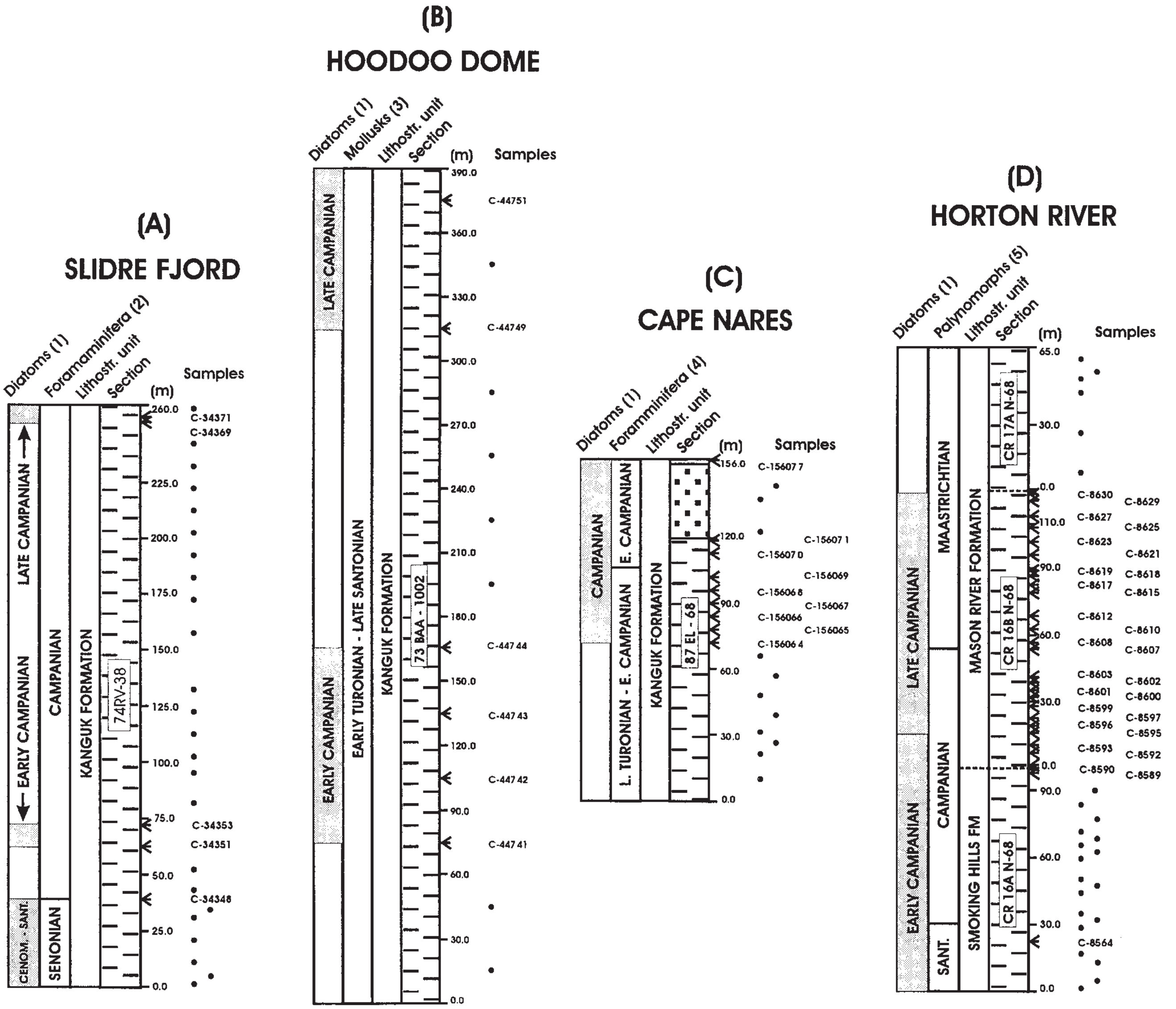
proximately 100m of a variable sequence of black, bituminous shale, bedded yellow jarosite, and locally dark maroon beds of earthy hematite (Yorath et al. 1969, McIntyre 1974). The Smoking Hills Formation is considered Lower Campanian based on vertebrate fauna (Russell 1967) and Santonian to Campanian based on palynomorphs (McIntyre 1974). The depositional environment is interpreted to be nearshore to open marine (Plautchut and Jutard 1976). (2) The GSC location CR



TEXT-FIGURE 4
Schematic stratigraphic columns of the studied sections. The positions of diatom-bearing samples are indicated by small arrows and GSC sample codes (e.g. C-34348). Barren samples postions are marked by small dots. A = Slidre Fjord, Ellesmere Island; B = Hoodoo Dome, Ellef Ringes Island; C = Cape Nares, Eglington Island; D = Horton River, NWT. Numbers within the lithologic columns are GSC codes for stratigraphic sections. 1 = Diatom biostratigraphy (this study); 2 and 4 = J. H. Wall (personal communication); 3 = Blakwill & Hopkins (1976); 5 = McIntyre (1974).

16B-N68 (69°28'N, 126°58'W) represents part of the Mason River Formation (McIntyre 1974), which at this locality is approximately 125m-thick and comprises a lower unit composed of pale gray-weathering shale with minor amounts of mudstone and rusty, dark ferruginous dolomite concretionary beds. This is overlain by a middle unit of medium to locally dark gray shale with some gypsum; and an upper unit of medium to dark-gray-brown and brown ferruginous shale that grades upward into gray sandy shale (Yorath et al. 1969, McIntyre 1974). The Mason River Formation gradationally and conformably overlies the Smoking Hills Formation and is unconformably overlain by a Recent unconsolidated gravel and sand unit (Plautchut and Jutard 1976). (3) The GSC location CR 17A-N68 (69°58'30"N, 127°4'W) represents the upper part of the Mason River Formation, measuring approximately 62m (McIntyre 1974). The Mason River Formation was dated as Campanian to Maastrichtian based on palynomorph biostratigraphy (McIntyre 1974) and the depositional environment is thought to be marine shelf with minor continental influences (Plautchut and Jutard 1976).

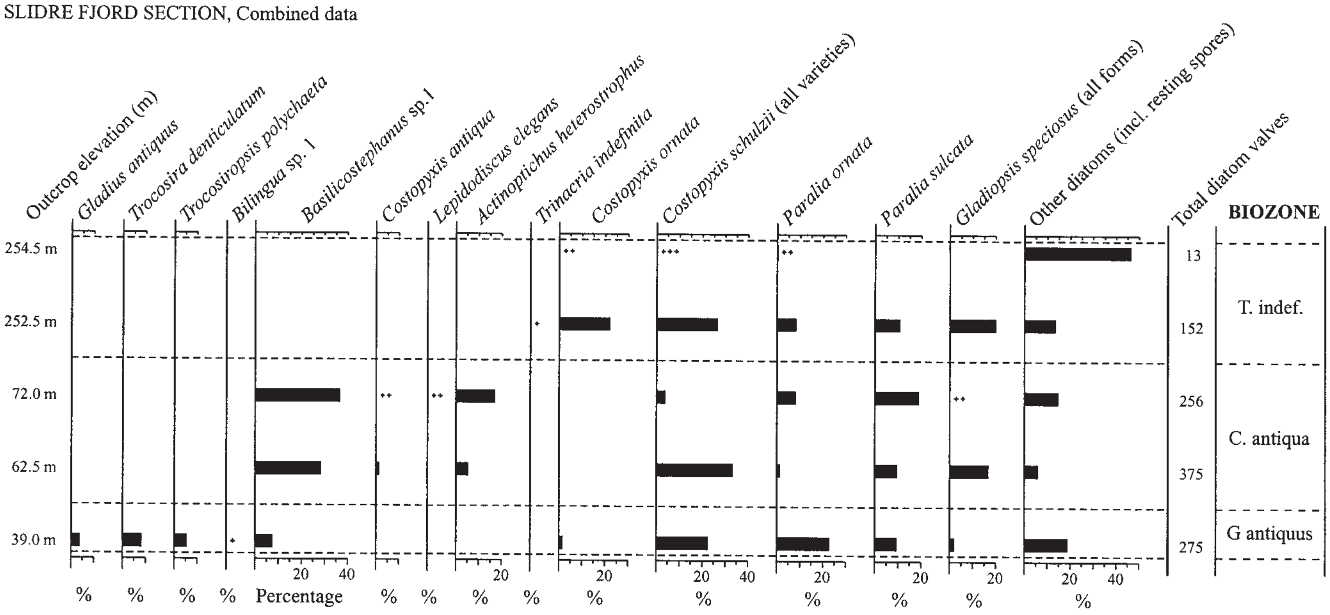
*Sample preparation.* Approximately 1cc of unconsolidated sediment was placed into a 1000ml beaker and dried on a hot plate. After the beaker cooled, 10-20ml of concentrated hydrochloric acid and 40-50ml of 30% hydrogen peroxide were added. This solution was heated and left to react until the strong reaction ceased. The beaker was then filled with filtered water and 10ml of 5% Calgon solution, stirred, and left to settle overnight. The next day, the supernatant solution (approximately 3/4 parts of the volume) was decanted. The beaker was refilled with filtered

TABLE 2
Selected diatom data (total counts) from Slidre Fjord Section of both size-fractions (greater and lesser than 25m). Preservation: G= Good, M= Moderate, P= Poor; Relative Abundance: A= Abundant, C= Common, F= Few, R= Rare.

| | | Cenom - Sant. | Early Campanian | | Early-Late Campanian | | | | Cenom - Sant. | Early Campanian | | Early-Late Campan. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Slidre Fjord, >25microns, <2.2 SG | C-34348 | C-34351 | C-34353 | C-34369 | C-34371 | Total specimens >25um | Slidre Fjord, <25microns, <2.2 SG | C-34348 | C-34351 | C-34353 | C-34369 | Total specimens <25um | Total of the 2 size fractions |
| **Outcrop elevation (m)** | | 39 | 62.5 | 72 | 252.5 | 254.5 | | | 39 | 62.5 | 72 | 252.5 | | |
| **Preservation** | | M | P | M | M | P | | | M-P | M-P | P | P | | |
| **Abundance** | | C | C | C-F | F | R | | | R | F | R | F-R | | |
| *Actinoptychus heterostrophus* | | | | 43 | | | 43 | | | 19 | | | 19 | 62 |
| *Actinoptychus tenuis* | | | | 5 | | | 5 | | | | | | 0 | 5 |
| *Aulacodiscus septus* f. *septus* | | | | 2 | 6 | 1 | 9 | | | | 1 | | 1 | 10 |
| *Basilicostephanus* sp. 1 | | 8 | | 93 | | | 101 | | 12 | 106 | | | 118 | 219 |
| *Bilingua* sp. 1 | | | | | | | 0 | | 1 | | | | 1 | 1 |
| *Corinna* sp. 1 | | 4 | | 2 | | | 6 | | | | | | 0 | 6 |
| *Cortinocornus rossicus* | | | | | | | 0 | | | | 1 | 1 | 2 | 2 |
| *Costopyxis antiqua* | | | 4 | 2 | | | 6 | | | | | | 0 | 6 |
| *Costopyxis ornata* | | 4 | | | 5 | 2 | 11 | | | | | 28 | 28 | 39 |
| *Costopyxis shulzii* f. *shulzii* | | 30 | 124 | 9 | 16 | 3 | 182 | | 4 | | | 24 | 28 | 210 |
| *Costopyxisshulzii* var. *nuda* | | 12 | | | | | 12 | | 15 | | | | 15 | 27 |
| *Gladiopsis speciosus* f. *aculeolatus* | | | | 2 | | | 2 | | 2 | | | | 2 | 4 |
| *Gladiopsis speciosus* f. *speciosus* | | 3 | 62 | | | | 65 | | | | | 30 | 30 | 95 |
| *Gladius antiquus* | | 1 | | | | | 1 | | 9 | | | | 9 | 10 |
| *Hemiaulus antiquus* | | | | | | | 0 | | 1 | | | 2 | 3 | 3 |
| *Hemiaulus echinulatus* | | 1 | | | | | 1 | | 2 | | | | 2 | 3 |
| *Hemiaulus elegans* | | 1 | | | | 1 | 2 | | | | | | 0 | 2 |
| *Hemiaulus polymorphus* var. *frigida* | | 1 | 1 | | | | 2 | | | | 1 | | 1 | 3 |
| *Hemiaulus schmidti* | | 4 | | | | | 4 | | | | | | 0 | 4 |
| *Hemiaulus* sp. A | | 2 | | | | | 2 | | 2 | | 1 | | 3 | 5 |
| *Hemiaulus sporalis* (spores) | | | 4 | | | | 4 | | | | | | 0 | 4 |
| *Lepidodiscus elegans* | | | | 2 | | | 2 | | | | | | 0 | 2 |
| *Micrampula parva* | | 1 | | | | | 1 | | | | | | 0 | 1 |
| *Paralia ornata* | | 36 | | | 12 | 2 | 50 | | 26 | 4 | 20 | | 50 | 100 |
| *Paralia sulcata* | | 19 | | 32 | 10 | | 61 | | 6 | 35 | 16 | 6 | 63 | 124 |
| *Pseudopyxilla* sp. cf. *P. rossica* | | 1 | | | | | 1 | | | | | | 0 | 1 |
| *Pterotheca aculeifera* | | | | | 1 | | 1 | | | | 1 | | 1 | 2 |
| *Stellarima stenyi* | | 3 | | | | | 3 | | | | | | 0 | 3 |
| *Stepahnopyxis arctica* | | | | | | 2 | 2 | | | | | | 0 | 2 |
| *Stephanopyxis grunowi* | | 5 | | | 2 | | 7 | | | | | | 0 | 7 |
| *Stephanopyxis* sp. A | | 5 | | 1 | | | 6 | | | | | | 0 | 6 |
| *Stephanopyxis turris* | | | | | 1 | | 1 | | | | | | 0 | 1 |
| *Thalassiosiropsis wittiana* | | | | | 1 | | 1 | | | | | | 0 | 1 |
| *Trinacria acutangulum* | | | | | | | 0 | | | | 2 | | 2 | 2 |
| *Trinacria indefinita* | | | | | 1 | | 1 | | | | | | 0 | 1 |
| *Trochosira denticulatum* | | 22 | | | | | 22 | | | | | | 0 | 22 |
| *Trochosiropsis polychaeta* | | 12 | | | | | 12 | | 2 | | | | 2 | 14 |
| Other diatoms (including resting spores) | | 14 | 12 | 19 | 4 | 2 | 51 | | 4 | 4 | 1 | 2 | 11 | 62 |
| TOTAL DIATOMS | | 189 | 207 | 212 | 59 | 13 | 680 | | 86 | 168 | 44 | 93 | 391 | 1071 |

water, allowed to settle for 6 hours and then decanted. This procedure was repeated four times to wash out the hydrochloric acid, hydrogen peroxide and Calgon, as well as to remove the finer clay size-fraction. The cleaned sample was then filled with filtered water, stirred vigorously, and allowed to settle for 5 minutes. This time the supernatant solution was sieved through a 25µm mesh and the finer fraction was collected in two 2000ml beakers. This step was repeated four times or until the supernatant water was clear after five minutes of settling. The sample of size 25µm was saved in a 10ml vial. The 25µm size fraction was saved in a 125 ml Nalgene bottle after the fine sediment in the beakers settled overnight, and the supernatant water was decanted. The coarse (=heavy) sediment residue that remained in the 1000ml beaker after the 5 minute gravitational settling period was dried in an electrical oven at 75°C and then saved in a labeled plastic sample bag.

Strewn slides of the 25µm size fraction were made for the entire set of samples in order to identify productive samples for siliceous microfossil analysis, and to determine if more chemical



TEXT-FIGURE 5
Diatom stratigraphy of selected diatom taxa in the Slidre Fjord section. Relative abundances (percentage) of taxa were calculated after the combined data (sum of greater and lesser than 25 micrometer fractions). Crosses indicate rare occurrences (usually <1%).

treatment was needed. The samples containing siliceous microfossils were then concentrated by floating with the heavy liquid sodium polytungstate (SPT) at a density of 2.2g/cc.

The sodium polytungstate flotation technique requires the previous chemical treatment in order to release the diatoms from the sediment matrix and clean the frustules. The acid-resistant subsample was then resuspended in 10ml of distilled water. To begin the floatation, 3.5ml of SPT (=2.2g/cc) was placed in the bottom of a 15ml disposable centrifuge tube. The subsample was resuspended and the 10ml suspension was carefully added to the top of the SPT in order to prevent mixing of these two solutions. The centrifuge tube was then filled up with distilled water and centrifuged at low speed (500 rpm) for 3 minutes. The SPT/water interface was carefully pipetted out and placed into another centrifuge tube. To remove the SPT from the diatom frustules, the working aliquot was resuspended in 15ml of distilled water and centrifuged at 1500 rpm for 3 minutes. The residue was washed again, up to four times or until all of the SPT was removed. The cleaned subsample was stored into a 10ml labeled vial.

Permanent slides were made for both size fractions (greater and lesser than 25µm) using cleaned, 22x40mm, cover slides. The cover slide was placed on a warm hot plate and six to eight drops of distilled water were added. One or two drops of the concentrated subsample were placed into the water at the middle of the slide and then two to three drops of alcohol (ethanol) were added. Alcohol helped disperse the sample across the slide. Two to three drops of mounting medium Norland Optical Adhesive # 61 (R.I. 1.56), was placed on a clean, labeled, 25x75mm, microscope slide. The microscope slide was fixed over the dried cover slip, and then flipped over to warm the *Norland* Optical Adhesive for a few minutes on the hot plate to reduce the media's viscosity and assure effective impregnation throughout the diatom valves. Finally, these permanent slides were cured under ultraviolet light for 15-20 minutes.

The slides were examined using an Olympus BH-2 Transmitted Light Microscope with Differential Interference Contrast. Photomicrographs were taken using B/W Technical Pan Kodak film, ASA 25. Data was collected at magnification ×500 (fraction >25µm), and 750X (fraction <25µm). Final identifications were made at magnification ×1250. Specimens were counted following the convention stated in Schrader and Gersonde (1978). A total of 500 specimens were counted per sample, 300 in the fraction >25µm and 200 at the fraction <25µm. After the counting process was completed, the rest of the slide was scanned for rarer diatoms. Several slides contained a limited number of specimens, in this case the whole slide was scanned and the total number of frustules taken into account. Slides with less than 100 specimen counts should be regarded as highly qualitative.

## RESULTS

### The fossil microflora at the studied sections

The Canadian Arctic samples yielded abundant marine diatoms, silicoflagellates, radiolarians, chrysophyte statocysts, and pollen and spores. Diatoms are the dominant group present in these samples and they show compositional changes throughout the sections. Silicoflagellates and chrysophyte statocysts will be the subject of a subsequent paper.

*Slidre Fjord section*. Only 5 of 29 samples from the measured 260.5m-thick Kanguk Formation contained sufficiently well-preserved siliceous microfossils for biostratigraphic analysis (text-fig. 4, column A, table 2). Six samples from the lowest 36m contained only a few occurrences of pollen and spores. Siliceous microfossils were encountered in the interval 39m to 42.5m (samples C-34348, and C-34349). Poor preservation and

TABLE 3
Selected diatom data (total counts) from Hoodoo Dome Section of both size-fractions (greater and lesser than 25µm). Preservation: G= Good, M= Moderate, P= Poor; Relative Abundance: A= Abundant, C= Common, F= Few, R= Rare.

| | **Hoodoo Dome, >25 microns, <2.2 SG** | **EARLY CAMPANIAN** | | | | **EARLY-LATE CAMPANIAN** | | Total specimens >25um | **Hoodoo Dome, <25 microns, <2.2 SG** | **EARLY CAMPANIAN** | | Total specimens <25um | **Total of the 2 size fractions** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C-44741 | C-44742 | C-44743 | C-44744 | C-44749 | C-44751 | | | C-44742 | C-44744 | | |
| **Outcrop sample interval (m)** | | 60-90 | 90-120 | 120-150 | 150-180 | 300-330 | 360-390 | | | 90-120 | 150-180 | | |
| **Average outcrop elevation (m)** | | 75.0 | 105.0 | 135.0 | 169.0 | 315.0 | 375.0 | | | 105.0 | 169.0 | | |
| **Preservation** | | P | P | P | M | P-M | M | | | P-M | P-M | | |
| **Abundance** | | R | C | R | C | R | R | | | F | R | | |
| *Aulacodiscus septus* f. *quatroradiatus* | | | | | 2 | | | 2 | | | | 0 | 2 |
| *Aulacodiscus septus* f. *septus* | | | | | | 1 | | 1 | | | | 0 | 1 |
| *Basilicostephanus* sp. 1 | | | 1 | | | | | 1 | | | | 0 | 1 |
| *Corinna* sp. 1 | | | | | | | | 0 | | 1 | | 1 | 1 |
| *Cortinocornus rossicus* | | | | | 17 | | | 17 | | 6 | | 6 | 23 |
| *Costopyxis antiqua* | | | 28 | 3 | 26 | | 1 | 58 | | | | 0 | 58 |
| *Costopyxis ornata* | | 3 | | | 10 | 1 | | 14 | | P | | 0 | 14 |
| *Costopyxis shulzii* f. *shulzii* | | 3 | 116 | 8 | 64 | 3 | 2 | 196 | | 17 | 2 | 19 | 215 |
| *Costopyxis shulzii* var. *nuda* | | | | | 17 | | 2 | 19 | | 37 | 3 | 40 | 59 |
| *Gladiopsis speciosus* f. *aculeolatus* | | | | | | | | 0 | | 4 | | 4 | 4 |
| *Gladiopsis speciosus* f. *speciosus* | | | 102 | 8 | 17 | | 2 | 129 | | 1 | | 1 | 130 |
| *Hemiaulus altus* | | | | | 1 | | | 1 | | 1 | | 1 | 2 |
| *Hemiaulus sp.* cf. *H. polymorphus* | | | | | 20 | 2 | 2 | 24 | | 29 | 2 | 31 | 55 |
| *Hemiaulus curvatulus* | | | | | | | | 0 | | 5 | | 5 | 5 |
| *Hemiaulus echinulatus* | | | | | 1 | 1 | | 2 | | | | 0 | 2 |
| *Hemiaulus kittonni* | | | | | | | | 0 | | 2 | | 2 | 2 |
| *Hemiaulus polymorphus* var. *frigida* | | | 1 | | 5 | | | 6 | | 7 | | 7 | 13 |
| *Hemiaulus schmidti* | | | | | 2 | | | 2 | | 5 | | 5 | 7 |
| *Hemiaulus* sp. A | | | | | 6 | | | 6 | | | | 0 | 6 |
| *Hemiaulus sporalis* (spores) | | | 1 | | | | | 1 | | P | | 0 | 1 |
| *Lepidodiscus elegans* | | | 1 | | 1 | | | 2 | | | | 0 | 2 |
| *Melosira? campaniensis* | | | | | | | | 0 | | 1 | | 1 | 1 |
| *Odontotropis cristata* | | | | | 4 | | | 4 | | | | 0 | 4 |
| *Paralia ornata* | | | | | | 2 | | 2 | | 5 | 10 | 15 | 17 |
| *Paralia sulcata* | | | | | 48 | 7 | 2 | 57 | | 55 | 14 | 69 | 126 |
| *Pseudopodosira witti* | | | | | 1 | | | 1 | | | | 0 | 1 |
| *Stellarima steinyi* | | | | | | 2 | | 2 | | | | 0 | 2 |
| *Stephanopyxis arctica* | | | | | 6 | | | 6 | | | | 0 | 6 |
| *Stephanopyxis dissonus* | | | | | | | | 0 | | 2 | | 2 | 2 |
| *Stephanopyxis grunowi* | | | | | 14 | 2 | 2 | 18 | | | | 0 | 18 |
| *Thalassiosiropsis wittiana* | | | | | 1 | | | 1 | | | | 0 | 1 |
| *Triceratium schulzii* | | | | | 7 | | | 7 | | 1 | | 1 | 8 |
| *Trinacria indefinita* | | | | | | 1 | | 1 | | | | 0 | 1 |
| Other diatoms (including resting spores) | | 5 | 19 | 4 | 19 | 5 | 1 | 53 | | 27 | 8 | 35 | 88 |
| **TOTAL DIATOMS** | | 11 | 269 | 23 | 289 | 27 | 14 | 633 | | 206 | 39 | 245 | 878 |

paucity of diatoms in sample C-34349, however, prevents its inclusion in the final biostratigraphic account. In the interval 42.5 to 62.5m only a few spores were observed. A second horizon of siliceous microfossils is present in the interval from 62.5 to 72m (samples C-34351 and C-34353). The interval from 82 to 242.5m is barren of siliceous microfossils, but some pollen and spores were present. A third interval that contains siliceous microfossils occurs near the top of the section between 252.5 and 254.5m (samples C-34369 and C-34371).

The diatoms *Gladius antiquus*, *Bilingua* sp. 1, and *Trochosira denticulatum* first appear in the sample C-34348 at 39m (text-fig. 5, table 2). *Basilicostephanus* sp. 1 and *Actinoptychus heterostrophus* were not observed above 72m. The First Occurrence Datum (FOD) of *Costopyxis antiqua* is noted in sample C-34351 at 62.5m, whereas the FOD of *Trinacria indefinita* is in C-34369 at 252.5m. *Lepidodiscus elegans* occurs only in sample C-34353 at 72m. Common diatom taxa present in this section are *Basilicostephanus* sp. 1, *Costopyxis schulzii* f.

*schulzii*, *Paralia ornata*, and *P. sulcata*. The silicoflagellates *Vallacerta hortoni* and *Vallacerta tumidula* are well represented in the Slidre Fjord samples.

*Hoodoo Dome section*. At this section, 6 out of the 12 samples contained siliceous microflora of sufficiently good preservation for biostratigraphic analysis (text-fig. 4, column B, table 3). The lowest 30m of the measured 390m-thick Kanguk Formation at Hoodoo Dome, contain only scarce spores. An interval of poor to moderate biogenic silica preservation occurs between 60 and 180m (samples C-44741 to C-44744). The interval from 180 to 300m (samples C-44745 to C-44748) and 330 to 360m (sample C-44750) is barren of siliceous microfossils, containing only a few pollen and spore grains. Samples C-44749 (between 300 and 330m) and C-44751 (between 360 and 390m) yielded diatoms, but of poor to moderate preservation.

The diatoms *Costopyxis antiqua*, *Basilicostephanus* sp. 1, *Triceratium schulzii*, and *Lepidodiscus elegans* are confined to the lower 180m (text-fig. 6, table 3). A single occurrence of *C. antiqua* in sample C-44751 (between 360 and 390m) may indicate some reworking or possible contamination. Common diatoms are *Costopyxis antiqua*, *C. schulzii* f. *schulzii*, *Gladiopsis speciosus* f. *speciosus*, and *Paralia sulcata*. Scarce silicoflagellates were noted in the lowest 180m.

*Cape Nares section.* At this section, 9 out of 20 samples contained diatoms in a degraded preservation state. All of the slides from the <25µm size fraction are barren of siliceous microfossils. The Kanguk Formation is 156m-thick in this region. The lower 66m of the Lower Shale Member was barren of siliceous microfossils but contained pollen and spores. A continuous poorly-preserved siliceous microfossil assemblage was noted between 72 and 119m (text-fig. 4, column C; table 4). Samples of sandstone from the Eglinton Member (123 to 144m) were barren or contained rare pollen grains. One sample at 156m from the Upper Shale Member contained poorly-preserved and recrystalized diatoms. The siliceous microflora at this section is highly altered and many identifications were possible only to a generic level.

*Horton River composite section*

*GSC locality CR16A-N68*. The siliceous microfossils from this section occur in variable states of preservation. Only 2 out of 20 samples yielded enough material for biostratigraphic analysis (text-fig. 4, column D, tables 5, 6). The Smoking Hills Formation is about 100m-thick at this location. The lowest 21m are barren of siliceous microfossils, but contains scarce pollen and spores. Sample C-8564 (interval from 21.3 to 24.4m) contains siliceous microfossils of moderate preservation. The interval from 24.4 to 97m is barren of siliceous microfossils. Sample C-8589 (interval from 97.5 to 100.6m) contains a siliceous microfossil assemblage of moderate preservation. Diatom-bearing samples were placed at the bottom of the distribution table (text-figures 7, 8; Tables 5, 6) based on field evidence and palynomorph divisions (McIntery 1974).

*GSC locality CR16B-N68*. A suite of 25 samples contained good to moderately well-preserved siliceous microfossils (text-fig. 4, column D; tables 5, 6) from the 125m-thick Mason River Formation. The Last Occurrence Datum (LOD) of *Costopyxis antiqua* is observed in sample C-8593 (interval from 9.1 to 12.2m) (text-fig. 8, table 6). Most of the long-ranging Campanian diatoms are present in the lowest 12m of the section. Sample C-8592 (interval from 6.1 to 9.1m) marks the level of the FOD of *Sheshukovia* sp. 1 (text-fig. 8, table 5). The stratigraphic interval between 15 to 55m is dominated by diatom colonial vegetative cells. The FOD of *Strelnikovia antiqua* occurs in sample C-8596 (interval 18.3 to 21.3m, table 6), continuing up to sample C-8607 (interval 51.2 to 54.9m, table 5). Meanwhile, the FOD of the biostratigraphic indicator *Stephanopyxis simonseni*, is observed at sample C-8608 (interval 54.9 to 57.9, table 5, text-fig. 7). The interval between 55 to 125 m contains an increased number of diatom resting spores. Here, the unidentified resting spores # 3 and # 4 seem to be potential biostratigraphic markers. The Horton River diatom assemblage is dominated by *Aulacodiscus septus*, *Cortinocornus rossicus*, *Costopyxis ornata*, *Goniothecium odontella*, *Hemiaulus schmidti*, *H. polymorphus* var. *frigida*, *H. sporalis* (spore stage), *Meristiosolen* sp. 1, *Paralia sulcata*, *Pterotheca aculeifera*, spore # 12, *Stellarima stenyi*, *Stephanopyxis arctica*, *S. grunowi*, *S. superba*, *S. dissonus*, *S. simonseni*, *S. turris*, *Thalassiosiropsis wittiana*, *Trinacria acutangula*, *T. indefinita*, and *Trochosiropsis polychaeta*. The silicoflagellates *Lyramula furcula* and *Vallacerta hortoni* are among the most conspicuous taxa. Some silicoflagellate taxa attributable to the genus *Mesocena* (or *Bachmanocena*) occur rarely in the lower half of this section.

The Horton River Section is the most continuous Upper Cretaceous diatom-bearing section known from North America. Siliceous microfossils are present throughout the section in varying abundance, allowing for the proposal of a diatom biostratigraphy in the northern high-latitudes.

*GSC locality CR17A-N68*. The 6 samples examined from this section of the Mason River Formation were barren of siliceous microfossils and yielded few pollen and spores.

### Diatom biostratigraphy in the Canadian Arctic

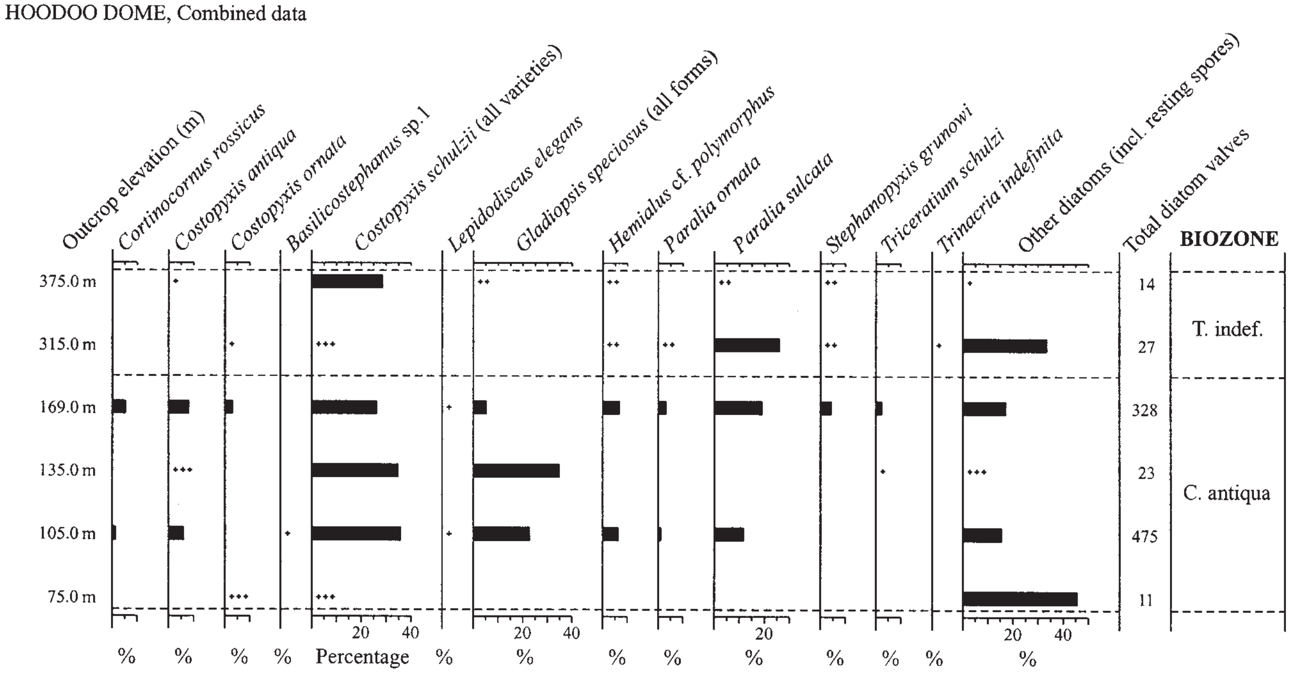
Four diatom biostratigraphic zones are proposed based on the distribution of diatoms in the stratigraphic sections described above (text-fig. 9). The proposed broad zones represent a starting point to aid the application of diatom biostratigraphy to Upper Cretaceous strata. Additional biostratigraphic control from continuous sections recovered in the future is needed to better characterize the zones and eventually subdivide them.

#### *Gladius antiquus* Concurrent Range Zone, new zone

*Definition:* The stratigraphic interval between the FOD of *Basilicostephanus* sp. 1 up to the LOD of *Gladius antiquus* Forti et Schulz. The lower boundary in this section coincides with the lowest diatom-bearing strata and does not represent the total range of this zone. The upper boundary is identified in the Slidre Fjord section 74RV-38, sample C-34348 (39.0m).

*Age:* Undefined post-Albian to pre-Campanian (Late Cenomanian to Late Santonian?). The age of the *G. antiquus* Zone is based on a similar age based on mollusks and foraminifera from the lower Kanguk Formation (Jeletzky in Blakwill and Hopkins 1976, Jeletzky in Plauchut and Jutard 1976, Wall 1983, J. H. Wall, pers. comm.).

*Associated species: Basilicostephanus* sp. 1, *Bilingua* sp. 1, *Corinna* sp. 1, *Costopyxis ornata* (Schulz) Strelnikova, *C. schulzii* (Steinecke) Gleser, *C. schulzii* var. *nuda* Strelnikova, *Gladiopsis speciosus* f. *aculeolatus* Strelnikova, *G. speciosus* f. *speciosus* (Schulz) Strelnikova, *Hemiaulus* sp. A, *H. antiquus* Jousé, *H. echinulatus* Jousé, *H. polymorphus* var. *frigida* Grunow, *H. schmidti* Hajós, *Hemiaulus* sp. 1, *Hyalodiscus* sp. 2,



TEXT-FIGURE 6
Diatom stratigraphy of selected diatom taxa in the Hoodoo Dome section. Relative abundances (percentage) of taxa were calculated after the combined data (sum of greater and lesser than 25 micrometer fractions). Crosses indicate rare occurrences (usually <1%).

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*Micrampula parva* Hanna, *Paralia ornata* (Grunow) Grunow ex van Heurck, *P. sulcata* (Ehrenberg) Cleve, *Porpeia* sp. 2, *Pseudopyxilla* sp. cf. *P. rossica* (Pantocsek) Forti, *Stellarima stenyi* (Hanna) Hasle et Sims, *Stephanopyxis grunowi* Grove et Sturt, *S.* sp. A, *Trochosira denticulatum* (Strelnikova) Tapia, and *Trochosiropsis polychaeta* (Strelnikova) Tapia.

*Reference section:* Slidre Fjord, Ellesmere Island, District of Franklin, Canada. GSC locality 74RV-38, sample C-34348, at approximately 39.0m from the base of the section.

*Comments: The Gladius antiquus* Zone is, at present, a poorly documented biostratigraphical zone. It is differentiated from the overlying *Costopyxis antiqua* Zone by the presence of *G. antiquus* Forti et Schulz and *Bilingua* sp. 1. The stratigraphic level of the lower boundary is poorly defined and may range to the lower part of the Upper Cretaceous. As this zone is based on the occurrence of *G. antiquus* in only one sample, more reliable samples are needed to better define the zonal boundaries. The genera *Basilicostephanus* Gersonde et Harwood, *Bilingua* Gersonde et Harwood and *Gladius* Forti et Schulz are widely represented in the Lower Cretaceous (Harwood and Nikolaev 1995) and are well-known in the Aptian-Albian sediments of Antarctica (Gersonde and Harwood 1990). This zone is, however, not likely to be Lower Cretaceous due to the absence of many Lower Cretaceous taxa and the presence of Upper Cretaceous diatoms (*Costopyxis* Gleser, *Gladiopsis* Gersonde et Harwood, *Hemiaulus sensu lato*, *Stellarima* Hasle et Sims, and *Stephanopyxis* Ehrenberg). The rare occurrence of Lower Cretaceous forms (*Basilicostephanus*, *Bilingua*, and *Gladius*) indicates a transitional interval including the last survivors from a previous diatom radiation (Harwood and Nikolaev 1995).

### *Costopyxis antiqua* Partial Range Zone, new zone

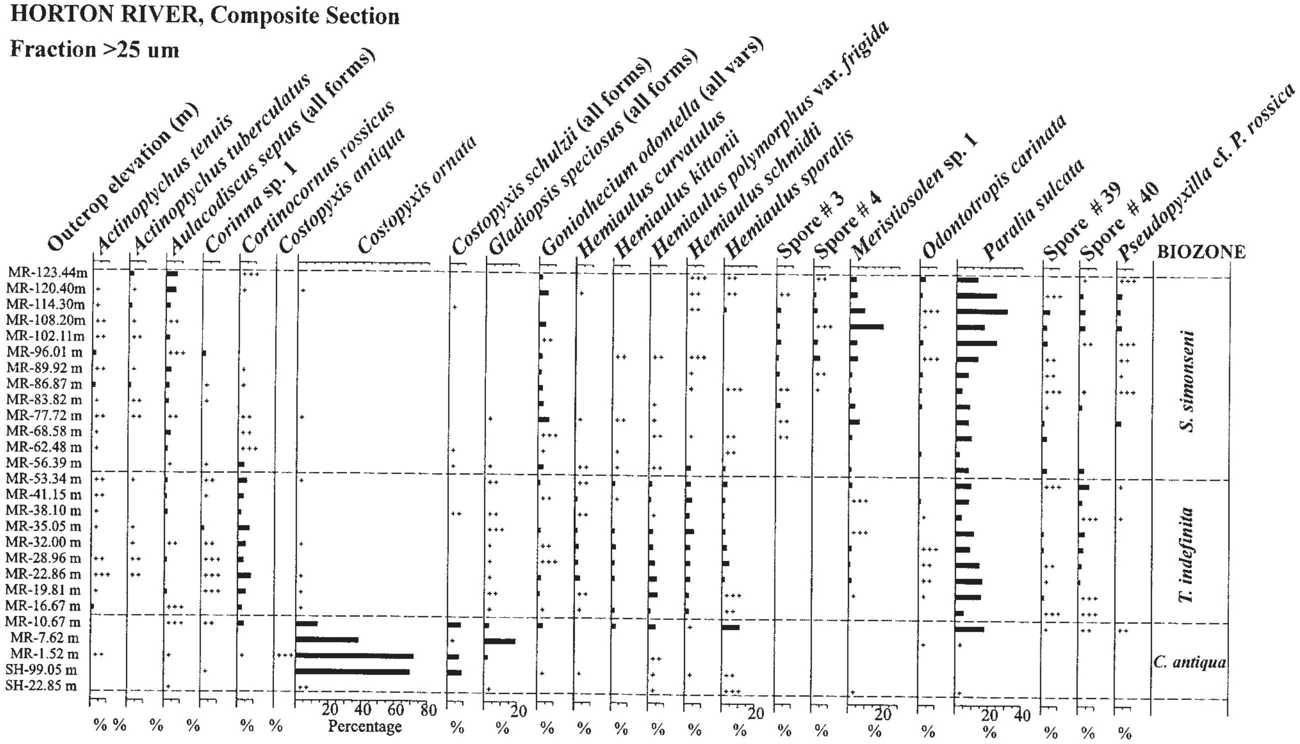
*Definition:* The stratigraphic interval between the LOD of *Gladius antiquus* Forti et Schulz up to the LOD of *Costopyxis antiqua* (Jousé) Gleser. The lower boundary is identified in the Slidre Fjord section 74RV-38, sample C-34351 (62.5m), and the upper boundary is identified at the Horton River section CR16B-N68, sample C-8593 (9.1-12.2m).

*Age:* Early Campanian, based on diatom biostratigraphic correlation to the First Diatom Complex (Early Campanian) of Strelnikova (1974). The lower boundary may be slightly older problably into the Late Santonian.

*Associated species: Actinodiscus* sp. 2, *Actinoptychus heterostrophus* Schmidt, *Basilicostephanus* sp. 1, *Costopyxis ornata* (Schulz) Strelnikova, *C. schulzii* (Steinecke) Gleser, *Lepidodiscus elegans* Witt, *Paralia ornata* (Grunow) Grunow ex van Heurck, and *Triceratium schulzii* Jousé.

*Reference sections:* Lower part of the *C. antiqua* Zone: Slidre Fjord section, 74RV-38, samples C-34351 and C-34353 (section interval from 62.5 to 72.0m). Upper part of the *C. antiqua* Zone: Horton River section, locality CR16A-N68, samples C-8564 (21.3-24.4m), and C-8589 (97.5-100.6m); locality CR16B-N68, samples C-8590 (0.0-3.0m) to C-8593 (9.1-12.2m).

*Comments:* The *C. antiqua* Zone is not fully represented in a single section. In order to establish this biostratigraphic zone, it was necessary to combine intervals from the Slidre Fjord and Horton River sections.



TEXT-FIGURE 7
Diatom stratigraphy in the Horton River composite section. Relative abundance (percentage) of selected diatom taxa in the fraction greater than 25 micrometers. Dots indicate rare occurrences (<1%). MR = Mason River Fm.; SH = Smoking Hills Fm.

### ***Trinacria indefinita* Interval Zone, new zone**

*Definition:* The stratigraphic interval from the LOD of *Costopyxis antiqua* (Jousé) Gleser, up to the FOD of *Stephanopyxis simonseni* Hajós. The lower boundary is identified in the Horton River section CR16B-N68, sample C-8595 (15.2-18.3m), and the upper boundary is identified in the same section, sample C-8607 (51.2-54.9m).

*Age:* Early Late Campanian, based on diatom biostratigraphic correlation to the Second Diatom Complex (early Late Campanian) of Strelnikova (1974).

*Associated species:* This zone includes the long-ranging Upper Campanian assemblage including diatoms *Actinoptychus tenuis* Strelnikova, *A. tuberculatus* Strelnikova, *Aulacodiscus septus* Schmidt, *Cortinocornus rossicus* (Pantocsek) Gleser, *Goniothecium odontellum* Ehrenberg, *Hemiaulus polymorphus* var. *frigida* Grunow, *H. schmidti* Hajós, *H. sporalis* Strelnikova (spore stage), *Odontotropis carinata* Grunow, *Paralia sulcata* (Ehrenberg) Cleve, *Pterotheca aculeifera* Grunow, *Stellarima stenyi* (Hanna) Hasle et Sims, *Stephanopyxis arctica* (Grunow) Strelnikova et Nikolaev, *S. dissonus* (Schulz) Strelnikova et Nikolaev, *S. grunowi* Grunow et Sturt, *S. turris* Greville et Arnott, *Thalassiosiropsis wittiana* (Pantocsek) Hasle, and *Trinacria acutangula* (Strelnikova) Barron. Characteristic diatoms from this zone are *Sheshukovia* sp. 1, *Stephanopyxis superba* (Greville) Grunow, *Strelnikovia antiqua* (Strelnikova) Ross et Sims, and *Trinacria indefinita* Jousé.

*Reference section:* Horton River section locality CR16B-N68, samples C-8595 (15.2-18.3m) to C-8607 (51.2-54.9m).

*Comments:* The occurrence of the peculiar taxon *Strelnikovia antiqua* (Strelnikova) Ross et Sims is observed along the interval of the *T. indefinita* Zone, although the low abundance of *S. antiqua* excludes naming this zone after this diatom.

### ***Stephanopyxis simonseni* Partial Range Zone, new zone**

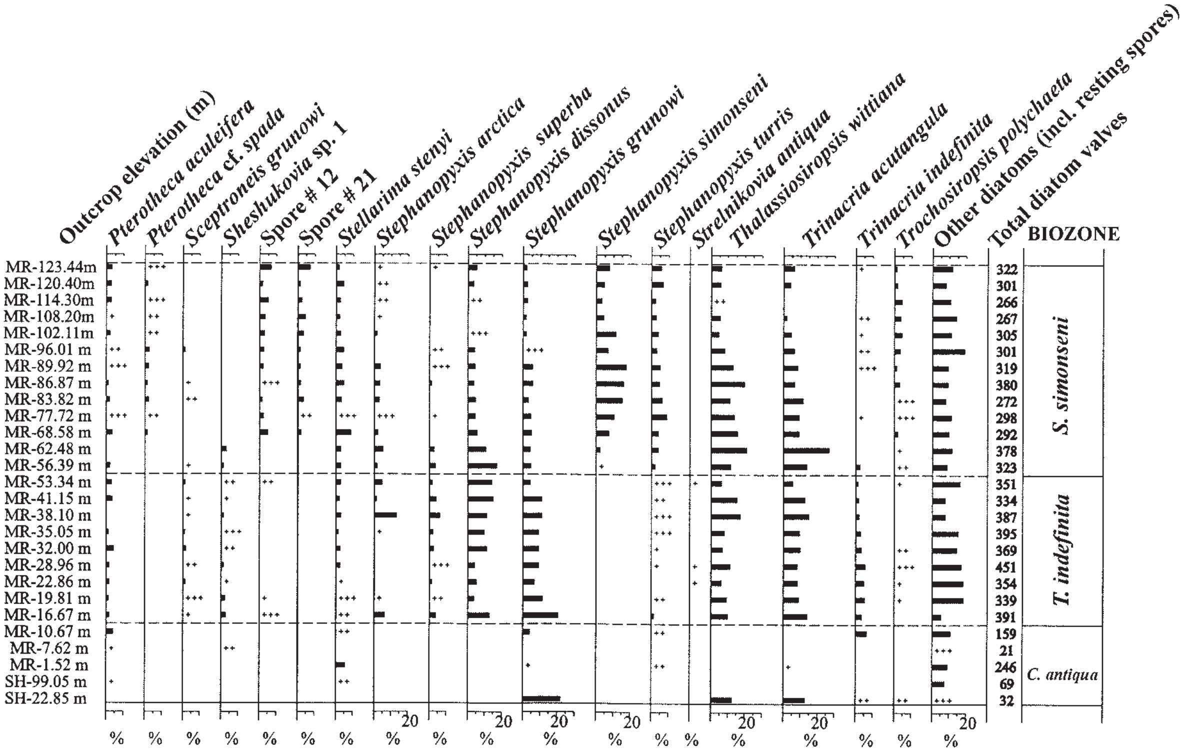
*Definition:* The stratigraphic interval from the FOD of *Stephanopyxis simonseni* Hajós up to the FOD of *Azpeitiopsis morenoensis* (Hanna) Sims. The lower boundary is identified at the Horton River section CR16B-N68, sample C-8608 (54.9-57.9m). The upper boundary was not identified in this section.

*Age:* Late Late Campanian, based on diatom biostratigraphic correlation to the Third Diatom Complex (late Late Campanian) of Strelnikova (1974).

*Associated species:* The diatom assemblage in this zone includes the long-ranging Upper Campanian assemblage (see above) and the presence of the unidentified resting spores #3 and # 4, *Trinacria* sp. 3, *Biddulphia* sp. 6, *Trochosiropsis polychaeta* (Strelnikova) Tapia, *Pterotheca* sp. cf. *P. spada* Tempère et Brun, and resting spore #12.

*Reference section:* Horton River section locality CR16B-N68, samples C-8608 (54.9-57.9m) to C-8630 (121.9-125.0m).

*Comments:* The upper boundary of the *Stephanopyxis simonseni* Zone is here defined as the FOD of *Azpeitiopsis morenoensis* (Hanna) Sims. *A. morenoensis* does not occur in the Arctic samples, although is a common element of Maastrichtian diatom as-



TEXT-FIGURE 7
*Continued.*

semblages around the world (Sims 1994a, Nikolaev and Harwood 2000).

Global records of Maastrichtian diatom-bearing sediments indicate that another diatom biostratigraphic zone outside the Canadian Arctic region can also be proposed.

***Azpeitiopsis morenoensis* Concurrent Zone, new zone**

*Definition:* The stratigraphic interval from the FOD of *Azpeitiopsis morenoensis* (Hanna) Sims up to the LOD of *Gladiopsis speciosus* (Schulz) Gersonde et Harwood *sensu lato.*

*Age:* Early to Late Maastrichtian. Correlative to the Maastrichtian Diatom Complex of Strelnikova (1975).

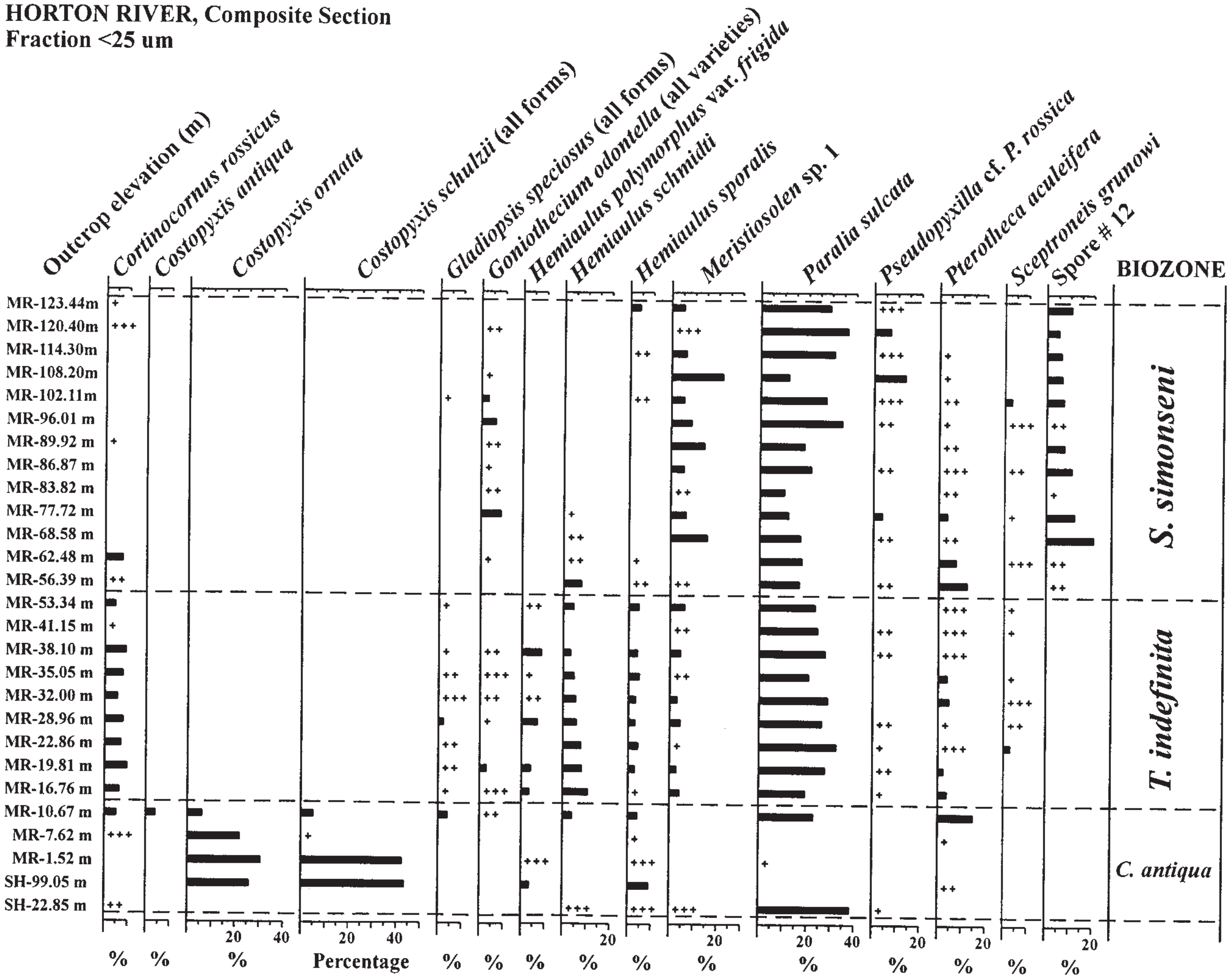
*Associated species:* Extensive flora described in Hanna (1927, 1934), Long et al. (1946), Barker and Meakin (1944, 1945, 1946, 1948, 1949), Brigger and Hanna (1965), Hasle and Syvertsen (1985), Nikolaev et al. (2001), Ross and Sims (1985, 1997), Sims and Hasle (1987), Sims and Ross (1988), and Sims (1986, 1989, 1994a,b) for the Moreno Formation of California.

*Reference section:* Not identified. There are accounts of well-dated Lower Maastrichtian diatoms in the Raggatt Basin, ODP Hole 748C, Kerguelen Plateau, Southern Ocean (Nikolaev and Harwood 2000), and the intensively studied Upper Maastrichtian Moreno Formation, Moreno Gulch, Fresno County, California, USA (see references above).

*Comments:* This zone is proposed in view of the global distribution of *Azpeitiopsis morenoensis* (Hanna) Sims. The lower boundary of this zone may appear in the stratigraphic record between the uppermost Campanian and the lowermost Maastrichtian. This is inferred because the uppermost Campanian section is missing in the Mason River Fm., Arctic Canada, but it appears to be recovered in the Lower Maastrichtian sediments of ODP Site 748, Raggatt Basin, Kerguelen Plateau (Nikolaev, pers. comm.). The upper boundary defined as the LOD of *G. speciosus* (*sensu lato*) occurs in the Upper Maastrichtian Lopez de Bertodano Fm. on Seymour Island, Antarctic Peninsula (Harwood 1988).

## DISCUSSION

Before the present study, only two diatom biostratigraphic zonal schemes were proposed for the Upper Cretaceous. The northern high-latitude (Russia) diatom complexes and the southern high-latitude (Campbell Plateau, SW Pacific) diatom biostratigraphic zones. The new Arctic Upper Cretaceous diatom biostratigraphy is in general agreement with biostratigraphical divisions based on three diatom assemblage zones from the Ural Mountains, Russia (Strelnikova 1974, 1975; text-fig. 3-A). The *Costopyxis antiqua* Zone is correlated tentatively with the First Diatom Complex (Early Campanian) (Strelnikova 1974), based on the occurrence of *Costopyxis antiqua* (Jousé) Gleser, *Lepidodiscus elegans* Witt, *Paralia ornata* (Grunow) Grunow ex van Heurck, *Triceratium schulzii* Jousé, and *Hemiaulus echinulatus* Jousé. The *Trinacria indefinita* Zone is correlated tentatively with Strelnikova's (1974) Second Diatom Complex (early Late Campanian) based on the presence of *Stephanopyxis turris* (Greville et Arnott) Ralfs, *Paralia sulcata* (Ehrenberg) Cleve, *Trochosiropsis polychaeta* (Strelnikova) Tapia, *Hemiaulus antiquus* Jousé, *H. kittonii* Grunow, *Gladiopsis speciosus* f. *speciosus* (Schulz) Strelnikova, and *Pterotheca aculeifera* Grunow. The *Stephanopyxis simonseni* Zone is tentatively correlated to the Third



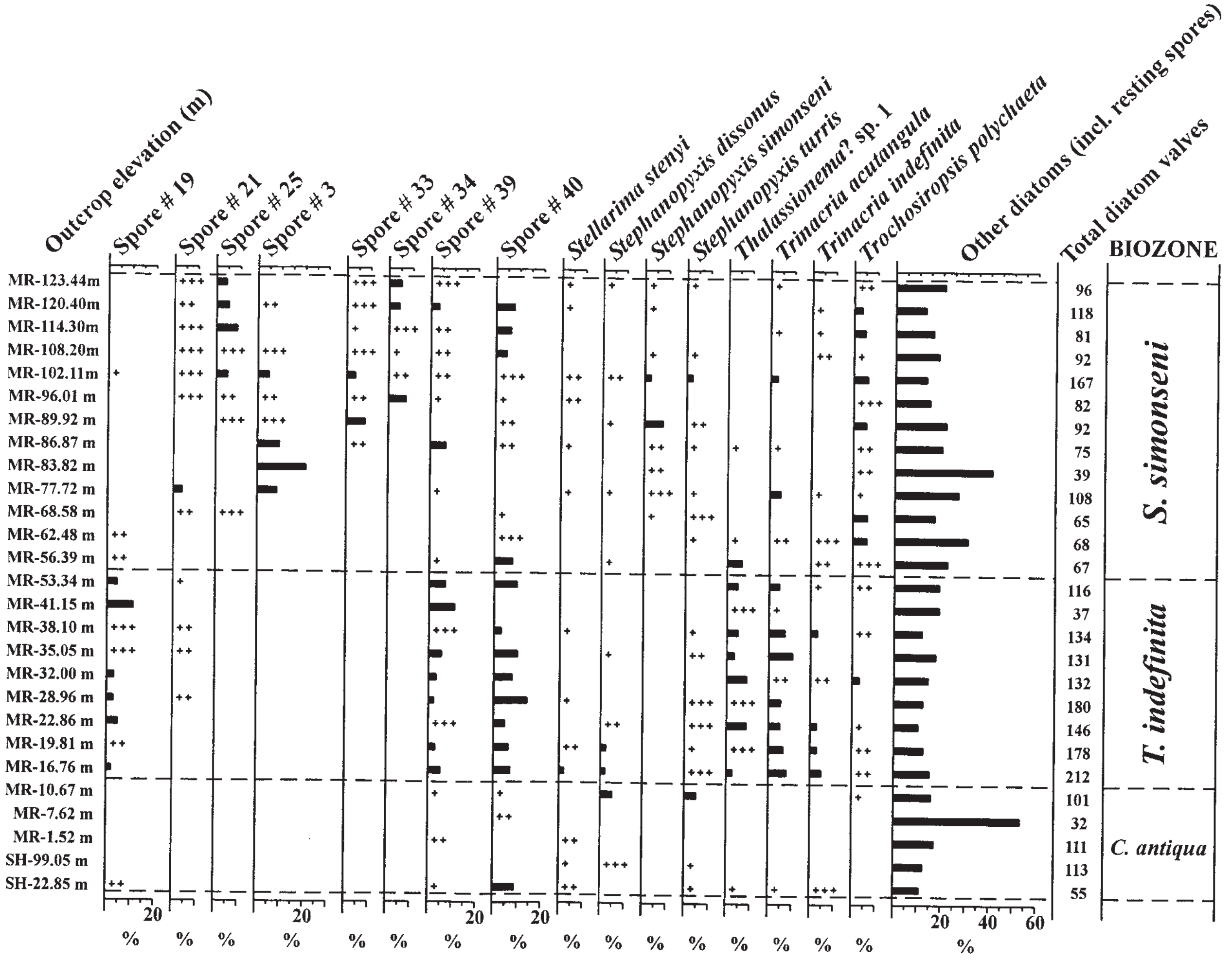
TEXT-FIGURE 8
Diatom stratigraphy in the Horton River composite section. Relative abundance (percentage) of selected diatom taxa in the fraction lesser than 25 micrometers. Crosses indicate rare occurrences (<1%). MR = Mason River Fm.; SH = Smoking Hills Fm.

Diatom Complex (late Late Campanian) (Strelnikova 1974), based on the co-occurrence of *Costopyxis reticulata* (Long, Fuge et Smith) Gleser, *Paralia sulcata* (Ehrenberg) Cleve, *Pseudopyxilla* sp. cf. *P. rossica* (Pantocsek) Forti and *Stephanopyxis turris* (Greville et Arnott) Ralfs. No correlation can be made with the oldest zone, the *Gladius antiquus* Zone, as it is known only from the Sverdrup Basin (this study). Diatoms analyzed from Alpha Ridge, Arctic Ocean Basin, (Barron 1985, Dell'Agnese 1988, Dell'Agnese and Clark 1994) bear close resemblance to the Upper Campanian *Trinacria indefinita* and *Stephanopyxis simonseni* zones.

The Upper Campanian diatom record is the best known interval of the Upper Cretaceous, either from low latitudes (Ninety-east Ridge), southern-intermediate latitudes (Tonga Trench), and southern high-latitudes (Campbell Plateau) with many taxa in common. The nine biostratigraphic zones from Campbell Plateau core sediments (Hajós and Stradner 1975; text-fig. 3B) cannot be compared directly with the Canadian Arctic zonation, because key taxa do not occur in the Arctic sediments.

As evident in the Canadian samples, the state of silica preservation plays an important role in determining the presence of siliceous microfossils at the different subsample fractions. As a general rule, the presence of moderate to well-preserved microfossils at the >25μm fraction will guarantee the presence of small siliceous microfossils at the <25μm fraction. Similarly, poorly preserved siliceous microfossils in the greater subsample are associated with barren preparations in the finer subsample.

Moreover, the presence of other microfossil groups in the same samples allowed a microfossil correlation throughout the sections. At Slidre Fjord, diatoms are better biostratigraphic indicators than their foraminiferal counterparts. The diatom zones (*G. antiquus, C. antiqua,* and *T. indefinita*) span three different time periods (Cenomanian-Santonian, Early Campanian, early Late



TEXT-FIGURE 8
*Continued.*

Campanian) and coincide with an undifferentiated Campanian foraminiferal assemblage (J. H. Wall, pers. comm.).

Currently, it is not possible to correlate the diatom biostratigraphic record from Hoodoo Dome to other microfossil zonations. The diatom record is not completely clear in Hoodoo Dome to discern whether it represents 1 or 2 biostratigraphic zones. The single occurrence of *C. antiqua* in the upper section may be a reworked element, thus we think that both *C. antiqua* and *T. indefinita* zones are present in this section.

The diatom record at Cape Nares is highly altered by diagenetic processes. Foraminiferal data indicate an age range from Late Turonian to Early Campanian due to the presence of taxa from the *Dorotia smokyensis* Zone (J. H. Wall, pers. comm.). The diatoms indicate an undifferentiated Campanian age, although Early Campanian may be suggested due to the presence of some partially recognizable specimens of *C. antiqua* and *P. ornata*.

A microfossil correlation is better achieved with samples from the composite Horton River section. The palynological divisions reported from this section (McIntyre 1974) agree with the diatom data. Microfloral divisions 1 and 2 correspond with the Early Campanian *C. antiqua* Zone. The Upper Campanian diatom zones, are equivalent to the lower two-thirds of McIntyre's division 3. Following McIntyre's zonation, the boundary between the Campanian-Maastrichtian corresponds approximately to the boundary between the *T. indefinita* and *S. simonseni* diatom zones.

A correlation between the Upper Cretaceous sediments from the Anderson Plains and the Sverdrup Basin was proposed based on palynological data (Yorath et al. 1975, Plauchut and Jutard 1976). The Smoking Hills Formation was correlated with the lower Kanguk Formation, whereas the Mason River Formation with the upper Kanguk Formation. The diatom record indicates a partial correlation among those formations (text-fig. 9). The Kanguk Formation in the Sverdrup Basin –e.g. Slidre Fjord Section- has a much older record (*G. antiquus* Zone) in comparison to the sediments at the continental margin. Moreover, it correlates to the Smoking Hills Formation (*C. antiqua* Zone) and partially to the Mason River Formation (*T. indefinita* Zone) of the Anderson Plain Syncline. No evidence of the upper Mason River Formation equivalent (*S. simonseni* Zone) was identified in samples of the Kanguk Fm.

TABLE 4
Diatom data (total counts) from Cape Nares Section of the fraction greater than 25µm. Preservation: G= Good, M= Moderate, P= Poor; Relative Abundance: A= Abundant, C= Common, F= Few, R= Rare.

| | Campanian | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C-156077 | C-156071 | C-156070 | C-156069 | C-156068 | C-156067 | C-156066 | C-156065 | C-156064 | **Total specimens** |
| **Outcrop elevation (m)** | 156 | 119 | 113 | 102 | 96 | 90 | 84 | 78 | 72 | |
| **Preservation** | P | P | P | P | P | P | P | P | P | |
| **Abundance** | R | R | R | R | R | F-C | F | R | R | |
| *Coscinodiscus* sp. | | | | | 2 | | | | | 2 |
| *Costopyxis* spp. | 17 | 20 | 10 | 47 | 97 | 145 | 91 | 7 | 7 | 441 |
| *Gladiopsis* sp. | 2 | | 5 | 11 | 15 | 17 | 9 | 2 | 3 | 64 |
| *Gonothecium odontella* | | | | 4 | 9 | | 5 | 1 | 1 | 20 |
| *Hemiaulus* spp. | 3 | | | 12 | 26 | 39 | 52 | 4 | | 136 |
| *Odontotropis* sp. | | | | | | | 1 | | | 1 |
| *Paralia* sp. | | | 1 | | | 1 | | | 2 | 4 |
| *Pseudopyxilla* sp. | | | | 2 | | 1 | | | | 3 |
| *Pterotheca* sp. | | | | | | 1 | | | | 1 |
| *Stephanopyxis* sp. | 1 | 5 | | 1 | | 10 | | | | 17 |
| *Triceratium* sp. | | | | 1 | | 2 | 5 | | 2 | 10 |
| *Trinacria* sp. | | | | | | | | 1 | | 1 |
| **Total diatoms** | 23 | 25 | 16 | 78 | 149 | 216 | 163 | 15 | 15 | 700 |

The present diatom biostratigraphic study from the Canadian Arctic permitted the construction of a new northern high-latitude biostratigraphy framework based upon four biostratigraphic zones. The *Azpeitiopsis morenoensis* Zone is proposed in light of the worldwide occurence of this taxon ranging from deposits of California (Hanna 1927, Long et al. 1946), Akupa River basin, Koryak Range, Russia (Strelnikova 1975), Tonga Trench, South Pacific (Nikolaev, pers. comm. 1996), and Kerguelen Plateau, Southern Ocean (Nikolaev, pers. comm., 1996). Figured specimens from Seymour Island, Campbell Plateau, and Ninety-east Ridge are possible misidentifications (Nikolaev, pers. comm. 1996). The samples at Kerguelen Plateau (ODP Leg 120, Site 748, Raggatt Basin) bear a special flora including *A. morenoensis* and several species of *Pomphodiscus* (Nikolaev and Harwood 2000). Biostratigraphic control in the best productive sample (748C, 48R-01, 4-6cm) is based on calcareous nannoplankton; cores 40R to 48R are restricted to the Last Appearance Datum (LAD) of *Aspidolithus parcus* and the LAD of *Eiffellithus eximius*, narrowing the depositional time to an Early Maastrichtian age (Watkins et al. 1992). At the present, this is the only well-dated, diatomaceous-bearing sample for the Lower Maastrichtian in the world. At Kerguelen Plateau, *A. morenoensis* is not as abundant as it is in Upper Maastrichtian Moreno Formation sediments from California. As defined, the top of *A. morenoensis* Zone is marked by the LOD of *Gladiopsis speciosus* (*sensu lato*) a species that radiates in the Upper Cretaceous and appears to die out at the end of the Cretaceous (Late Maastrichtian) (Harwood and Nikolaev 1995). An example of the extinction of *G. speciosus* is given in the Upper Maastrichtian Lopez de Bertodano Formation on Seymour Island, Antarctic Peninsula (Harwood 1988) where the genus *Gladiopsis* does not continue across the K/T boundary.

## CONCLUSIONS

The results of 49 samples containing sufficiently preserved diatoms from a composite stratigraphic section of 1094m of the Kanguk, Mason River and Smoking Hills formations in the Canadian Arctic provide biostratigraphic data to enable the construction of a northern high-latitude Campanian diatom biostratigraphic zonation.

A high siliceous microfossil diversity was encountered. The microfossil assemblages comprise 203 diatom taxa, 20 silicoflagellate taxa, and 16 chrysophyte statocyst taxa.

Four diatom biostratigraphic zones are proposed for the Canadian Arctic. In ascending order they are: (1) The Upper Cenomanian to Upper Santonian(?) *Gladius antiquus* Concurrent Range Zone; (2) the Lower Campanian *Costopyxis antiqua* Partial Range Zone, (3) the lower Upper Campanian *Trinacria indefinita* Interval Zone; and (4) the upper Upper Campanian *Stephanopyxis simonseni* Partial Range Zone. A fifth diatom biostratigraphic zone, the Maastrichtian *Azpeitiopsis morenoensis* Concurrent Range Zone, is proposed based on stratigraphic information from other sites around the globe.

Founded on the proposed diatom biostratigraphic zones, we attempt the following diatom-based correlation among Upper Cretaceous lithostratigraphic units in the Canadian continental margin and Sverdrup Basin. The Kanguk Formation is correlated in part with the lower Mason River and Smoking Hills formations (*C. antiqua* and *T. indefinita* zones). The younger *S. simonseni* Zone is not present in other samples than from the upper part of the lower Mason River Formation. The oldest zone, the *G. antiquus* zone, is restricted to the lowermost Kanguk Formation interval examined here.

## ACKNOWLEDGMENTS

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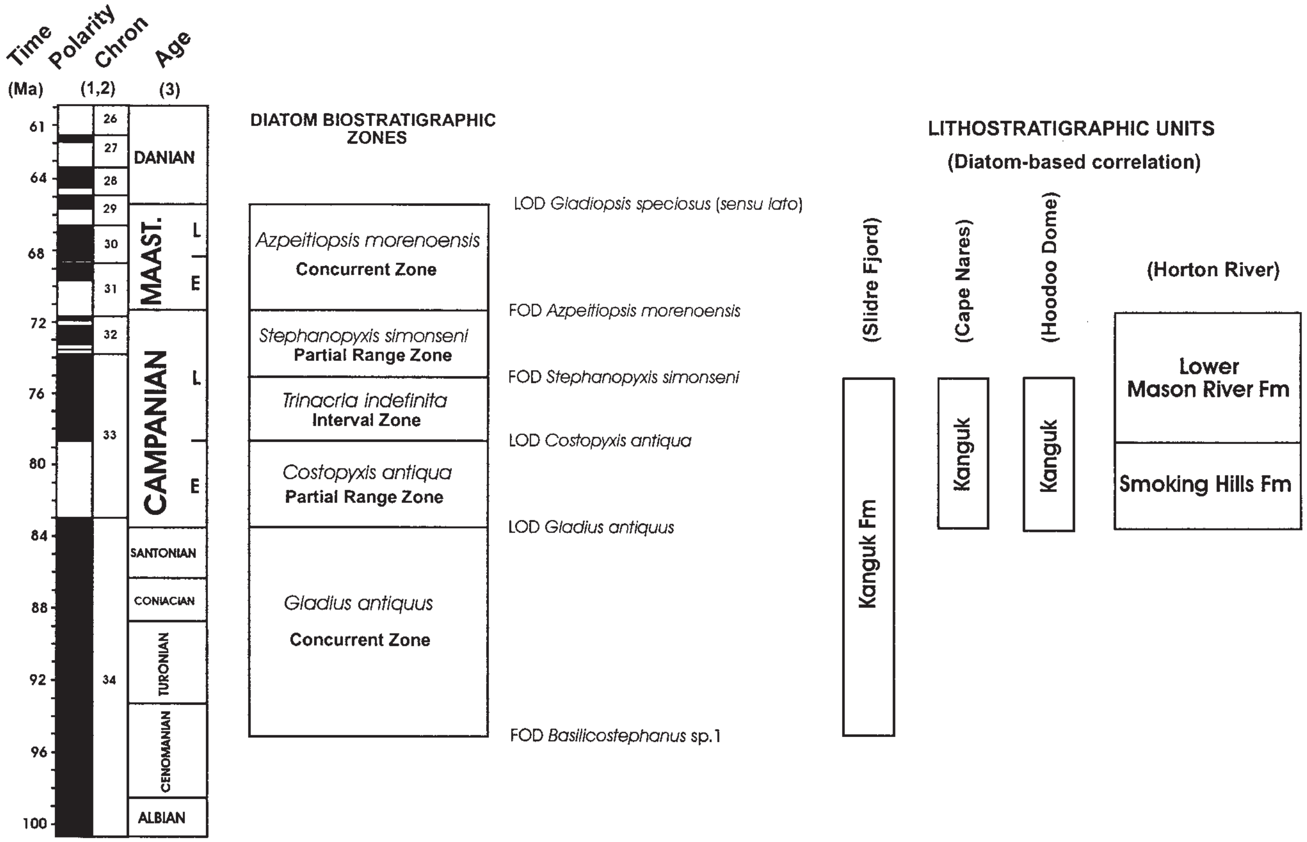
APPENDIX 1
Diatom taxonomic list. The following list comprises most of the diatom species identified during the present work and listed on tables 2 to 6. Many unknown forms are placed in uncertain generic categories. This clearly indicates that proper taxonomic studies are required for many taxa. Refer to Tapia (1996) for a complete list of diatom encountered in this study.

*Actinodyction weissflogii* Pantocsek 1892: Bd. 3, Tab. 5, fig. 84; Strelnikova 1974: 72, Tab. 18, figs. 2-6.

*Actinoptychus heterostrophus* Schmidt in Schmidt et al. 1875-1959: Tab. 29, fig 2, Tab. 109, figs. 9-11; Witt 1886:152, Tab. 8, fig. 1; Jousé et al. 1949: Vol. 2, p. 97, Tab. 40, fig. 12; Strelnikova 1974: 69, Tab. 14, fig. 8.

*Actinoptychus simbriskianus* Schmidt in Schmidt et al. 1875-1959: Tab. 29, fig. 11; Tab 109, figs. 3-9; Barron 1985: Pl. 10.1, fig. 8; Dell'Agnese and Clark 1994: 38, fig. 3.1. [Plate III, figs. 9-10]

*Actinoptychus tenuis* Strelnikova 1974: 67, Tab. 14, figs. 1-4; Barron 1985: 141, Pl. 10.1, fig. 7; Dell'Agnese and Clark 1994: 38, figs. 3.2. [Plate VII, fig. 1]



TEXT-FIGURE 9
Proposed Upper Cretaceous diatom zonation for Arctic Canada and correlation of lithostratigraphic units in Arctic Canada. The diatom biostratigraphic zones are referenced against Cretaceous geochronology (1), Geomagnetic Polarity time scale (2), and Cretaceous ages (3). 1= Kent and Gradstein (1995); 2= Cande and Kent (1992); 3= Obradovich (1993). Correlation among lithostratigraphic units is based only in diatom-bearing intervals within each studied sections.

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*Actinoptychus tuberculatus* Strelnikova 1974: 68, Tab. 14, figs. 5, 6. [Plate VII, fig. 4]

*Anaulus* sp. cf. *A. sibiricus* Strelnikova 1974: 106, Tab. 52, figs. 1-5; *Anaulus sibericus* Strelnikova *sensu* Barron 1985: 141, Pl. 10.2, fig. 10; Harwood 1988: 79: figs. 9.12-14; Dell'Agnese and Clark 1994: 38, fig. 3.3

*Aulacodiscus breviprocessus* Strelnikova 1974: 76, Tab. 25, figs. 1-4; Harwood 1988: 79: fig. 12.3.

*Aulacodiscus septus* forma *quattuorradiata* Pantocsek 1886: Bd. I, p. 62, Tab. 10, fig. 84; Strelnikova 1974: 73-74, Tab. 20, fig. 6; *Aulacodiscus septus* forma *tetragonus* Jousé 1949: 70.

*Aulacodiscus septus* forma *septus* (Schmidt) Strelnikova; *Aulacodiscus septus* Schmidt in Schmidt et al. 1875-1959: Tab. 36, figs. 19-21; Schulz 1935: 387, Tab. 2, fig. 4; Jousé 1949: 70, Tab. 1, fig, 11; Jousé et al. 1949: Vol. 2, p. 107, Tab. 37, fig. 1; Strelnikova 1965b: 32, Tab. 2, figs. 1-3; *Aulacodiscus septus* Schmidt forma *septus* Strelnikova 1974: 73, Tab. 19, figs. 1-6, Tab. 20, figs. 1-5. [Plate VII, fig. 3]

*Basilicostephanus* sp. 1. [Plate I, figs. 7, 8; Plate II, figs. 2-4]

*Biddulphia grunowi* Pantocsek 1892: Bd. 3, Taf. 24, fig. 366.

*Bilingua* sp. 1. [Plate I, figs. 9, 10]

*Corinna* sp. 1. [Plate IX, figs. 11, 12]

*Cortinocornus rossicus* (Pantocsek) Gleser; *Hemiaulus polycystinorum* Ehrenberg var. *simbriskianus* Grunow 1884: 65, Tab. II(B), figs. 44, 45; Jousé et al. 1949: Vol. 2, p. 185, Tab. 71, fig. 4; *Hemiaulus rossicus* Pantocsek 1889: Bd. 2, p. 84; Strelnikova 1974: 102-103, Tab. 43, figs. 1-18; Harwood 1988: 83, figs. 14.18-21, 15.4-5; *Hemiaulus polycistinorum* var. *brevicornis* Jousé 1951: 54, Tab. 4, figs. a-c; *Cortinocornus rossicus* (Pantocsek) Gleser 1984: 290-291. [Plate III, figs. 5-8]

*Coscinodiscus polymorphus* Strelnikova 1974: 65-66, Tab. 3, figs. 8-17.

*Costopyxis antiqua* (Jousé) Gleser; *Stephanopyxis antiqua* Jousé 1951: 46, Tab. 1, figs. 3a,b; Strelnikova 1974: 56, Tab. 3, figs. 18-20; Fenner 1985: 738, figs. 14.13-14; *Stephanopyxis cancellata* Jousé 1951: 46, Tab. I, figs. 4a,b; *Costopyxis antiqua* (Jousé) Gleser 1984: 292; Gleser et al. 1988: 49, Tab. 31, figs. 1-3, 6. [Plate II, figs. 10-11, 14-15]

*Costopyxis ornata* (Schulz) Strelnikova; *Stephanopyxis ornata* Schulz 1935: 397, Tab. 2, fig. 4; Jousé et al. 1949: Vol. 2, p. 41, Tab. 79, fig. 3; Strelnikova 1974: 56, Tab. 4, figs. 4-7, 9a,b; Fenner 1985: 738, fig. 14.7; *Costopyxis schulzii* Steinecke forma *ornata* (Schulz) Strelnikova, Gleser et al. 1988: 51, Tab. 32, figs. 1-4, 9-16. [Plate I, figs. 15-16]

*Costopyxis reticulata* (Long, Fuge et Smith) Gleser; *Stephanopyxis reticulata* Long, Fuge and Smith 1946: 111, Pl. 19, fig. 9; Strelnikova 1965b: 29, Tab. 1, figs. 1-6; Strelnikova 1974: 57, Tab. 5, figs. 7-13; Fourtanier 1991: 201, Pl. 5, fig. 11; *Costopyxis reticulata* (Long, Fuge et Smith) Gleser 1984: 292; Gleser et al. 1988: 50, Tab. 31, figs. 10-14. [Plate VI, fig. 6]

TABLE 5
Selected diatom data (total counts) from Horton River composite Section, fraction greater than 25µm. Preservation: G= Good, M= Moderate, P= Poor; Relative Abundance: A= Abundant, C= Common, F= Few, R= Rare, P= Present.

| Horton River, >25 microns, <2.2 SG | EARLY CAMPANIAN | | | | | EARLY-LATE CAMPANIAN | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C-8564 | C-8589 | C-8590 | C-8592 | C-8593 | C-8595 | C-8596 | C-8597 | C-8599 | C-8600 | C-8601 | C-8602 | C-8603 | C-8607 |
| **Outcrop sample interval (m)** | 21.3-24.4 | 97.5-100.6 | 0.0-3.0 | 6.1-9.1 | 9.1-12.2 | 15.2-18.3 | 18.3-21.3 | 21.3-24.4 | 27.4-30.5 | 30.5-33.5 | 33.5-36.6 | 36.6-39.6 | 39.2-42.7 | 51.2-54.9 |
| **Average outcrop elevation (m)** | 22.85 | 99.05 | 1.52 | 7.62 | 10.67 | 16.76 | 19.81 | 22.86 | 28.96 | 32.00 | 35.05 | 38.10 | 41.15 | 53.34 |
| **Preservation** | M | M | P | P | P | M | M | M | M | M | M | M | M | M |
| **Abundance** | R | R-F | C | F | F | C | F | F | F-C | F-C | C | C | F | F-C |
| *Actinodyction weissflogii* | | | | | | | | | | | | | | |
| *Actinoptychus simbriskianus* | | | | | | | | | | | | | | |
| *Actinoptychus tenuis* | | | 2 | | | 6 | 1 | 3 | 2 | | 1 | 1 | 2 | 2 |
| *Actinoptychus tuberculatus* | | | | | | | | 2 | 2 | 1 | 1 | | P | 1 |
| *Anaulus* sp. cf. *A. sibericus* | | | | | | | | | | 3 | 1 | | | |
| *Aulacodiscus breviprocesus* | | | | | | | | | | | | | | |
| *Aulacodiscus septus* f. *quattuorradiata* | 1 | | 1 | | 3 | 1 | 2 | | | 1 | | 5 | | |
| *Aulacodiscus septus* f. *septus* | | | | | | 2 | 3 | | 6 | 1 | P | 1 | 4 | 5 |
| *Biddulphia grunowi* | | | | | | | | | | | | 1 | | |
| *Corinna* sp. 1 | | 1 | | | 2 | | 3 | 3 | 3 | 2 | 6 | | 1 | 2 |
| *Cortinocornus rossicus* | | | 1 | | 6 | 10 | 16 | 28 | 15 | 17 | 27 | 7 | 11 | 19 |
| *Coscinodiscus polymorphus* | | | | | | 3 | | 2 | | | | | | |
| *Costopyxis antiqua* | | | 3 | | | | | | | | | | | |
| *Costopyxis ornata* | 2 | 48 | 176 | 8 | 21 | 1 | 1 | 1 | | 1 | | | | 1 |
| *Costopyxis reticulata* | | | | | | | 1 | | 3 | | 2 | 2 | 2 | 5 |
| *Costopyxis schulzii* f. *nuda* | | | 5 | | 2 | | | | | | | | | |
| *Costopyxis schulzii* f. *shulzii* | | 6 | 12 | 1 | 11 | | | | | | P | 2 | P | |
| *Eunotogramma bivitata* | | | | | | | | | | 1 | | | | |
| *Eunotogramma enorme* | | | | | | | | | | | | | | |
| *Gladiopsis speciosus* f. *aculeolatus* | | | | | | 1 | | | 1 | | 3 | | P | P |
| *Gladiopsis speciosus* f. *poratus* | | | | | | | | | | 1 | | 1 | | P |
| *Gladiopsis speciosus* f. *speciosus* | 1 | | 5 | 4 | 4 | | 2 | 1 | P | | P | 1 | | 2 |
| *Goniothecium odontella* | | | | | 5 | 1 | 4 | 7 | 3 | | 6 | | 1 | 4 |
| *Goniothecium odontella* var. *danica* | | 1 | | | | | | | | 2 | | | 1 | |
| *Hemiaulus altus* | | | | | | 2 | 2 | 4 | 2 | 1 | 5 | 1 | 2 | 1 |
| *Hemiaulus antiquus* | | | 2 | | | | | 3 | 1 | 4 | | | | |
| *Hemiaulus arcticus* | | | | | | | | | | | | | 1 | |
| *Hemiaulus curvatulus* | | 1 | | | | 1 | 2 | 11 | 9 | 8 | 6 | 2 | 5 | 2 |
| *Hemiaulus danicus* | | | | | | | 1 | | | | | | | |
| *Hemiaulus echinulatus* | | | | | | | 12 | 11 | P | 2 | P | | | 1 |
| *Hemiaulus elegans* | | | 2 | | 1 | | 3 | 1 | | | | | | 1 |
| *Hemiaulus februatus* | | | | | | | 2 | 4 | 2 | 2 | 3 | | P | 2 |
| *Hemiaulus kittoni* | | | | | 4 | 7 | | 6 | 6 | 8 | 7 | | 1 | 6 |
| *Hemiaulus orthoceras* | | 1 | 6 | 1 | 3 | 3 | 4 | | 2 | | 7 | 1 | | 1 |
| *Hemiaulus polymorphus* var. *frigida* | 1 | 1 | 2 | | 7 | 5 | 18 | 18 | 16 | 9 | 9 | 1 | 4 | 6 |
| *Hemiaulus praelegans* | | | | | | | | | | | | | | |
| *Hemiaulus punctatus* | | | | | | | | | 1 | | | | | |
| *Hemiaulus schmidti* | | 1 | | | 1 | 8 | 7 | 10 | 12 | 10 | 19 | 8 | 12 | 10 |
| *Hemiaulus sporalis* (spores) | 3 | 2 | | | 16 | 2 | 3 | 2 | 15 | 7 | 6 | 4 | 5 | 9 |
| *Hemiaulus sporalis* (vegetative cell) | | | | | 1 | | | 3 | 3 | 3 | | | | 1 |
| *Hemiaulus tumidicornis* | | | | | | | | | | | | | | |
| *Hemiaulus undulatus* | | | | | | | | | | 1 | | | 1 | |
| *Meristiosolen* sp. 1 | 1 | | | | | | 1 | 6 | 4 | 6 | 3 | | 3 | 6 |
| *Micrampula parvula* | | | | | | 1 | 5 | 6 | 3 | 1 | 3 | 1 | 1 | 5 |
| *Odontotropis carinata* | | | | 1 | | | 1 | 2 | 2 | 3 | | 1 | 4 | |
| *Odontotropis cristata* | | | | | | 1 | | | | | 1 | 1 | | 3 |
| *Odontotropis hyalina* | | | | | 1 | | | | | | | | | |
| *Paralia ornata* | | | | | | | | | | | | | | |
| *Paralia sulcata* | 1 | | | 1 | 28 | 20 | 53 | 57 | 65 | 32 | 43 | 14 | 27 | 33 |
| *Prosbocia cretacea* | | | | | | | | 3 | | | | 1 | P | |
| *Pseudopodosira reticulata* | | | | | | | | | | | | | | 1 |
| *Pseudopyxilla* sp. cf. *P. rossica* | | | | | 2 | | | | | | P | 1 | | 1 |
| *Pterotheca aculeifera* | | 1 | | 1 | 6 | 6 | 4 | 5 | 7 | 15 | 4 | | 11 | 10 |
| *Pterotheca* sp. cf. *P. spada* | | | | | | | | | | | | | | |
| *Pterotheca cretacea* | | | | | | | | | | | | | | |
| *Pterotheca pokrovskajae* | | | | 1 | 2 | | | | | | | | | |
| *Sceptroneis grunowii* | | | | | | 1 | 3 | 4 | 2 | 6 | 4 | 1 | 1 | 4 |
| Spore # 3 | | | | | | | | | | | | | | |
| Spore # 4 | | | | | | | | | | | | | | |
| Spore # 12 | | | | | | 3 | 1 | | | | | | | 2 |
| *Sheshukovia* sp. 1 | | | | 2 | | 10 | 7 | 1 | 5 | 2 | 3 | 5 | 1 | 2 |
| *Stellarima steinyi* | | 2 | 13 | | 2 | 2 | 3 | 1 | 10 | 9 | 4 | 11 | 6 | 9 |
| *Stephanopyxis arctica* | | | | | | 24 | 1 | | | P | 1 | 50 | 4 | 16 |
| *Stephanopyxis superba* | | | | | | 15 | 2 | 4 | 3 | 9 | 8 | 23 | 12 | 5 |
| *Stephanopyxis dissonus* | | | | | | 49 | 12 | 18 | 18 | 39 | 38 | 42 | 49 | 49 |
| *Stephanopyxis dissonus* var. | | | | | | | | | | 2 | | | | |
| *Stephanopyxis grunowi* | 7 | | 1 | | 6 | 80 | 38 | 23 | 41 | 33 | 35 | 41 | 36 | 14 |
| *Stephanopyxis lavrenkoi* | 2 | | | | | | | | | | | | | |
| *Stephanopyxis simonseni* | | | | | | | | | | | | | | |
| *Stephanopyxis turris* | | | 2 | | 2 | 5 | 2 | | 1 | 1 | 3 | 3 | 2 | 3 |
| *Strelnikovia antiqua* | | | | | | | | 1 | 1 | | | | | 1 |
| *Thalassiosiropsis wittiana* | 4 | | | | | 38 | 31 | 21 | 50 | 24 | 31 | 66 | 51 | 21 |
| *Triceratium kolbei* | | | | | | | | | | | | | | |
| *Triceratium planum* | | | | | | | | | | | | | | |
| *Triceratium synicum* | | | | | | | | | | | | | | |
| *Trinacria acutangula* | 4 | | 1 | | | 54 | 30 | 29 | 36 | 36 | 37 | 57 | 42 | 18 |
| *Trinacria aries* | | | | | | | | | | | | | | 1 |
| *Trinacria coronatum* | | | | | | | | | | | | | | |
| *Trinacria excavata* | | | | | | | | | | | | | | |
| *Trinacria indefinita* | 2 | | | | 10 | 13 | 17 | 17 | 24 | 12 | 11 | 7 | 6 | 4 |
| *Trinacria tessela* | | | | | | 1 | 2 | 1 | 1 | | P | | P | |
| *Trochosiropsis polychaeta* | 2 | | | | | | 1 | 1 | 3 | 2 | | | | 1 |
| Other diatoms (including resting spores) | 1 | 4 | 12 | 1 | 13 | 15 | 38 | 34 | 71 | 52 | 57 | 24 | 25 | 61 |
| **TOTAL DIATOMS** | 32 | 69 | 246 | 21 | 159 | 391 | 339 | 354 | 451 | 369 | 395 | 387 | 334 | 351 |

TABLE 5
*Contninued.*

| Horton River, >25 microns, <2.2 SG | LATE-LATE CAMPANIAN | | | | | | | | | | | | | Total specimens |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C-8608 | C-8610 | C-8612 | C-8615 | C-8617 | C-8618 | C-8619 | C-8621 | C-8623 | C-8625 | C-8627 | C-8629 | C-8630 | |
| **Outcrop sample interval (m)** | 54.9-57.9 | 61.0-64.0 | 67.1-70.1 | 76.2-79.3 | 82.3-85.3 | 85.3-88.4 | 88.4-91.4 | 94.4-97.5 | 100.6-103.6 | 106.7-109.7 | 112.8-115.8 | 118.9-121.9 | 121.9-125.8 | |
| **Average outcrop elevation (m)** | 56.39 | 62.48 | 68.58 | 77.72 | 83.82 | 86.87 | 89.92 | 96.01 | 102.11 | 108.20 | 114.30 | 120.40 | 123.44 | |
| **Preservation** | M | M-G | M | M | P-M | M | M | M | P-M | P-M | M | P-M | M | |
| **Abundance** | F-C | C | F | F-C | F | F-C | F-C | F-C | F | F | F | F | F | |
| *Actinodyction weissflogii* | | | | | | | | | 1 | | | | 1 | 2 |
| *Actinoptychus simbriskianus* | | | | | | P | | | | | | | | 0 |
| *Actinoptychus tenuis* | P | 1 | 1 | 2 | 1 | 7 | 2 | 6 | 2 | 2 | 1 | 1 | | 46 |
| *Actinoptychus tuberculatus* | P | | P | 2 | 2 | 5 | 1 | | 2 | 1 | 4 | 1 | 8 | 33 |
| *Anaulus* sp. cf. *A. sibericus* | 1 | | P | 1 | | 1 | | 1 | | P | 1 | | | 9 |
| *Aulacodiscus breviprocesus* | | | | | | 1 | | | 1 | 1 | | | 4 | 7 |
| *Aulacodiscus septus* f. *quattuorradiata* | | P | 4 | P | 3 | 4 | 7 | | 3 | 1 | 3 | 6 | 7 | 52 |
| *Aulacodiscus septus* f. *septus* | 1 | 6 | 6 | 2 | 2 | 5 | 4 | 3 | 4 | 1 | 4 | 12 | 15 | 87 |
| *Biddulphia grunowi* | | | | | | | | | | | | | | 1 |
| *Corinna* sp. 1 | 1 | | | | 1 | 1 | | 6 | | P | | | | 32 |
| *Cortinocornus rossicus* | 12 | 3 | 2 | 2 | | 1 | 1 | P | | P | | 1 | 3 | 182 |
| *Coscinodiscus polymorphus* | | | | | | | | | | 2 | | | | 7 |
| *Costopyxis antiqua* | | | | | | | | | | | | | | 3 |
| *Costopyxis ornata* | | P | P | 1 | | | | | | P | | 1 | | 262 |
| *Costopyxis reticulata* | 3 | 1 | | P | 1 | 1 | 1 | P | | P | P | 2 | 3 | 27 |
| *Costopyxis schulzii* f. *nuda* | | | | | | | | | | | 1 | | | 8 |
| *Costopyxis schulzii* f. *shulzii* | 1 | 1 | P | | | | | | | | | P | | 34 |
| *Eunotogramma bivitata* | | | | | 1 | | | 1 | | | 1 | | | 4 |
| *Eunotogramma enorme* | | | | | | | | | | | P | | | 0 |
| *Gladiopsis speciosus* f. *aculeolatus* | P | | | | | | | | | | | | | 5 |
| *Gladiopsis speciosus* f. *poratus* | P | P | | | | P | | | | | | | | 2 |
| *Gladiopsis speciosus* f. *speciosus* | 1 | | P | 1 | | | | P | | | | | | 22 |
| *Goniothecium odontella* | 6 | 1 | 3 | 19 | 8 | 9 | 5 | 4 | 2 | 10 | P | 14 | 4 | 116 |
| *Goniothecium odontella* var. *danica* | 3 | | | | | | | 2 | | | P | 2 | 2 | 13 |
| *Hemiaulus altus* | 1 | | | | | | | | | | | | | 21 |
| *Hemiaulus antiquus* | | | | | | | | | | | | | | 10 |
| *Hemiaulus arcticus* | 1 | 2 | | | | | | 1 | | | | | | 5 |
| *Hemiaulus curvatulus* | 2 | | P | 1 | | | | | | | | 1 | | 51 |
| *Hemiaulus danicus* | | | | | 1 | 2 | | 1 | | | | | | 5 |
| *Hemiaulus echinulatus* | | P | | | 1 | | | | | | | | | 27 |
| *Hemiaulus elegans* | | | | | | | | 2 | | | P | 1 | | 11 |
| *Hemiaulus februatus* | 1 | 1 | | 1 | 1 | P | | | | | | | 1 | 20 |
| *Hemiaulus kittoni* | 1 | 1 | | 2 | | | | 2 | | | | | | 51 |
| *Hemiaulus orthoceras* | P | 1 | 1 | 1 | | | 1 | | 1 | | 1 | P | | 35 |
| *Hemiaulus polymorphus* var. *frigida* | 2 | | 2 | 1 | 1 | P | | 2 | | | | | | 105 |
| *Hemiaulus praelegans* | | 2 | | | | | | | | | | | | 2 |
| *Hemiaulus punctatus* | | | | | | | | | | | | | | 1 |
| *Hemiaulus schmidti* | 9 | | 1 | | | 1 | 1 | 3 | | | 2 | 2 | 3 | 120 |
| *Hemiaulus sporalis* (spores) | 5 | 2 | 2 | P | | 3 | | P | | P | 4 | 2 | 2 | 94 |
| *Hemiaulus sporalis* (vegetative cell) | | | | | | | | | | | | | | 11 |
| *Hemiaulus tumidicornis* | | | | | | | 1 | 1 | 1 | 1 | | | | 4 |
| *Hemiaulus undulatus* | 2 | | P | | | | | 1 | | | | | | 5 |
| *Meristiosolen* sp. 1 | 4 | | 5 | 18 | 9 | 4 | 4 | 14 | 13 | 54 | 24 | 13 | 12 | 204 |
| *Micrampula parvula* | 1 | P | 1 | 1 | 2 | 1 | 2 | 2 | | 1 | 1 | | | 38 |
| *Odontotropis carinata* | | 5 | | | 4 | 5 | 6 | 3 | 6 | 1 | 3 | 4 | 10 | 61 |
| *Odontotropis cristata* | P | 2 | | 1 | P | P | | | | | 1 | | | 10 |
| *Odontotropis hyalina* | | 2 | | 1 | 1 | 2 | 1 | 1 | 1 | | | | | 10 |
| *Paralia ornata* | | | | | | | | | | | R | | | 0 |
| *Paralia sulcata* | 25 | 9 | 28 | 23 | 23 | 14 | 24 | 40 | 74 | 45 | 82 | 73 | 41 | 875 |
| *Prosbocia cretacea* | P | | P | P | 2 | P | | 7 | | 1 | | | | 14 |
| *Pseudopodosira reticulata* | | | | 1 | 2 | | | | | 2 | | | | 6 |
| *Pseudopyxilla* sp. cf. *P. rossica* | P | | | 9 | P | 3 | 1 | 2 | 3 | 8 | 6 | 9 | 3 | 48 |
| *Pterotheca aculeifera* | 6 | | 9 | 3 | 5 | 4 | 3 | 2 | 6 | 1 | 7 | 8 | 9 | 133 |
| *Pterotheca* sp. cf. *P. spada* | | | 4 | 2 | 6 | 5 | 7 | 7 | 2 | 2 | 3 | 4 | 3 | 45 |
| *Pterotheca cretacea* | | | | | | | 1 | 1 | 2 | 1 | 2 | | | 7 |
| *Pterotheca pokrovskajae* | | | | | | | | | | | | | | 3 |
| *Sceptroneis grunowii* | 1 | | | | 2 | 1 | | 4 | P | | | | | 34 |
| Spore # 3 | | | 2 | 2 | 7 | 2 | 6 | 4 | 8 | 5 | 6 | 2 | | 44 |
| Spore # 4 | | | | | | 1 | 2 | 12 | 8 | 3 | 6 | 4 | 2 | 38 |
| Spore # 12 | | | 14 | 7 | 4 | 3 | 7 | 8 | 9 | 8 | 13 | 5 | 21 | 105 |
| *Sheshukovia* sp. 1 | 4 | 11 | P | | | | P | | | | | | | 53 |
| *Stellarima steinyi* | 8 | 10 | 25 | 3 | 8 | 18 | 11 | 13 | 8 | 5 | 6 | 13 | 5 | 205 |
| *Stephanopyxis arctica* | 5 | 19 | 6 | 3 | 8 | 12 | 11 | | 4 | 1 | 2 | 2 | 1 | 170 |
| *Stephanopyxis superba* | 11 | 9 | P | 1 | | 4 | 3 | 2 | | | | | 1 | 112 |
| *Stephanopyxis dissonus* | 41 | 38 | 14 | 13 | 11 | 11 | 13 | 8 | 3 | P | 2 | 10 | 15 | 493 |
| *Stephanopyxis dissonus* var. | 13 | 1 | 1 | | 1 | 2 | | 4 | P | P | | | 1 | 25 |
| *Stephanopyxis grunowi* | 14 | 15 | 14 | 13 | 8 | 21 | 17 | 3 | 5 | 4 | 6 | 7 | 6 | 488 |
| *Stephanopyxis lavrenkoi* | | | | | | | | | | | | | | 2 |
| *Stephanopyxis simonseni* | 1 | 8 | 21 | 31 | 41 | 61 | 56 | 20 | 35 | 12 | 8 | 14 | 24 | 332 |
| *Stephanopyxis turris* | 7 | 15 | 11 | 26 | 17 | 18 | 16 | 9 | 12 | 7 | 6 | 20 | 18 | 206 |
| *Strelnikovia antiqua* | | | | | | | | | | | | | | 3 |
| *Thalassiosiropsis wittiana* | 37 | 79 | 45 | 41 | 30 | 74 | 41 | 24 | 13 | 14 | 2 | 16 | 19 | 772 |
| *Triceratium kolbei* | | | | | | | | P | | | | | | 0 |
| *Triceratium planum* | | P | | | 2 | | | | | | | | | 2 |
| *Triceratium synicum* | | 1 | | | | | | 1 | | | | | | 2 |
| *Trinacria acutangula* | 44 | 100 | 26 | 27 | 31 | 25 | 27 | 19 | 14 | 5 | P | 12 | 20 | 694 |
| *Trinacria aries* | | 1 | P | | | 2 | | 2 | | | | | | 6 |
| *Trinacria coronatum* | | | | | | 2 | | | | | | | | 2 |
| *Trinacria excavata* | | 4 | | | | | | | | | | | | 4 |
| *Trinacria indefinita* | 8 | | | 1 | | | 3 | 2 | 1 | 2 | | | 1 | 141 |
| *Trinacria tessela* | | | P | 1 | | | 1 | | | | | 1 | | 8 |
| *Trochosiropsis polychaeta* | 2 | 1 | 5 | 3 | 3 | 11 | 4 | 10 | 13 | 10 | 11 | 5 | 4 | 92 |
| Other diatoms (including resting spores) | 38 | 26 | 39 | 31 | 22 | 33 | 28 | 41 | 48 | 56 | 47 | 33 | 53 | 903 |
| **TOTAL DIATOMS** | 323 | 378 | 292 | 298 | 272 | 380 | 319 | 301 | 305 | 267 | 266 | 301 | 322 | 7922 |

TABLE 6
Selected diatom data (total counts) from Horton River composite Section, fraction lesser than 25µm. Preservation: G=Good, M=Moderate, P=Poor; Relative Abundance: A=Abundant, C=Common, F=Few, R=Rare, P= Present.

| Horton River, <25 microns, <2.2 SG | EARLY CAMPANIAN | | | | | EARLY-LATE CAMPANIAN | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C-8564 | C-8589 | C-8590 | C-8592 | C-8593 | C-8595 | C-8596 | C-8597 | C-8599 | C-8600 | C-8601 | C-8602 | C-8603 | C-8607 |
| **Outcrop sample interval (m)** | 21.3-24.4 | 97.5-100.6 | 0.0-3.0 | 6.1-9.1 | 9.1-12.2 | 15.2-18.3 | 18.3-21.3 | 21.3-24.4 | 27.4-30.5 | 30.5-33.5 | 33.5-36.6 | 36.6-39.6 | 39.2-42.7 | 51.2-54.9 |
| **Average outcrop elevation (m)** | 22.85 | 99.05 | 1.52 | 7.62 | 10.67 | 16.76 | 19.81 | 22.86 | 28.96 | 32.00 | 35.05 | 38.10 | 41.15 | 53.34 |
| **Preservation** | M | M | M | P | P-M | M | M | M | M | M | M | M | M | M |
| **Abundance** | R | R | R | R | R | F-C | C | C | C | C | C | F-C | F-C | F-C |
| *Actinoptychus tenuis* | | 1 | | | | 1 | 1 | | | | 1 | | | 1 |
| *Actinoptychus tuberculatus* | | | | | | P | | | P | | | | | |
| *Anaulus* sp. cf. *A. sibericus* | | | | | | 1 | | 1 | | 1 | P | | | 1 |
| *Aulacodiscus septus* f. *septus* | | | | | | 1 | P | | P | | | 1 | | 1 |
| *Basilicostephanus* sp. 1 | | | | | | | | | | | | | | |
| *Corinna* sp. 1 | | | | | | P | | 1 | 2 | | 1 | 2 | | |
| *Cortinocornus rossicus* | 2 | | | 3 | 5 | 13 | 17 | 10 | 14 | 7 | 10 | 12 | 1 | 5 |
| *Costopyxis antiqua* | | | | | 4 | | | | | | | | | |
| *Costopyxis ornata* | | 29 | 34 | 7 | 6 | | | | | P | | | | P |
| *Costopyxis reticulata* | 1 | | | | | 2 | 2 | | 4 | 4 | 1 | P | 1 | 3 |
| *Costopyxis schulzii* f. *shulzii* | | 30 | 2 | | 1 | | | | | | | | | |
| *Costopyxis schulzii* var. *nuda* | | 19 | 45 | 1 | 4 | | | | P | | | | | |
| *Eunotogramma bivitata* | | | | | | | | | | | | 1 | | |
| *Gladiopsis speciosus* f. *aculeolatus* | | | | | | | 1 | P | 1 | 1 | P | | P | |
| *Gladiopsis speciosus* f. *speciosus* | | | P | | 4 | 1 | 1 | 2 | 3 | 2 | 2 | 1 | P | 1 |
| *Goniothecium odontella* | | | | | 1 | 3 | 5 | | 1 | 2 | | 2 | | |
| *Goniothecium odontella* var. *danica* | | | | | 1 | | | | | | 3 | | | |
| *Hemiaulus altus* | 1 | | | | | | 3 | 1 | 1 | | 1 | | | 3 |
| *Hemiaulus antiquus* | | | | | 5 | | | | | | | 1 | | |
| *Hemiaulus arcticus* | | | | | | 1 | | | | | | | | |
| *Hemiaulus* sp. cf. *H. polymorphus* | 1 | | | | | | | 1 | | | | | | |
| *Hemiaulus curvatulus* | | | | | | 2 | 1 | | 1 | 3 | 3 | | | 1 |
| *Hemiaulus echinulatus* | | | | | | | | | 1 | | 1 | 1 | | |
| *Hemiaulus februatus* | | | | | | 3 | | | | 1 | | 1 | | 1 |
| *Hemiaulus kittonii* | | | | | | 2 | | 2 | 1 | 3 | 2 | | 1 | 1 |
| *Hemiaulus polymorphus* var. *frigida* | | 4 | 3 | | | 7 | 7 | | 12 | 2 | 1 | 11 | | 2 |
| *Hemiaulus praelegans* | | | | | | | | | | | | | | |
| *Hemiaulus punctatus* | | | | | | | | | | | | | | |
| *Hemiaulus schmidti* | 3 | | | | 4 | 22 | 14 | 11 | 10 | 7 | 6 | 4 | P | 5 |
| *Hemiaulus sporalis* (spores) | 3 | 10 | 3 | 1 | 4 | 1 | 5 | 6 | 5 | 4 | 6 | 5 | P | 4 |
| *Hemiaulus sporalis* (vegetative cell) | | | | | | | | | | | P | | | 1 |
| *Hemiaulus undulatus* | | | | | | 1 | | | | | | | | |
| *Melosira? hokaidoana* | | | | | | | | | | P | 1 | | | |
| *Meristiosolen* sp. 1 | 3 | | | | | 9 | 5 | 1 | 8 | 4 | 2 | 6 | 2 | 7 |
| *Micrampula parvula* | 1 | | | | | 2 | 1 | 1 | 3 | 4 | 2 | 1 | 2 | 1 |
| *Odontotropis carinata* | | | | | | | 1 | | | | | | | |
| *Paralia ornata* | | | | | | | | | | | | R | | |
| *Paralia sulcata* | 21 | | 1 | | 23 | 41 | 49 | 47 | 47 | 38 | 27 | 37 | 9 | 27 |
| *Proboscia cretacea* | | | | | | | | | 1 | | | P | | |
| *Pseudopodosira reticulata* | | | | | | | | | | | | | | |
| *Pseudopyxilla* sp. cf. *P. rossica* | 1 | | | | | 1 | 2 | 1 | 2 | | P | 2 | 2 | P |
| *Pterotheca aculeifera* | | 2 | | 1 | 15 | 8 | 4 | 3 | 1 | 6 | 5 | 3 | 3 | 3 |
| *Pterotheca* sp. cf. *P. spada* | | | | | P | | | | | | P | | | |
| *Pterotheca cretacea* | | | | | | | | | | | | | | 1 |
| *Raphoneis elliptica* | | | | | | 1 | | | | 1 | | | | 1 |
| *Sceptroneis gracilis* | | | | | | | | | | | | | | |
| *Sceptroneis grunowi* | | | | | | | | 4 | 2 | 3 | 1 | | 1 | 1 |
| *Sheshukovia* sp. 1 | | | | | | | 2 | | P | P | | P | | P |
| Spore # 3 | | | | | | | | | | | | | | |
| Spore #4 | | | | | | | | | | | | | | |
| Spore # 12 | | | | | | | | | | | | | | |
| *Stellarima steinyi* | 2 | 1 | 2 | | | 4 | 2 | | 1 | P | P | 1 | | |
| *Stephanopyxis arctica* | | | | | | | | 1 | | | | | | |
| *Stephanopyxis dissonus* | | 3 | | | 5 | 4 | 4 | 2 | P | P | 1 | P | | |
| *Stephanopyxis dissonus var.* | | | | | | | | | | | | | | |
| *Stephanopyxis grunowi* | | | | | | | 1 | | | | | 1 | | |
| *Stephanopyxis simonseni* | | | | | | | | | | | | | | |
| *Stephanopyxis turris* | 1 | 1 | | | 5 | 3 | 1 | 3 | 3 | P | 2 | 1 | | |
| *Strelnikovia antiqua* | | | | | | | 1 | | | | | | | |
| *Thalassiosiropsis wittiana* | | | | | | 2 | 1 | 1 | | | | | | |
| *Triceratium indefinitum* sensu Strelnikova (1974) | | | | 1 | 4 | | | | | | | | | |
| *Triceratium planum* | | | | | | | | | | | 1 | | | |
| *Triceratium schulzii* | | | | | 1 | | | | | | | | | |
| *Triceratium synicum* | | | | | P | | | | | | | | | |
| *Trinacria acutangulum* | 1 | | | | | 16 | 11 | 7 | 9 | 2 | 13 | 9 | 1 | 5 |
| *Trinacria indefinita* | 3 | | | | | 10 | 5 | 4 | P | 2 | | 4 | P | 1 |
| *Trinacria tessela* | | | | | | 1 | | | | | | | | |
| *Trochosiropsis polychaeta* | | | | | 1 | 2 | 2 | 1 | P | 4 | | 2 | | 2 |
| Other diatoms (including resting spores) | 11 | 13 | 21 | 18 | 8 | 47 | 29 | 35 | 47 | 31 | 38 | 25 | 14 | 37 |
| **TOTAL DIATOMS** | 55 | 113 | 111 | 32 | 101 | 212 | 178 | 146 | 180 | 132 | 131 | 134 | 37 | 116 |

TABLE 6
*Continued.*

| Horton River, <25 microns, <2.2 SG | LATE-LATE CAMPANIAN | | | | | | | | | | | | | Total specimens |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C-8608 | C-8610 | C-8612 | C-8615 | C-8617 | C-8618 | C-8619 | C-8621 | C-8623 | C-8625 | C-8627 | C-8629 | C-8630 | |
| **Outcrop sample interval (m)** | 54.9-57.9 | 61.0-64.0 | 67.1-70.1 | 76.2-79.3 | 82.3-85.3 | 85.3-88.4 | 88.4-91.4 | 94.4-97.5 | 100.6-103.6 | 106.7-109.7 | 112.8-115.8 | 118.9-121.9 | 121.9-125.8 | |
| **Average outcrop elevation (m)** | 56.39 | 62.48 | 68.58 | 77.72 | 83.82 | 86.87 | 89.92 | 96.01 | 102.11 | 108.20 | 114.30 | 120.40 | 123.44 | |
| **Preservation** | M | M | M | M | P-M | M | M | M | M-G | M | P-M | M | M | |
| **Abundance** | F-C | F-C | F | F-C | C | C | C | F-C | C | F | F | F | F-C | |
| *Actinoptychus tenuis* | 1 | | | 3 | 1 | | 2 | 1 | 1 | 2 | P | P | | 16 |
| *Actinoptychus tuberculatus* | | | | 1 | | | | 1 | | | | | 1 | 3 |
| *Anaulus* sp. cf. *A. sibericus* | | | P | | P | | 1 | | | | P | 2 | | 7 |
| *Aulacodiscus septus* f. *septus* | | | | | | | | | P | | P | | | 3 |
| *Basilicostephanus* sp. 1 | | | R | | | | | | | | | | | 0 |
| *Corinna* sp. 1 | | 2 | | P | 4 | P | | | | P | | | | 12 |
| *Cortinocornus rossicus* | 2 | 5 | | P | | | 1 | | | | | 3 | 1 | 111 |
| *Costopyxis antiqua* | | | | | | | | | | | | | | 4 |
| *Costopyxis ornata* | | | | | | | | | P | | | | | 76 |
| *Costopyxis reticulata* | 2 | | P | | | P | | | | | | | 1 | 21 |
| *Costopyxis schulzii* f. *shulzii* | | | | | | | | | | | | | | 33 |
| *Costopyxis schulzii* var. *nuda* | | | | | | | | | | | | | | 69 |
| *Eunotogramma bivitata* | | | | | | P | | | | | | | | 1 |
| *Gladiopsis speciosus* f. *aculeolatus* | | | | | | | | | | | | | | 3 |
| *Gladiopsis speciosus* f. *speciosus* | | | P | | | | | | 1 | | | P | | 18 |
| *Goniothecium odontella* | | 1 | P | 9 | 2 | 1 | 2 | 5 | 5 | 1 | P | 2 | P | 42 |
| *Goniothecium odontella* var. *danica* | | | | | | | | | P | | | | | 4 |
| *Hemiaulus altus* | 2 | | | 1 | | | | | | | | | | 13 |
| *Hemiaulus antiquus* | | | | | | | | | | | | | | 6 |
| *Hemiaulus arcticus* | | | | | | | | | | | | | | 1 |
| *Hemiaulus* sp. cf. *H. polymorphus* | | | P | | | | | | | | | | | 2 |
| *Hemiaulus curvatulus* | 1 | 1 | | 1 | 1 | 1 | | 1 | | 2 | | | | 19 |
| *Hemiaulus echinulatus* | | | | | | | | | | | | | | 3 |
| *Hemiaulus februatus* | | | | P | | | P | | P | | | | P | 6 |
| *Hemiaulus kittonii* | | 2 | | 1 | P | | | | | | | | | 15 |
| *Hemiaulus polymorphus* var. *frigida* | P | | | | | | | P | | | | | | 49 |
| *Hemiaulus praelegans* | | | | | | | | | 1 | | | | | 1 |
| *Hemiaulus punctatus* | | 1 | | | | | | | | | | | | 1 |
| *Hemiaulus schmidti* | 5 | 2 | 2 | 1 | P | P | P | P | | | | P | | 96 |
| *Hemiaulus sporalis* (spores) | 1 | 1 | P | | P | | | | 2 | P | 2 | | 4 | 67 |
| *Hemiaulus sporalis* (vegetative cell) | 1 | | | | P | | | | | | | | | 2 |
| *Hemiaulus undulatus* | | | | | | | P | | | | | | | 1 |
| *Melosira? hokaidoana* | | | | | | | | | | | | | | 1 |
| *Meristiosolen* sp. 1 | 2 | | 10 | 7 | 2 | 4 | 13 | 7 | 9 | 20 | 5 | 3 | 5 | 134 |
| *Micrampula parvula* | 2 | 6 | | P | 2 | 2 | 1 | P | | | | 1 | P | 32 |
| *Odontotropis carinata* | | | | | | | | | | | | | | 1 |
| *Paralia ornata* | | | | R | | R | | | | | | | | 0 |
| *Paralia sulcata* | 11 | 12 | 11 | 13 | 4 | 16 | 17 | 28 | 46 | 11 | 25 | 43 | 28 | 632 |
| *Proboscia cretacea* | | | | | 1 | | 1 | | | | | | | 3 |
| *Pseudopodosira reticulata* | | 2 | | | | | | | | | | | P | 2 |
| *Pseudopyxilla* sp. cf. *P. rossica* | 2 | | 2 | 4 | P | 2 | | 2 | 3 | 12 | 3 | 8 | 3 | 52 |
| *Pterotheca aculeifera* | 8 | 5 | 2 | 4 | 2 | 3 | 2 | 1 | 2 | 1 | 1 | | | 85 |
| *Pterotheca* sp. cf. *P. spada* | | 1 | P | | | P | P | | P | | | | | 1 |
| *Pterotheca cretacea* | | | | | | | | P | P | P | P | | | 1 |
| *Raphoneis elliptica* | | | | | | 1 | | | | | 2 | | | 6 |
| *Sceptroneis gracilis* | | 1 | | | | | | | | | | | | 1 |
| *Sceptroneis grunowi* | P | 3 | P | 1 | P | 2 | P | 3 | 5 | | | | P | 26 |
| *Sheshukovia* sp. 1 | 1 | | | | | | | | | | | | P | 3 |
| Spore # 3 | | | | 9 | 8 | 7 | 3 | 2 | 8 | 3 | P | 2 | P | 42 |
| Spore #4 | | | | | | | | | P | | | P | | 0 |
| Spore # 12 | 2 | 2 | 13 | 13 | 1 | 8 | 7 | 2 | 12 | 6 | 5 | 6 | 10 | 87 |
| *Stellarima steinyi* | | | P | 1 | P | 1 | | 2 | 2 | | | 1 | 1 | 21 |
| *Stephanopyxis arctica* | | 1 | | | | | | | | | | | | 2 |
| *Stephanopyxis dissonus* | 1 | | P | 1 | | | 1 | P | 2 | P | | | 1 | 25 |
| *Stephanopyxis dissonus var.* | | | P | | | P | | | | | | | | 0 |
| *Stephanopyxis grunowi* | | | | 1 | | | P | | 1 | | | | | 4 |
| *Stephanopyxis simonseni* | | | 1 | 3 | 2 | 2 | 7 | | 4 | 1 | P | 1 | 1 | 22 |
| *Stephanopyxis turris* | | 1 | 3 | 1 | P | 1 | 2 | P | 4 | 1 | | P | 1 | 34 |
| *Strelnikovia antiqua* | | | | | | | | | | | | | | 1 |
| *Thalassiosiropsis wittiana* | | | 1 | | 1 | P | 1 | P | P | | | | | 7 |
| *Triceratium indefinitum* sensu Strelnikova (1974) | | | | | | | | | | | | | | 5 |
| *Triceratium planum* | | | | | | | | | | | | | 1 | 2 |
| *Triceratium schulzii* | | | | | | | | | | | | | | 1 |
| *Triceratium synicum* | | | | | | | | | | | | | | 0 |
| *Trinacria acutangulum* | P | 2 | P | 5 | P | 1 | P | | 5 | | 1 | | 1 | 89 |
| *Trinacria indefinita* | 2 | 3 | | 1 | | | P | | | 2 | 1 | 1 | | 39 |
| *Trinacria tessela* | | | | | | | | | | | | | | 1 |
| *Trochosiropsis polychaeta* | 3 | 4 | 4 | 1 | 2 | 2 | 5 | 3 | 10 | 1 | 4 | 4 | 2 | 59 |
| Other diatoms (including resting spores) | 18 | 10 | 16 | 26 | 6 | 21 | 26 | 24 | 44 | 29 | 32 | 41 | 35 | 702 |
| **TOTAL DIATOMS** | 67 | 68 | 65 | 108 | 39 | 75 | 92 | 82 | 167 | 92 | 81 | 118 | 96 | 2828 |

*Costopyxis schulzii* (Steinecke ex Schulz) Gleser; *Stephanopyxis schulzii* Steinecke ex Schulz 1935: 396, Tab. 1, fig. 12, Tab. 2, figs. 1, 2; Jousé et al. 1949: Vol. 2, p. 41, Tab. 2, fig. 1; Fenner 1985: 739, fig. 14.6; Fourtanier 1991: Pl. 5, fig. 8; *Stephanopyxis schulzii* var. *cretacea* Jousé 1949: 65, Tab. 1, figs. 2-4; Jousé et al. 1949: vol. 2, p. 41, Tab. 2, figs. 2a, b. *Stephanopyxis schulzii* Steinecke forma *schulzii* Strelnikova 1974: 55, Tab. 4, figs. 1-3, 8; *Costopyxis schulzii* (Steinecke) Gleser 1984: 291. *Costopyxis schulzii* (Steinecke) Gleser forma *schulzii* Gleser et al. 1988: 50, Pl. 31, figs. 15-19.

*Costopyxis schulzii* Gleser var. *nuda* Strelnikova; *Stephanopyxis schulzii* Steinecke forma *nuda* Strelnikova 1974: 55, Tab. 4, figs. 10-12; Tab. 5, figs. 1, 2. *Costopyxis schulzii* (Steinecke) Gleser var. *nuda* Strelnikova; Gleser et al. 1988: 51, Tab. 32, figs. 5-8. [Plate II, figs. 6, 7]

*Eunotogramma bivittata* Grunow et Pantocsek ex Pantocsek; *Eunotogramma*? *bivittata* Grunow et Pantocsek in Pantocsek 1886: Bd. I, p. 50, Tab. 26, fig. 247; *Eunotogramma marginopunctatum* Long, Fuge et Smith 1946: 105, Tab. 17, fig. 14; *Eunotogramma bivittatum* Grunow et Pantocsek, Strelnikova 1974: 107, Tab. 52, figs. 6,7; *Drepanotheca bivittata* (Grunow et Pantosek) Schrader 1969: 123, Pl. 38, fig. 9; Harwood 1988: 80.

*Eunotogramma enorme* Krotov 1959: 111, fig. 11; Strelnikova 1974: 108-109, Tab. 52, figs. 16-19; Harwood 1988: fig. 21.22.

*Gladiopsis speciosus* forma *aculeolatus* Strelnikova; *Gladius clavatus* Jousé 1951: 55, fig. 1; *Pyxilla speciosa* forma *aculeolata* Strelnikova 1966: 35, Tab. 4, figs. 3, 4, 11; *Gladius speciosus* Schulz forma *aculeolatus* Strelnikova 1974: 105-106, Tab. 51, figs. 5-10; Gleser et al. 1988: 55, Tab. 35, figs. 1-10. [Plate III, figs. 3-4]

*Gladiopsis speciosus* forma *poratus* Strelnikova; *Gladius hispidus* Jousé 1955: 55, fig. 1; *Pyxilla speciosa* forma *porata* Strelnikova 1966a: 35, Tab. 4, figs. 5, 6, 12; *Gladius speciosus* forma *poratus* Strelnikova 1974: 106, Tab. 49, fig. 22, Tab. 51, figs. 11, 12; Gleser et al. 1988: 55, Tab. 35, figs. 11-17. [Plate V, figs. 5-6]

*Gladiopsis speciosus* forma *speciosus* (Schulz) Strelnikova; *Gladius speciosus* Schulz 1935: 391, Tab. 1, figs. 6-8; Jousé et al. 1949: Vol. 2, p. 199, Tab. 97, fig. 4; Jousé 1955: 76, fig. 4; Barron 1985: 141, Pl. 10.2, fig. 14; Fenner 1985: 730, figs. 1-5; Fourtanier 1991: Pl. 5, figs. 9-10; Nikolaev et al. 2001: p. 12-13, Pl. 2, fig. 1-7; *Pyxilla speciosa* forma *speciosa* Strelnikova 1966b: 34, Tab. 2, figs. 1-7, Tab. 3, figs. 5-9, Tab. 4, fig. 1, 2, 10; *Gladius speciosus* forma *speciosus* (Schulz) Strelnikova; Strelnikova 1974: 104-105, Tab. 49, figs. 2-11, 14, 15, 18, 20, 21, Tab. 50, figs. 1-19, Tab. 51, figs. 1, 4; Gleser et al. 1988: 55, Tab. 36, figs. 1-10; *Gladiopsis speciosa* (Schulz) Gersonde et Harwood 1990: 373. [Plate II, fig. 1; Plate V, figs. 1-4]

*Gladius antiquus* Forti et Schulz; Gersonde et Harwood 1990: 373, Pl. 7, figs. 1, 2; Pl. 8, figs. 1, 2, 5, 6; Pl. 15, figs. 6, 7. [Plate I, fig. 2]

*Gladius antiquus* var. *tenuis* Gersonde et Harwood 1990: 373, Pl. 7, figs. 3, 4, 10, 11, 15; Pl. 8, figs. 3, 4, 7. [Plate I, fig. 1]

*Goniothecium odontella* Ehrenberg 1844: 82; Ehrenberg 1854: Tab. 18, fig. 94, Tab. 33, XIII, figs. 13, 14, Tab. 33, XV, fig. 16; Witt 1886: 161, Tab. 7, figs. 7, 8; Jousé et al. 1949: Vol. 2, p. 205, Tab. 75, fig. 10a; Jousé 1951: 60, Tab. 5, figs. 1-7; Hajós and Stradner 1975: 935, Pl. 10, figs. 11-12; Barron 1985: Pl. 10.2, fig. 13; Harwood 1988: 82, figs. 10.21-22; Dell'Agnese and Clark 1994: 38, fig. 3.8; *Gonothecium odontellum* Ehrenberg, Strelnikova 1974: 116-117, Tab. 55, figs. 1-12, Tab. 56, figs. 1-5.

*Goniothecium odontella* var. *danica* Grunow ex van Heurck 1880-1885: Tab. 105, figs. 11, 12; Schulz 1935: 391, Tab. 1, fig. 9; Jousé et al. 1949: Vol. 2, p. 205, Tab. 75, fig. 10b; Jousé 1951: 62, Tab. 5, figs. 8-17; Hajós and Stradner 1975: 935.

*Hemiaulus altus* Hajós in Hajós et Stradner 1975: 931, Pl. 5, figs. 17-19.

*Hemiaulus antiquus* Jousé 1951: 52, Tab. 3, figs. 1a, b; Strelnikova 1974: 101, Tab. 46, figs. 1-14; Barron 1985: Pl. 10.2, fig. 4; Dell'Agnese and Clark 1994: 38, fig. 3.9. [Plate IV, figs. 11-12]

*Hemiaulus arcticus* Grunow 1884: 11 [63], Tab. B, fig. 27.

*Hemiaulus curvatulus* Strelnikova 1971: 49, Tab. 1, figs. 12, 13; Strelnikova 1974: 96-97, Tab. 47, figs. 14-16; Hajós

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## PLATE 1

Representative diatom assemblage of the *Gladius antiquus* Zone.

1 *Gladius antiquus* var. *tenuis* Gersonde et Harwood; girdle view, ×1875, Sample C-34348, Slidre Fjord.

2 *Gladius antiquus* Forti et Schulz; girdle view, ×1875; Sample C-34348, Slidre Fjord.

3-4 *Paralia ornata* (Grunow) Grunow; girdle view, ×1250, high and low focus of the same specimen; Sample C-34348, Slidre Fjord.

5, 6 *Trochosira denticulatum* (Strelnikova) Tapia; 5, girdle view; 6, valve view, ×1875; Sample C-34348, Slidre Fjord.

7-8 *Basilicostephanus* sp. 1; girdle view, ×1875; high and low focus of the same specimen; Sample C-34348, Slidre Fjord.

9-10 *Bilingua* sp. 1; valve view, ×1875, high and low focus of the same specimen; Sample C-34348, Slidre Fjord.

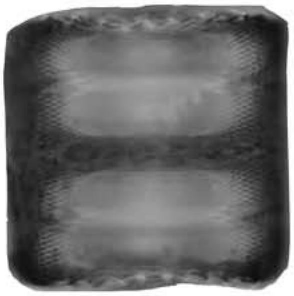
11-12 *Hemiaulus* sp. A; girdle view, ×1875, high and low focus of the same specimen; Sample C-34348, Slidre Fjord.

13-14 *Stephanopyxis* sp. A; valve view, ×1250, high and low focus of the same specimen; Sample C-34348, Slidre Fjord.

15-16 *Costopyxis ornata* (Schulz) Strelnikova; girdle view, ×1250, high and low focus of the same specimen; Sample C-8590, Horton River


1


2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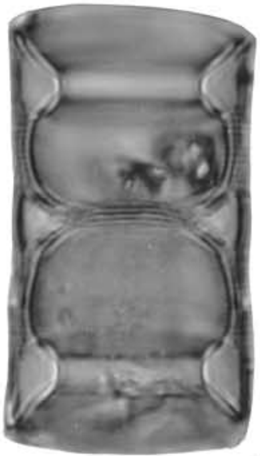
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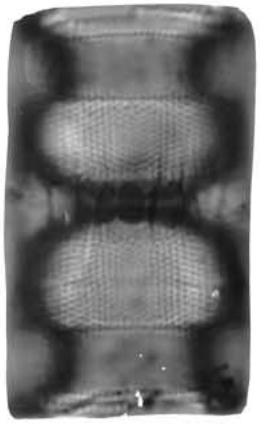
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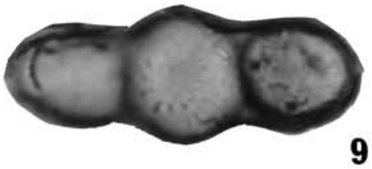
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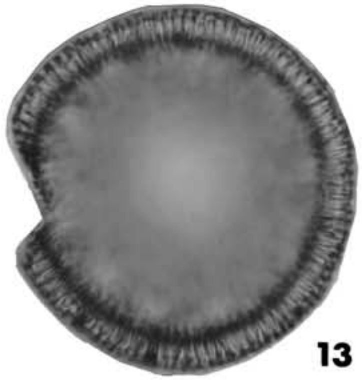
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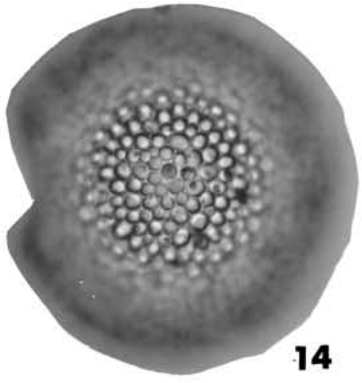
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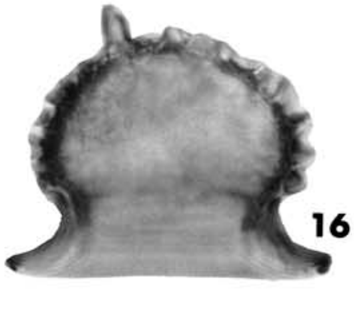
16

and Stradner 1975: 931, Pl. 6, fig. 8; Harwood 1988: 82, fig. 13.12.

*Hemiaulus danicus* Grunow 1884: 65, Tab. II (B), figs. 40, 41; Schmidt et al. 1875-1959: Tab. 143, fig. 43; Hustedt 1930 :877, fig. 521; Jousé et al. 1949: Vol. 2, p. 186, fig. 186, Tab. 72, fig. 11; Strelnikova 1974: 100-101, Tab. 43, fig. 19; Hajós and Stradner 1975: 931, Pl. 5, fig. 10-11; Harwood 1988: 82, figs. 13.16-17.

*Hemiaulus echinulatus* Jousé in Jousé et al. 1949: Vol. 2: 186, Tab. 72, fig. 5; Jousé 1951: 53, Tab. III, figs. 3a,c; Strelnikova 1974: 100, Tab. 44, figs. 15-23; Hajós and Stradner 1975: 931, Pl. 5, figs. 21, 22; Fenner 1985: 731, fig. 14.10; Harwood 1988: 92, Fig.13.4. [Plate VII, figs. 7-8]

*Hemiaulus elegans* (Heiberg) Grunow 1884: 14; Strelnikova 1974: 98-99, Tab. 44, fig. 11, 12, 15 (only); Barron 1985: Pl. 10.2, fig. 3; Harwood 1988: 82, fig. 13.18.

*Hemiaulus februatus* Heiberg 1863: 49, Tab. 2, fig. 5; Homann 1991: 85, Taf. 18, figs. 12, 13.

*Hemiaulus kittonii* Grunow 1884: 61; Schmidt et al. 1875-1959: Tab. 142, figs. 2-11; Jousé et al. 1949: Vol. 2: 190, Tab. 73, fig. 5, Tab. 95, figs. 8a-d; Barron 1985: Pl. 10.2, fig. 8; Harwood 1988: 83, fig. 13.15; Dell'Agnese and Clark 1994: 38, fig. 4.1; *Hemiaulus* sp.?: Kitton 1870-1871: Pl. 14, fig. 11.

*Hemiaulus orthoceras* Strelnikova 1974: 103-104, Tab. 45, figs. 20-24; Fenner 1985: 732, figs. 16-18.

*Hemiaulus polymorphus* var. *frigida* Grunow 1884: 66, Tab. 2 (B), figs. 47-49; Hustedt 1930: 881, fig. 525; Jousé et al. 1949: Vol. 2, p. 185, Tab. 71, figs. 6a-d; Krotov and Schibkova 1961: 210: Tab. 3, fig. 13; Strelnikova 1974: 103, Tab. 45, figs. 1-19; Harwood 1988: 83, figs. 14.7, 13.29; Dell'Agnese and Clark 1994: 38, fig. 4.2. [Plate V, fig. 8]

*Hemiaulus praelegans* Jousé 1951: 53-54, Tab. 3, figs. 4a,b; Krotov 1959: 107-108, fig. 2; Hajós and Stradner 1975: 932, Pl. 6, figs. 12, 14; Harwood 1988: figs. 13.19-20.

*Hemiaulus punctatus* Greville 1865: 28, Pl. III, fig. 7.

*Hemiaulus schmidti* Hajós ex Hajós et Stradner 1975: 932, Pl. 7, figs. 2-5.

*Hemiaulus* sp. A. [Plate I, figs. 11-12, Plate III, figs. 1-2]

*Hemiaulus* sp. cf. *H. polymorphus* Grunow 1884: 14; Schmidt et al. 1875-1959: Tab. 143, figs. 11-13, 30-34. [Plate II, figs. 8, 9]

*Hemiaulus sporalis* Strelnikova 1971: 48, Tab. 3, figs. 1-10; Strelnikova 1974: 95-96, Tab. 41, figs. 1-10; Tab. 42, figs. 1-11; Hajós and Stradner 1975: 932, Pl. 29, figs. 5, 6; Harwood 1988: 84, figs. 15.7-10. [Plate V, fig. 7]

*Hemiaulus tumidicornis* Strelnikova 1971: 49, Tab. I, figs. 14-16; Strelnikova 1974: 102, Tab. 47, figs. 17-25; Barron 1985: Pl. 10.2, fig. 5-6; Dell'Agnese and Clark 1994: 38, fig. 4.4; *Hemiaulus* sp. cf. *H. tumidicornis* Strelnikova in Harwood 1988: 84, figs. 14.9, 25.

*Hemiaulus undulatus* Jousé 1951: 38, Tab. 4, fig. 1; Strelnikova 1974: 98, Tab. 47, figs. 7-9.

*Lepidodiscus elegans* Witt 1886: 163, Tab. 7, fig. 6; Strelnikova 1965b: 30, Tab. III, figs. 1, 2; Strelnikova 1974: 70-71, Pl. 16, figs. 1-6.

*Melosira hokaidoana?* Pantocsek 1892: Bd. 3, Tab. 6, fig. 91.

*Melosira? campaniensis* Moshkovitz, Ehrlich et Soudry 1983: 184, figs. 7a-e.

*Meristiosolen* sp. 1

*Micrampula parvula* Hanna 1927: 26, Pl. 3, fig. 15; Long, Fuge and Smith 1946: 109; Jousé 1951: 60, Tab. 4, fig. 8; *Pterotheca* (*Micrampula*) *parvula* (Hanna) Hajós et Stradner 1975: 934, Pl. 12, figs. 12-15, Pl. 37, figs. 1-4; Fenner 1985: 735, figs. 13-14.

*Odontotropis carinata* Grunow 1884; Undescribed form (not diatomaceous?), Kitton 1871: 171, Pl. 14, figs. 12, 13; *Odontotropis? carinata* Grunow 1884: 7 [59]; *Odontotropis carinata* Grunow, Hustedt 1930: fig. 510; Schulz 1935: 393, Tab. 1, fig. 10; Jousé et al. 1949: Vol. 2, p. 179, Tab. 69, fig. 7; Krotov and Schibkova 1959: 121, Tab. 4, fig. 1, 2; Dell'Agnese and Clark 1994: 38, fig. 4.5.

*Odontotropis cristata* Grunow 1884: 59, Tab. 2, fig. 23, Tab. 5, figs. 58a,b; Hustedt 1930: 858, fig. 511; Schulz 1935: 393, fig. 4; Jousé et al. 1949: vol. 2, p. 179, Tab. 69, fig. 6.

*Odontotropis hyalina* Witt 1886: 165, Taf. 9, fig. 2; Homann 1991: 101, Taf. 25, figs. 11-13.

*Paralia crenulata* (Grunow) Gleser, *Paralia ornata* var. *crenulata* Grunow 1884: 44, Tab. 5 (E), fig. 34; *Melosira fausta* Schmidt *sensu* Hanna 1927: 25, Pl. 3, fig. 11-14; *Paralia crenulata* (Grunow) Gleser in Gleser et al. 1992: 50, Pl. 41, figs. 1-8; Nikolaev et al. 2001: 15, Pl. 8, figs. 1-8. [Plate IV, figs. 14-15]

*Paralia ornata* (Grunow) Grunow ex van Heurck; *Melosira ornata* Grunow 1884: 95, Tab. 5 (E), fig. 30, 40; Jousé et al. 1949: Vol. 2, p. 26, Tab. 4, fig. 5, Tab. 75, fig. 15;

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## PLATE 2

Representative diatom assemblage of the *Costopyxis antiqua* Zone.

1 *Gladiopsis speciosus* forma *speciosus* (Schulz) Gersonde et Harwood, *sensu lato*; composite low and high focus figure, ×1250; Sample C-44744, Hoodoo Dome.

2-4 *Basilicostephanus* sp. 1; 2, valve view, ×1250; 3-4, girdle view, ×1250, high and low focus of the same specimen; Sample C-34353, Slidre Fjord.

5, 12-13 *Triceratium schulzii* Jousé; 5, valve view, ×1875; Sample C-8593, Horton River; 12-13, valve view, ×1875, high and low focus of the same specimen; Sample C-44744, Hoodoo Dome.

6-7 *Costopyxis schulzii* f. *nuda* Strelnikova; girdle view, ×1875, high and low focus of the same specimen; Sample C-8690, Horton River.

8-9 *Hemiaulus* sp. cf. *H. polymorphus* Grunow; girdle view, ×1875, high and low focus of the same specimen; Sample C- 44742, Hoodoo Dome.

10-11, 14-15 *Costopyxis antiqua* (Jousé) Gleser; girdle view, ×1250; 10-11, high and low focus of the same specimen; Sample C-34353, Slidre Fjord; 14-15, high and low focus of the same specimen; Sample C-8590, Horton River.


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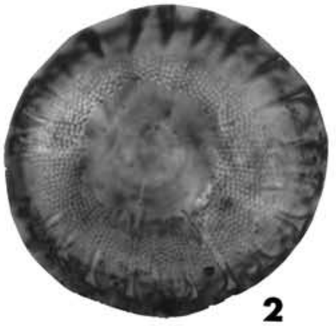
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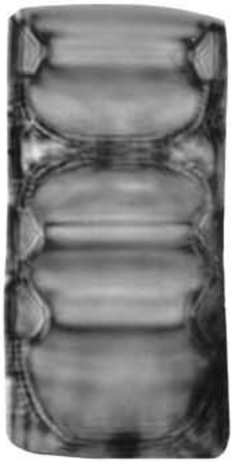
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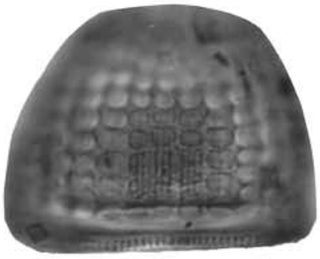
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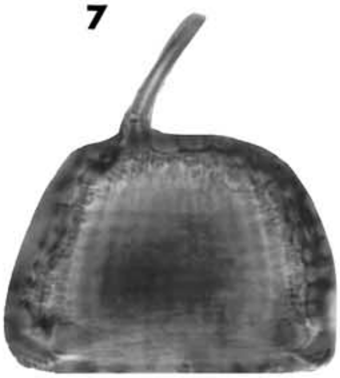
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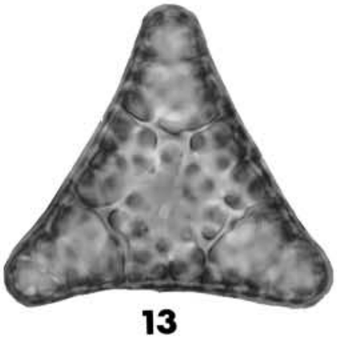
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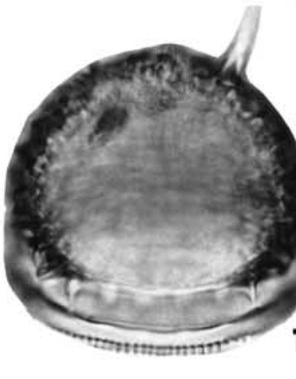
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Strelnikova 1974: 47-48, Tab. 1, figs. 5, 6. [Plate I, figs. 3-4]

*Paralia sulcata* (Ehrenberg) Cleve; *Gallionella sulcata* Ehrenberg 1838: 170, Tab. 21, fig. 5; *Melosira sulcata* (Ehrenberg) Kützing 1844: 55, Tab. 2, fig. 7; Jousé et al. 1949: vol. 2, p. 27, Tab. 4, figs. 6a-d; *Melosira sulcata* var. *sulcata* Strelnikova 1974: 48-49, Tab. 1, figs. 9-14; *Paralia sulcata* (Ehrenberg) Grunow, Harwood 1988: 85, figs. 16.8-9. Diatom counts of *P. sulcata* (Ehernberg) Cleve also include counts on the species *P. crenulata* (Grunow) Gleser. [Plate IX, fig. 13]

*Proboscia cretacea* (Hajós et Stradner) Jordan et Priddle 1991: 56, figs. 3, 4; *Rhizosolenia cretacea* Hajós et Stradner 1975: 929, Pl. 7, fig. 1, Pl. 31, figs. 4-6; Barron 1985: 141, Pl. 10.3, fig. 1; Martinez-Machiavello 1987: 282, Lam. 1, fig. 1; Harwood 1988: fig. 19.8; Fenner 1991: 140, Pl. 1, figs. 4, 9; Fourtanier 1991: 201, Pl. 5, fig. 12; Dell'Agnese and Clark 1994: 38, fig. 2.12.

*Pseudopodosira reticulata* Strelnikova 1974: 53, Tab. 3, fig. 2.

*Pseudopodosira witti* (Schulz) Vekschina 1961a: 90; Strelnikova 1974: 52, Tab. 2, figs. 12-16.

*Pseudopyxilla* sp. cf. *P. rossica* (Pantocsek) Forti; *Pyxilla rossica* Pantocsek 1892: Bd. 3, p. 91, Tab. 19, fig. 247; Jousé et al. 1949: Vol. 2: 200, Tab. 97, fig. 7; *Pseudopyxilla rossica* (Pantocsek) Forti 1909: 14, Tab. 1, fig. 13; Hajós and Stradner 1975: 933, Pl. 12, figs. 1-2; Pl. 27, fig. 9; Harwood 1988: 86, figs. 17.28-29; Nikolaev et al. 2001: 24, Pl. 35, fig. 1-2. [Plate IX, figs. 7-8]

*Pterotheca aculeifera* Grunow ex van Heurck 1880-1885: Tab. 83, figs. 13-14, Tab. 83 bis, fig. 5; Jousé et al. 1949: vol. 2, p. 202, Tab. 75, figs. 4a-b; Jousé 1951: 59, Tab. 4, figs. 5a-b; Strelnikova 1974: 114, Tab. 57, figs. 1-26; Harwood 1988: 86, figs. 18.3-4.

*Pterotheca cretacea* Hajós et Stradner 1975: 934, Pl. 12, figs. 16-18, 21; Pl. 26, fig. 1; Harwood 1988: 86, figs. 18.9-11.

*Pterotheca pokroskajae* Jousé 1951: 58, fig. 2; Harwood 1988: 86, fig. 18.19-23.

*Pterotheca* sp. cf. *P. spada* Tempère et Brun 1889; *Pterotheca spada* Tempère et Brun in Brun and Tempère 1889: Tab. 1, fig. 7; Schulz 1935: 395, figs. 7a,b; Jousé et al. 1949: vol. 2, p. 203, Tab. 75, figs. 8a-d; Harwood 1988: 87, figs. 18.24-25. [Plate VIII, figs. 7, 9]

*Raphoneis elliptica* Jousé 1951a: Tab. 4, fig. 6.

*Sceptroneis gracilis* Hajós in Hajós and Stradner 1975: 936, fig. 19.

*Sceptroneis grunowi* Anissimova 1938; Jousé et al. 1949: Vol. 2, p. 217; Jousé 1951: 41, Pl. 4, fig. 8; Hajós and Stradner 1975: 936, Pl. 11, figs. 14, 15; Schrader and Fenner 1976: 998, Pl. 22, figs. 26-28, Pl. 23, fig. 8, Pl. 25, figs. 7, 9; Harwood 1988: 87, figs. 17.9-10.

*Sheshukovia excavata* (Heiberb) Nikolaev et Harwood in Nikolaev et al. 2001: 21, Pl. 29, figs. 1-5; *Trinacria excavata* Heiberg 1863: 51, Tab. IV, fig. 9; Hanna 1927: 37, Pl. 5, fig. 6; Harwood 1988: 89, figs. 21.15-16; *Triceratium excavatum* (Heiberg) Strelnikova 1974: 82-83, Tab. 31, figs. 7-14; Hajós and Stradner 1975: 932, Pl. 10, fig. 1;

*Sheshukovia* sp. 1; *Triceratium exornatum* Greville sensu Strelnikova 1974: 85, Tab. 35, figs. 1-3; *Triceratium cristatum* Pantocsek, Hajós and Stradner 1975: 929, Pl. 8, figs. 11-12. [Plate IV, figs. 7-10]

Spore # 3. [Plate IX, figs. 1-2]

Spore # 4. [Plate IX, figs. 5-6]. This resting spore is very similar to Spore # 3, the main difference is that this form is smaller and has shorter lateral expansions.

Spore # 12. [Plate VIII, figs. 5-6]

*Stellarima stenyi* (Hanna) Hasle et Sims 1986; *Coscinodiscus stenyi* Hanna 1927: 19, Pl. 2, figs. 5, 6; Long, Fuge and Smith 1946: 105; *Coscinodiscus symbolophorus* Grunow, Strelnikova 1974: 63-64, Tab. 12, figs. 1-7; *Stellarima stenyi* (Hanna) Hasle et Sims 1986: 111; Sims and Hasle 1987: 230-234, figs. 1-18, 27-31; Harwood 1988: 88, figs. 20.3-4; Dell'Agnese and Clark 1994: 34, fig. 4.8; Nikolaev et al. 2001: 19, Pl. 20, figs. 1-6. [Plate VII, fig. 2]

*Stephanopyxis arctica* (Grunow) Strelnikova et Nikolaev; *Stephanopyxis turris* var. *arctica* Grunow 1884: 91, Tab. V, figs. 20-22; *Pyxidicula arctica* (Grunow) Strelnikova et Nikolaev *in* Gleser *et al*. 1988: 39, Tab. 19, figs. 1-15, Tab. 20, figs. 1-5. [Plate VI, figs. 7-8]

*Stephanopyxis dissonus* (Schulz) Strelnikova et Nikolaev; *Coscinodiscus dissonus* Schulz 1935: 387, Tab. 1, fig. 5, Jousé 1949: 72, Tab. 2, fig. 1; Jousé et al. 1949: vol. 2, p. 69, Tab. 8, fig. 10; *Pyxidicula dissona* (Schulz) Strelnikova et Nikolaev *in* Gleser et al. 1988: 41, Tab. 22, figs. 1-8. [Plate VI, figs. 1-3]

*Stephanopyxis grunowii* Grove et Sturt 1988 in Schmidt et al. 1875-1959: Tab. 130, figs. 1-4; Hanna 1927: 33-34, Pl. 4, fig. 12. [Plate VII, fig. 5]

*Stephanopyxis lavrenkoi* Jousé in Jousé et al. 1949: 40, Tab. 10, fig. 9; Strelnikova 1974: 60, Tab. VII, fig. 7.

*Stephanopyxis simonseni* Hajós ex Hajós et Stradner 1975: 926, Pl. 2, figs. 7, 8; Harwood 1988: 88, fig. 19.24. [Plate VIII, figs. 1-2, 8; Plate IX, figs. 3-4]

*Stephanopyxis* sp. A. [Plate I, figs. 13-14]

*Stephanopyxis superba* (Greville) Grunow 1884: 39; Hajós and Stradner 1975: 926, Pl. 2, figs. 11, 12; Harwood 1988: 88, fig. 19.25; *Creswellia superba* Greville 1861: 68, Pl. 8, figs. 3-5. [Plate VI, figs. 4-5]

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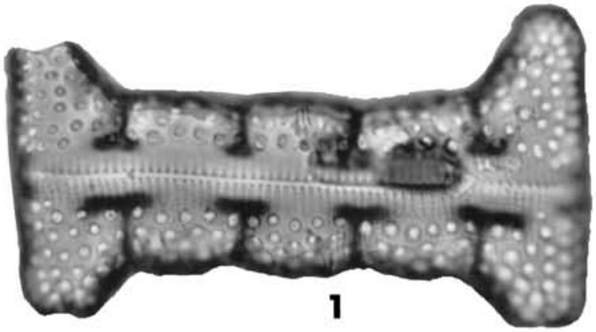
## PLATE 3

1-2 *Hemiaulus* sp. A; girdle view, ×1875, high and low focus of the same specimen; Sample C-34344, Slidre Fjord.

3-4 *Gladiopsis speciosus* f. *aculeolatus* Strelnikova; girdle view, ×1250, high and low focus of the same specimen; Sample C-34353, Slidre Fjord.

5-8 *Cortinocornus rossicus* (Pantocsek) Gleser, girdle view, ×1250; 5-6, high and low focus of the same specimen; Sample C-8593, Horton River; 7-8, high and low focus of the same specimen; Sample C-8597, Horton River.

9-10 *Actinoptychus simbriskianus* Schmidt; valve view, ×1250, high and low focus of the same specimen; Sample C-8618, Horton River.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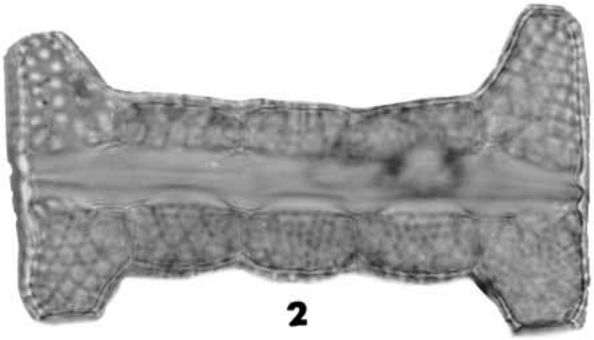
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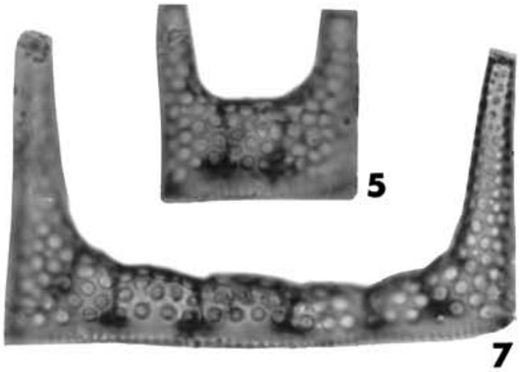
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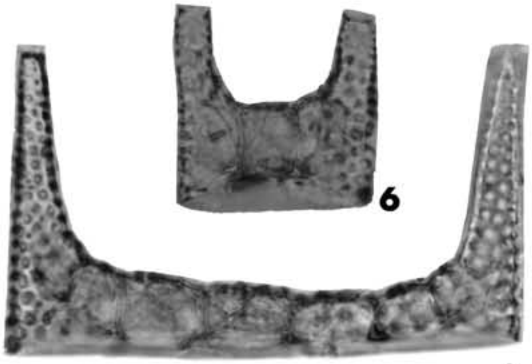
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*Stephanopyxis turris* (Greville et Arnott) Ralfs in Pritchard 1861; *Creswellia turris* Greville et Arnott 1857: 538, Tab. 14, fig. 109; *Stephanopyxis turris* (Greville et Arnott) Ralfs in Pritchard 1861: 826, Tab. 5, fig. 74; Schulz 1935: 397; Jousé et al. 1949: vol. 2, p. 40, Tab. 10, fig. 3; Hajós and Stradner 1975: 926, Pl. 1, figs. 13-15; Barron 1985: Pl. 10.3, fig. 5; Harwood 1988: 88, figs. 19.26-27; Dell'Agnese and Clark 1994: 38, fig. 5.1; Nikolaev et al. 2001: 14, Pl. 7, figs. 5-6; *Stephanopyxis turris* (Greville et Arnott) Ralfs var. *turris* Strelnikova 1974: 59, Tab. 8, figs. 1-13. [Plate IX, figs. 9-10]

*Strelnikovia antiqua* (Strelnikova) Ross et Sims 1985: 326-327, Pl. 20, figs. 1-6; Pl. 21, figs. 1-7; Pl. 33, fig. 1; *Rutilaria antiqua* Strelnikova 1964: 230, Tab. 2, figs. 1a-e; Strelnikova 1974: 109, Tab. 53, figs. 1-3. [Plate IV, figs. 3-4]

*Thalassiosiropsis wittiana* (Pantocsek) Hasle ex Hasle et Syvertsen 1985: 89-90, Pl. 1-5; Harwood 1988: 89, fig. 20.6; Nikolaev et al. 2001: 12, Pl. 1, figs. 1-4; *Coscinodiscus lineatus* Ehrenberg, Strelnikova 1974: 62, Tab. 9, figs. 3-12; Hajós and Stradner 1975: 927, Pl. 3, figs. 1-3; Pl. 38, fig. 1. [Plate IV, fig. 13; Plate VII, fig. 6]

*Triceratium indefinitum* (Jousé) sensu Strelnikova 1974: 82, Pl. 30, figs. 18-22 (only). Non *Trinacria indefinita* Jousé 1951.

*Triceratium kolbei* Hustedt 1930 in Schmidt et al. 1875-1959: Taf. 372, fig. 4; Strelnikova 1974: 86, Pl. 33, fig. 14; Pl. 34, figs. 1-4.

*Triceratium planum* Strelnikova 1974: 87, Tab. 29, figs. 12-17; Barron 1985: Pl. 10.3, fig. 7; Fenner 1985: 741, figs. 13.8-9; Dell'Agnese and Clark 1994: 38, fig. 4.10.

*Triceratium schulzii* Jousé 1949: 72, Tab. 1, fig. 8; Strelnikova 1974: 81, Tab. 29, figs. 1-7; Hajós and Stradner 1975: 930, Pl. 8, figs. 1-2; Pl. 33, fig. 2; Fourtanier 1991: Pl. 5, fig. 6. [Plate II, figs. 5, 12-13]

*Triceratium synicum* Strelnikova 1965: 34, Tab. V, fig. 5, Tab. VI, figs. 1-2; Strelnikova 1974: 85, Tab. 34, fig. 5; Tab. 35, figs. 6-8.

*Trinacria acutangulum* (Strelnikova) Barron 1985; *Triceratium acutangulum* Strelnikova 1974: 83-84, Tab. 32, figs. 1-10; *Trinacria acutangulum* (Strelnikova) Barron 1985: 141, Pl. 10.3, figs. 6, 8, 9; Harwood 1988: 89, figs. 21.8-10, 12; Dell'Agnese and Clark 1994: 38, figs. 4.10-11. [Plate V, figs. 9-11]

*Trinacria aries* Schmidt 1886 in Schmidt et al. 1875-1959: Taf. 96, figs. 14-17; Taf. 150, figs. 14, 15; Hanna 1927: 36, Pl. 5, figs. 1, 2; Hajós and Stradner 1975: 932, Pl. 9, figs. 9-11, Pl. 33, fig. 5; Harwood 1988: 89, fig. 21.14; Nikolaev et al. 2001: 21, Pl. 25, figs. 4-6.

*Trinacria coronatum* (Witt) Strelnikova 1974: 89, Tab. 34, figs. 1-4.

*Trinacria indefinita* Jousé 1951: 50, Tab. 2, figs. 5a,b; *Triceratium indefinitum* (Jousé) Strelnikova 1974: 82, Tab. 30, figs. 1-29, Tab. 31, figs. 1-6; Harwood 1988: 89, figs. 20.11, 21.4-7; Dell'Agnese and Clark 1994: 38, fig. 5.3. [Plate IV, figs. 1-2, 5-6]

*Trinacria tessela* Krotov 1959: 108-109, fig. 5; *Trinacria tessela* (Krotov) Strelnikova 1974: 84, Tab. 74, figs. 8-11; Barron 1985: 141, Pl. 10.3, fig. 10.

*Trochosira denticulatum* (Strelnikova) Tapia, nov. comb. Basionym: *Sceletonema denticulatum* Strelnikova 1974: 54, Tab. 1, fig. 3. Non *Trochosira spinosa* Kitton *in* Gleser et al. 1992: 68, Tab. 57, figs. 1, 2. [Plate I, figs. 5, 6]

*Trochosiropsis polychaeta* (Strelnikova) Tapia, nov. comb. Basionym: *Sceletonema polychateum* Strelnikova 1971: 42, Tab. 1, figs. 3-5. Synonyms: *Sceletonema polychaetum* Strelnikova in Strelnikova, 1974: 54, Tab. 3, figs. 3-7; Barron, 1985: Pl. 10.1, figs. 2-4; (?) *Pyrgodiscus triangulatus* Hajós et Stradner, 1975: 928, figs. 11a,b, Pl. 18, figs. 5, 6; *Trochosira polychaeta* (Strelnikova) Sims, 1988: 251-253, figs. 15-21, 29-34. [Plate VIII, figs. 3-4]

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## PLATE 4

Representative diatom assemblage of the *Trinacria indefinita* Zone.

1-2, 5-6 *Trinacria indefinita* Jousé; 1-2, valve view, ×1250, low and high focus of the same specimen; Sample C-8602, Horton River; 5-6, valve view, ×1875, low and high focus of the same specimen; Sample C-8599, Horton River.

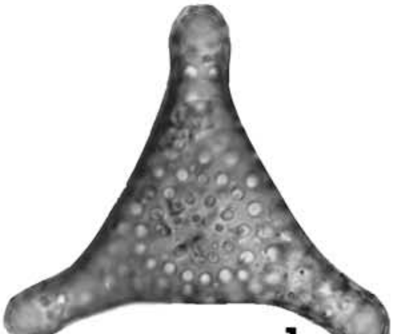
3-4 *Strelnikovia antiqua* (Strelnikova) Ross et Sims; valve view, ×1250, high and low focus of the same specimen; Sample C-8597, Horton River.

7-10 *Sheshukovia* sp. 1, valve view, ×1250; 7-8, low and high focus of the same specimen; Sample C-8595, Horton River; 9-10, low and high focus of the same specimen; Sample C-8599, Horton River.

11-12 *Hemiaulus antiquus* Jousé; girdle view, ×1875, high and low focus of the same specimen; Sample C-8600, Horton River.

13 *Thalassiosiropsis wittiana* (Pantocsek) Hasle, valve view, ×750; Sample C-8597, Horton River.

14-15 *Paralia crenulata* (Grunow) Gleser; valve view, ×1250, high and low focus of the same specimen; Sample C-8599, Horton River.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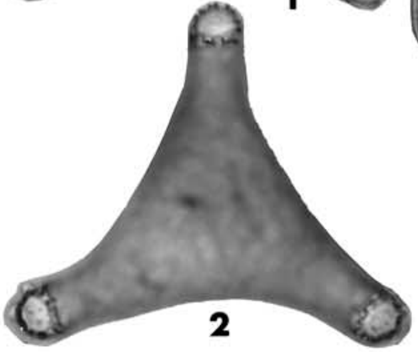
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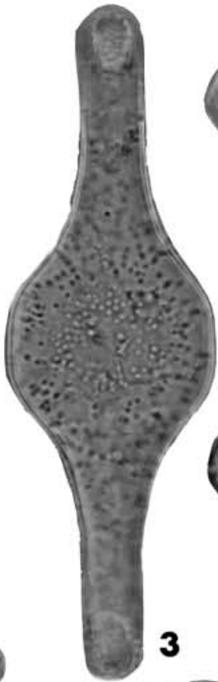
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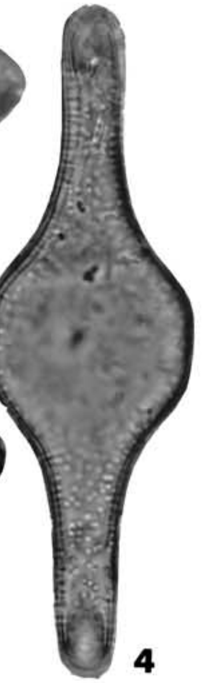
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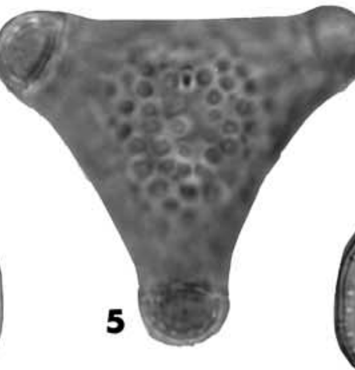
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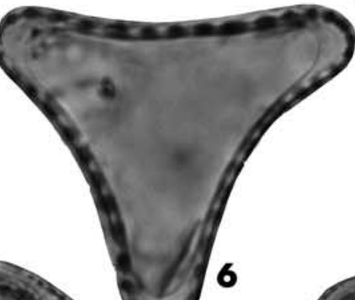
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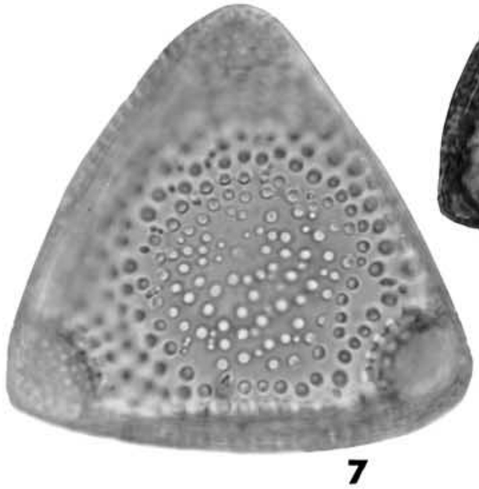
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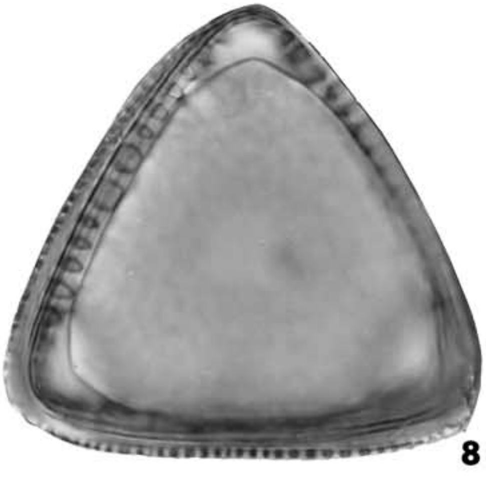
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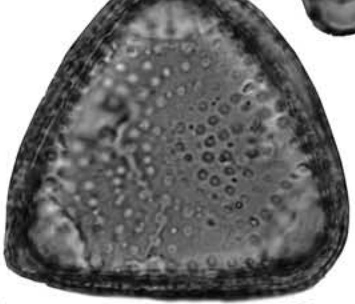
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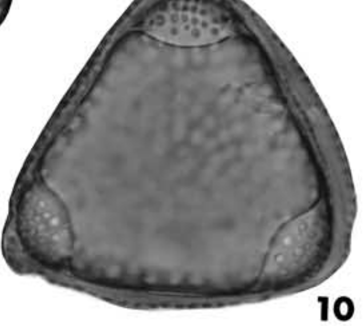
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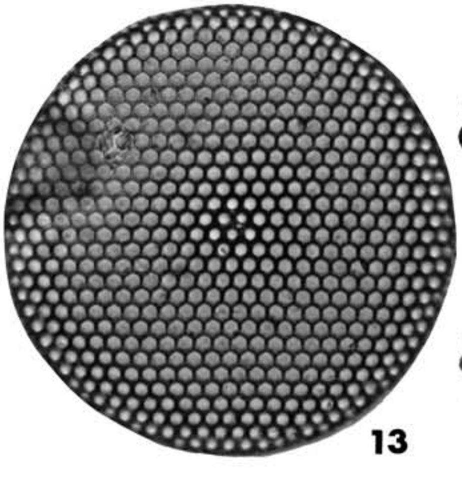
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## PLATE 5

1-4 *Gladiopsis speciosus* (Schulz) Gersonde et Harwood; 1-2, girdle view, ×1250, high and low focus of the same specimen; Sample C-44744, Hoodoo Dome; 3-4, girdle view, ×1875, high and low focus of the same specimen; Sample C-8603, Horton River.

5-6 *Gladiopsis speciosus* f. *poratus* Strelnikova; girdle view, ×1250, high and low focus of the same specimen; Sample C-8600, Horton River.

7 *Hemiaulus sporalis* Strelnikova (resting spore); valve view, ×1250. Sample C-8608, Horton River.

8 *Hemiaulus polymorphus* var. *frigida* Grunow; girdle view, ×1875; Sample C-8602, Horton River.

9, 10-11 *Trinacria acutangula* (Strelnikova) Barron; 9, girdle view, ×1250; Sample C-8603, Horton River; 10-11, valve view, ×1250, low and high focus of the same specimen; Sample C-8599, Horton River.

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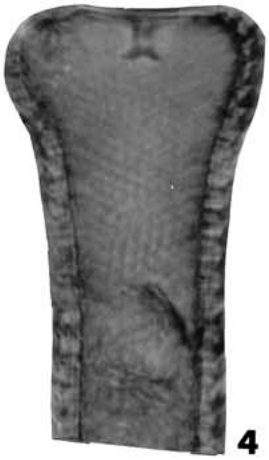

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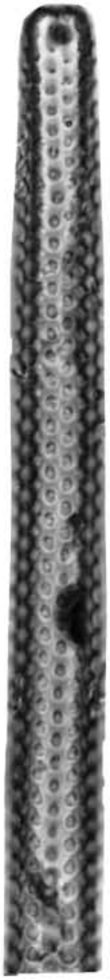

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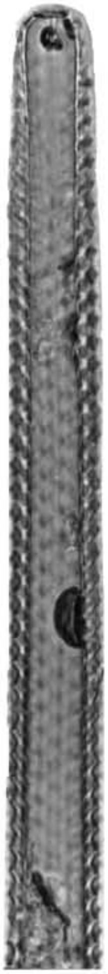

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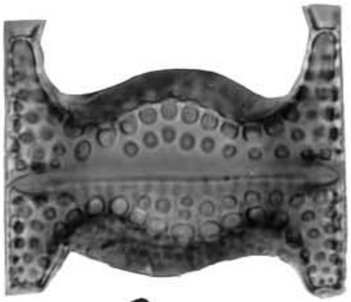

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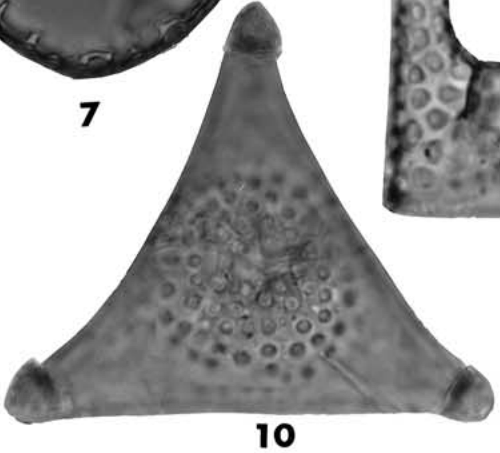

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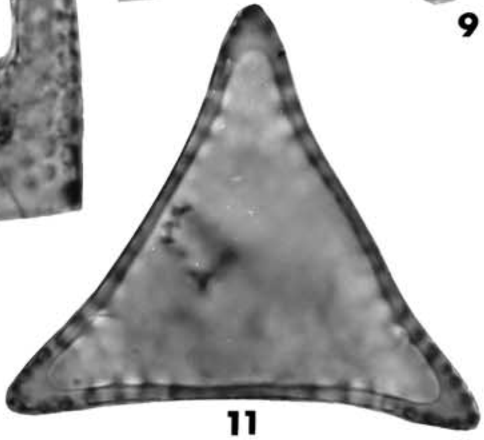

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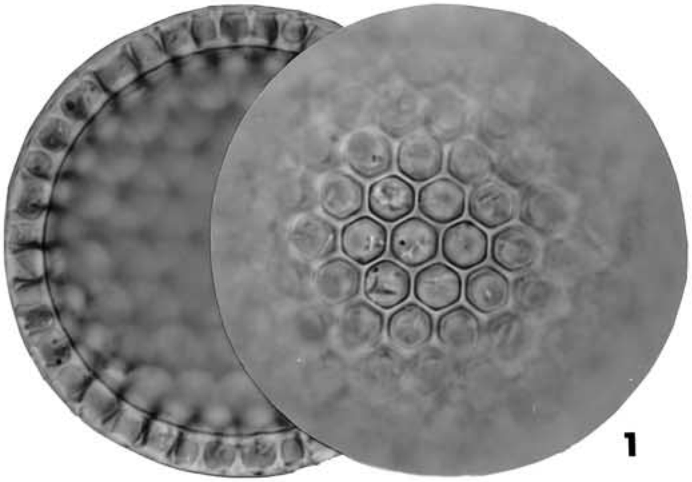
## PLATE 6

1, 2-3 *Stephanopyxis dissonus* (Schulz) Strelnikova et Nikolaev; 1, internal valve view, ×1250, low and high focus; Sample C-8597, Horton River; 2-3, girdle view, low and high focus of the same specimen; Sample C-8621, Horton River.

4-5 *Stephanopyxis superba* (Greville) Grunow; internal valve view, ×1250; 4, high and low focus of the same specimen; Sample C-8618, Horton River; 5, high focus; Sample C-8603, Horton River.

6 *Costopyxis reticulata* (Long, Fuge et Smith) Gleser; valve view, low and high focus, ×1250; Sample C-8610, Horton River.

7-8 *Stephanopyxis arctica* (Grunow) Strelnikova et Nikolaev; girdle view, ×1250, high and low focus of the same specimen; Sample C-8600, Horton River.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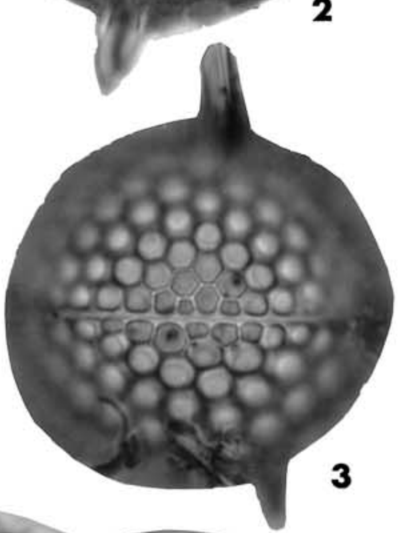
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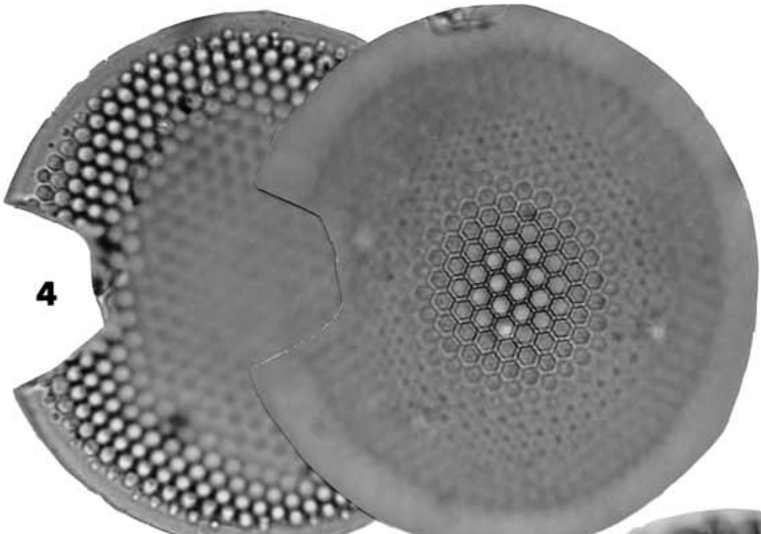
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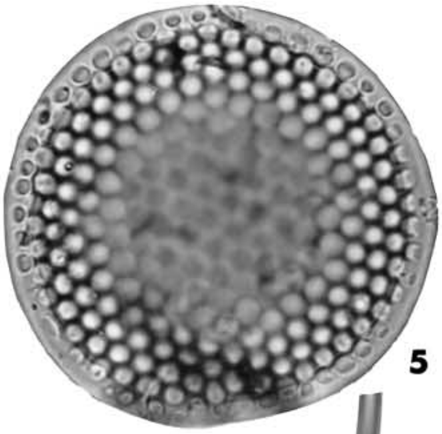
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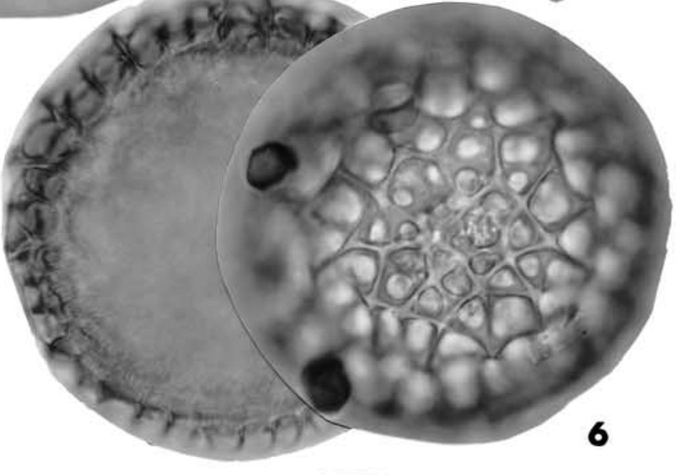
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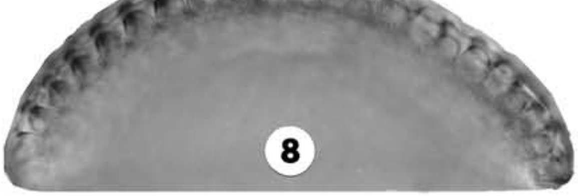
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## PLATE 7

1 *Actinoptychus tenuis* Strelnikova; valve view, high and low focus, ×1250; Sample C-8608, Horton River.

2 *Stellarima stenyi* (Hanna) Hasle et Sims; valve view, ×1250; Sample C-8612, Horton River.

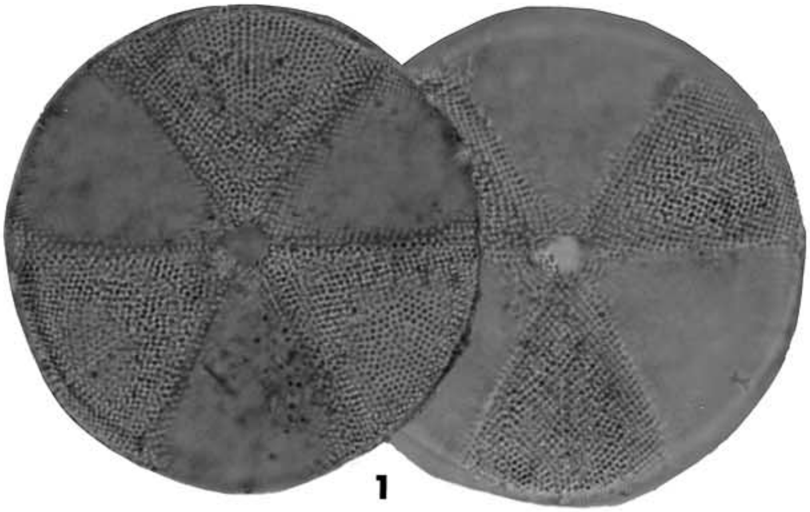
3 *Aulacodiscus septus* f. *septus* Schmidt; valve view, ×1250; Sample C-8630, Horton River.

4 *Actinoptychus tuberculatus* Strelnikova; valve view, ×1250; Sample C-8607, Horton River.

5 *Stephanopyxis grunowi* Grove et Sturt; valve view, ×1250; Sample C-8595, Horton River.

6 *Thalassiosiropsis wittiana* (Pantocsek) Hasle; valve view, ×750; Sample C-8601, Horton River.

7-8 *Hemiaulus echinulatus* Jousé; girdle view, ×1875, high and low focus of the same specimen; Sample C-8601, Horton River.



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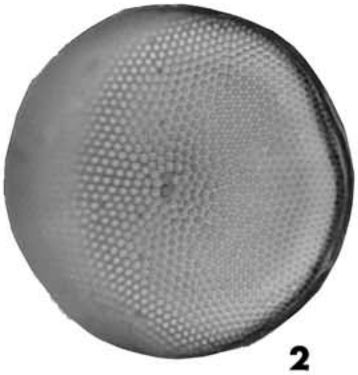

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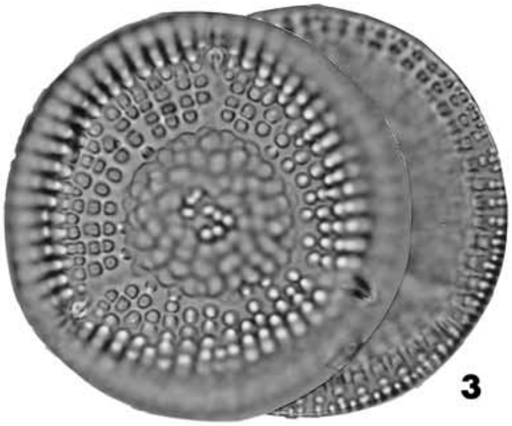

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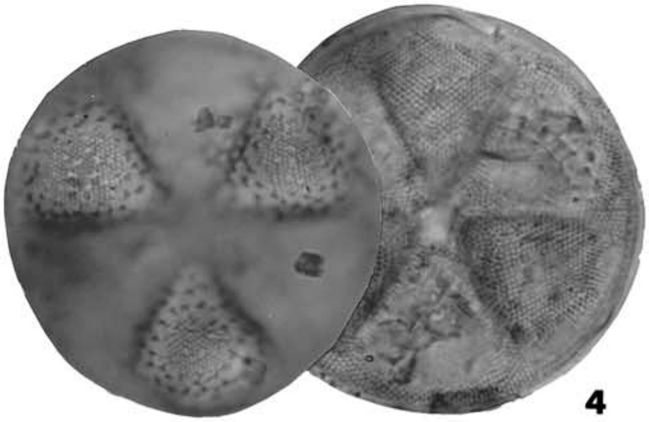

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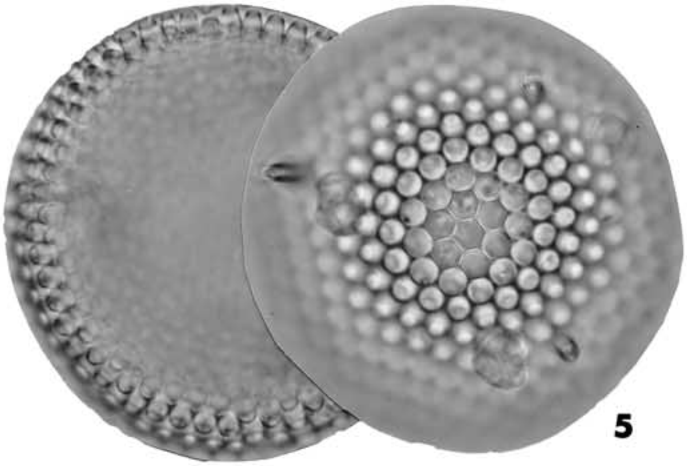

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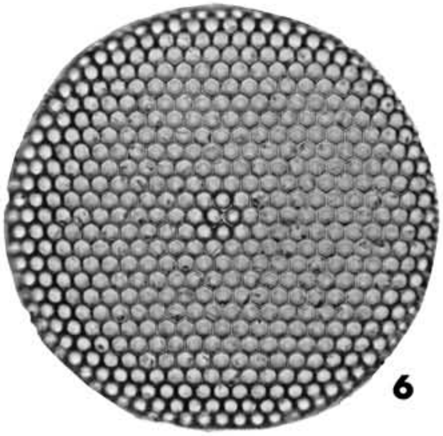

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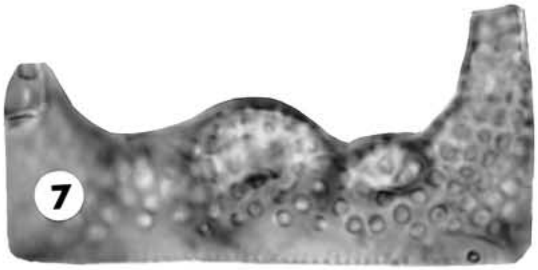

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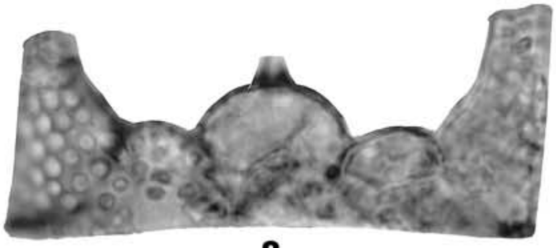

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## PLATE 8

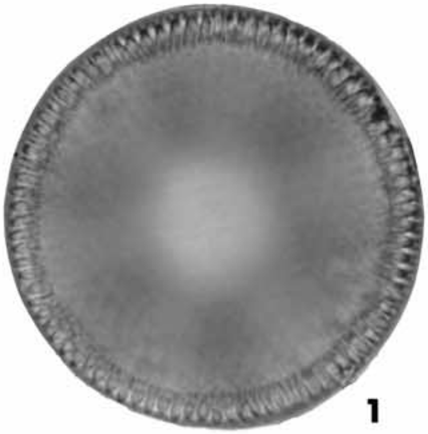
Representative diatom assemblage of the *Stephanopyxis simonseni* Zone.

1-2, 8 *Stephanopyxis simonseni* Hajós; external valve view, ×1250; 1-2, low and high focus of the same specimen; 8, internal valve view, high and low focus, ×1250; Sample C-8623, Horton River.

3-4 *Trochosiropsis polychaeta* (Strelnikova) Tapia; 3, girdle view, ×1250; Sample C-8612, Horton River; 4, valve view, ×1250; Sample C-8623, Horton River.

5-6 Unidentified resting spore #12; girdle view, ×1250, high and low focus of the same specimen; Sample C-8615, Horton River.

7, 9 *Pterotheca* sp. cf. *P. spada* Tempère et Brun; girdle view, ×750; 7, Sample C-8618, Horton River; 9, Sample C-8612, Horton River.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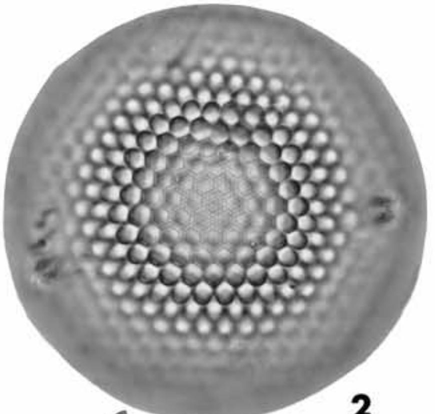
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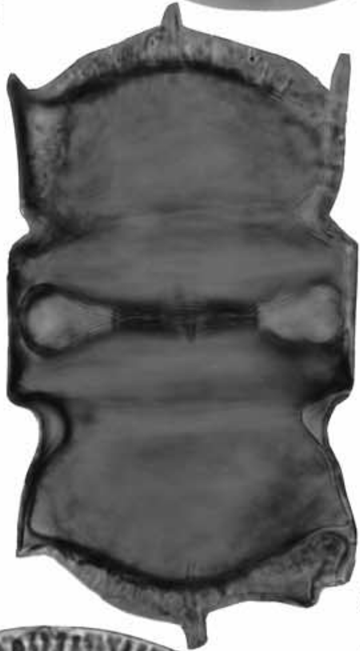
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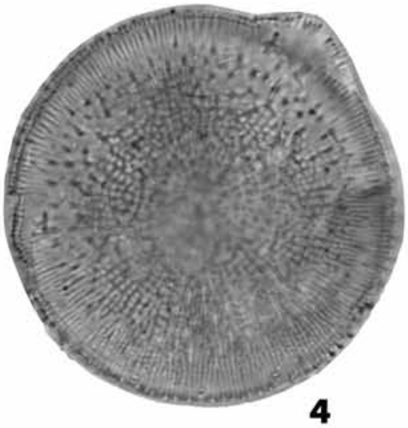
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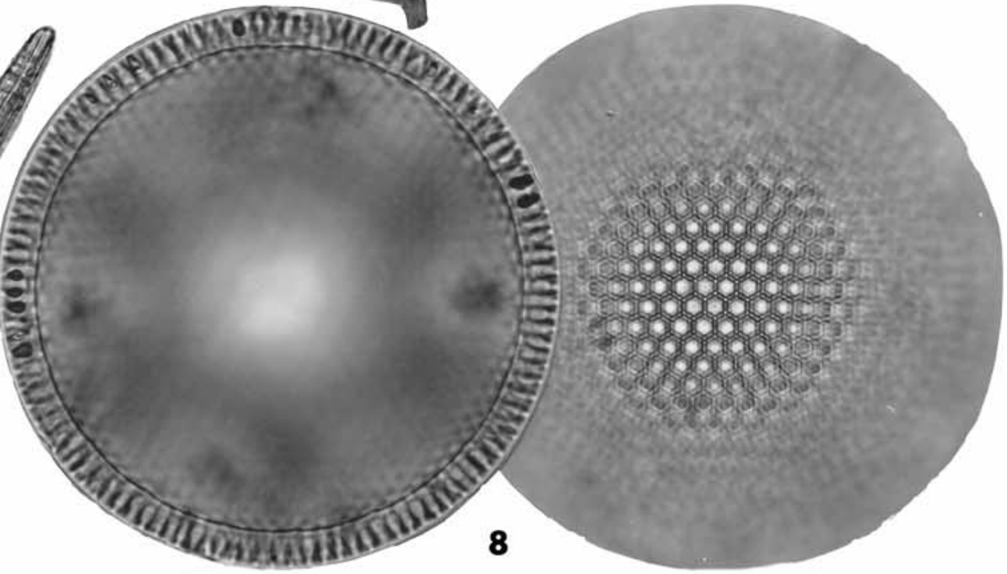
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## PLATE 9

1-2 Unidentified resting spore #3; girdle view, ×1875, low and high focus of the same specimen; Sample C-8629, Horton River.

3-4 *Stephanopyxis simonseni* Hajós; girdle view, ×1250, low and high focus of the same specimen; Sample C-8618, Horton River.

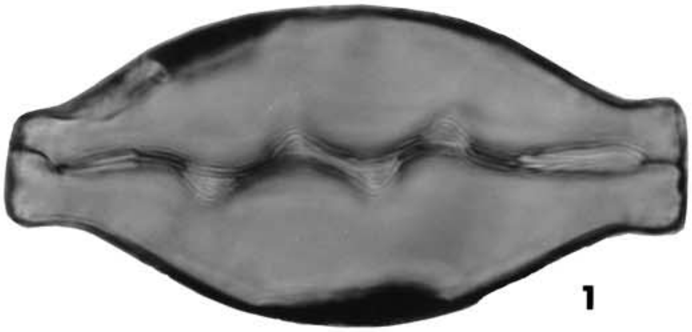
5-6 Unidentified resting #4; girdle view, ×1875, low and high focus of the same specimen; Sample C-8627, Horton River.

7-8 *Pseudopyxilla* sp. cf. *P. rossica* (Pantocsek) Forti; girdle view, ×1250, high and low focus of the same specimen; Sample C-8629, Horton River.

9-10 *Stephanopyxis turris* (Greville et Arnott) Ralfs; girdle view, ×1250; 9, low focus; 10, high focus; Sample C-8618, Horton River.

11-12 *Corinna* sp. 1; valve view, ×1875, high and low focus of the same specimen; Sample C-8621, Horton River.

13 *Paralia sulcata* (Ehrenberg) Cleve; valve view, ×1250, low and high focus; Sample C-8610, Horton River.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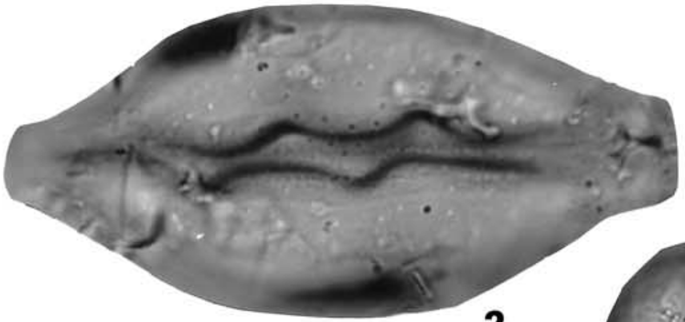
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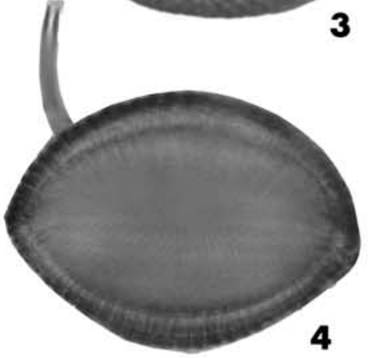
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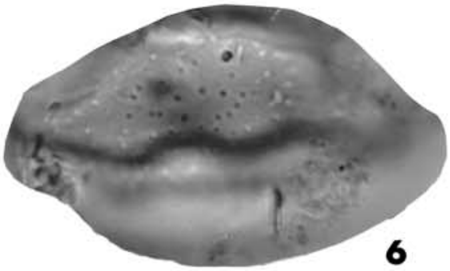
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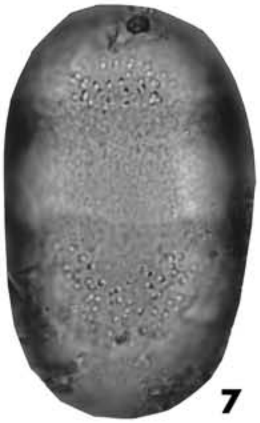
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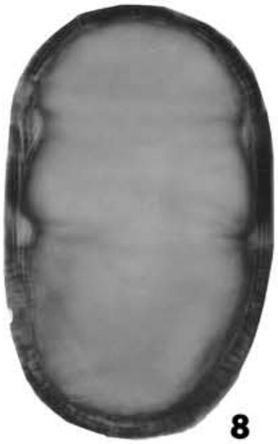
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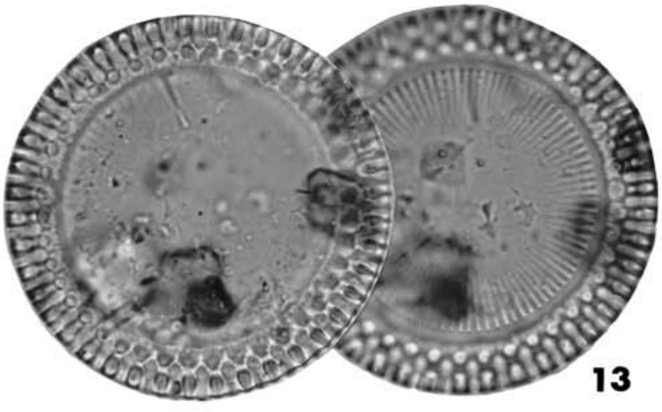
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