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Diatom flora of the Nastapoka River delta: an emerging coastal system on the eastern shore of Hudson Bay, subarctic Québec

by

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With 5 figures, 2 tables and 6 photographic plates

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Abstract: Fossil diatom compositional patterns associated with species ecology in an estuarine environment can provide important paleoecological information about past depositional environments. The evolution of a deltaic system at the mouth of the Nastapoka River has been studied using analyses of the sediment structure, grain size, macrofossils, and diatoms for distinguishing the hydraulic processes that were active at the time of sediment deposition in the top layers of the delta. In this paper, we present three distinct diatom assemblages that were identified and associated with changing sedimentation conditions: 1) an assemblage composed of marine planktonic genera (*Thalassiosira*), and epiphytic and tychoplanktonic freshwater species associated with the macroscopic plant remains found within the facies; 2) an estuarine assemblage characterized by epipelic coastal and freshwater species; and 3) an assemblage dominated by small brackish-water epipsammic taxa. A total of 6 photographic plates illustrate the most common taxa found within the different assemblage types.

Résumé: Les patrons de diatomées fossiles associés à l'écologie des espèces peuvent fournir d'importantes informations paléoécologiques sur les environnements de dépôts en milieu estuarien. L'évolution du système deltaïque à l'embouchure de la rivière Nastapoka a été étudiée en analysant les structures sédimentaires, la granulométrie, les macrofossiles et les diatomées pour distinguer les processus hydrauliques qui étaient actifs au moment du dépôt dans les couches supérieures des sédiments deltaïques. Nous présentons trois assemblages diatomifères spécifiques qui ont été identifiés et associés à des changements dans les conditions de sédimentation: 1) un assemblage composé par une espèce planctonique marine (*Thalassiosira*) et des espèces épiphytiques et tychoplanctoniques d'eau douce associées à la présence de restes de plantes macroscopiques remaniées; 2) un assemblage estuarien caractérisé par des espèces épipeliques côtières et d'eau douce; et 3) un assemblage dominé par des petites espèces épipsammiques d'eau saumâtre. De plus, six planches photographiques des taxons les plus communs trouvés à l'intérieur des différents types d'assemblages sont présentées.

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Introduction

The biostratigraphic analysis of 11 sediment cores at the mouth of the Nastapoka River located in the eastern coastal region of Hudson Bay in Nunavik territory (northern Québec, Canada) was completed to facilitate the interpretation of local fluvial and marine processes on a Holocene deltaic platform. The present data stem from a multidisciplinary study that aims at defining the Quaternary geomorphology of the area (Sarrazin 2000, Lajeunesse & Allard 2002, 2003a-b). Geophysical marine data obtained with side-scan sonar images and high-resolution chirp sonar profiles were used to describe the morphology of the sea floor and the acoustic stratigraphy of Holocene marine sediments, respectively, with paleoecological and grain size analyses of deltaic sediments within a subarctic coastal area (Lavoie et al. 2002).

After the Holocene deglaciation and marine inundation of the land, the east coast of Hudson Bay was affected by a falling relative sea-level (RSL) and shoreline emergence as a result of ongoing postglacial isostatic uplift. The eastern Hudson Bay lowlands were initially uplifted very rapidly, at a rate of ca. 9 m per century (Andrews & Falconer 1969, Hillaire-Marcel 1976, Hillaire-Marcel & Occhietti 1980, Allard and Séguin 1985, Lajeunesse & Allard 2003a), immediately following deglaciation, whereas this rate slowed to approximately 1.6 to 1.0 m per century after 6000 years (Hillaire-Marcel 1976, Allard & Tremblay 1983, Vincent et al. 1987, Lajeunesse & Allard 2003a). The coastal environment of the region was continuously modified by the offshore migration of the shoreline, resulting in raised beaches, headward incision of valleys, and progression of deltas.

The present paper focuses on the fossil diatom (Bacillariophyceae) flora recovered in the recent subaquatic Nastapoka river delta sediments. To date, studies of fossil diatoms completed on the east coast of Hudson Bay were mostly limited to lacustrine environments where specific diatom assemblages were used to determine those environmental variables which exerted the greatest influence on diatom community composition (Fallu & Pienitz 1999). Diatoms were used to study the isolation of coastal Lac Kachishayoot from the marine environment near Kuujjuarapik-Whapmagoostui (Saulnier-Talbot & Pienitz 2001), to reconstruct past levels of dissolved organic carbon (DOC) and water colour (Saulnier-Talbot et al. 2003), and to evaluate the impacts of past climate and vegetation changes in the catchment of Lac Karinbou north of Umiujaq (Ponader et al. 2002). In offshore environments, Poulin & Cardinal (1982a-b, 1983) and Poulin et al. (1983) described the sea ice diatom community identified from Manitounuk Sound; Anderson et al. (1981) determined diatom species composition, abundances, and distributions from 130 water samples covering the entire area of Hudson Bay during the open water season; and Simard et al. (1996) and Harvey et al. (1997) analyzed the first 100 meters of the water column from early September 1993 sampled in the eastern sector of Hudson Bay and in Hudson Strait. The literature shows that the sediments generally yield high-resolution paleoenvironmental records and that diatoms are excellent indicators of the retreat of postglacial seas and environmental changes. They are abundant and well preserved in the sediments, respond rapidly to environmental changes, and many different species characterize specific environments and habitats. However, no study derived from contemporary and fossil limnological investigations has been completed so far on coastal and estuarine sediments in northern Québec.

The objectives of this paper are to present 3 different depositional environments and their respective diatom assemblages that serve as sensitive indicators of changes based on their apparent preferences for salinity and habitat. Studies of modern diatoms in comparable dynamic coastal contents by Vos & de Wolf (1988, 1993) in the Netherlands, Juggins (1992) in the Thames Estuary of England, Nelson & Kashima (1993) in southern Oregon tidal marshes, and Campeau et al. (1999) from the Arctic Beaufort Sea provided analogues. To facilitate taxonomic comparisons, we have included photographic plates showing the 85 most common diatom taxa found in the sediments.

Study site

The study area is located approximately 260 km north of the Great Whale River estuary (Kuujjuarapik-Whapmagoostui; Fig. 1) in a region that has experienced only little human impacts. The mouth of the Nastapoka River is situated on the boundary between Archean metamorphic rocks of the Canadian Shield and Late Proterozoic metasedimentary rocks of the Nastapoka Islands located 2 km offshore (Stevenson 1968, Avramtchev 1982). The region is within the shrub tundra ecological zone (Payette 1975) and also lies in the widespread permafrost zone (Allard & Séguin 1987).

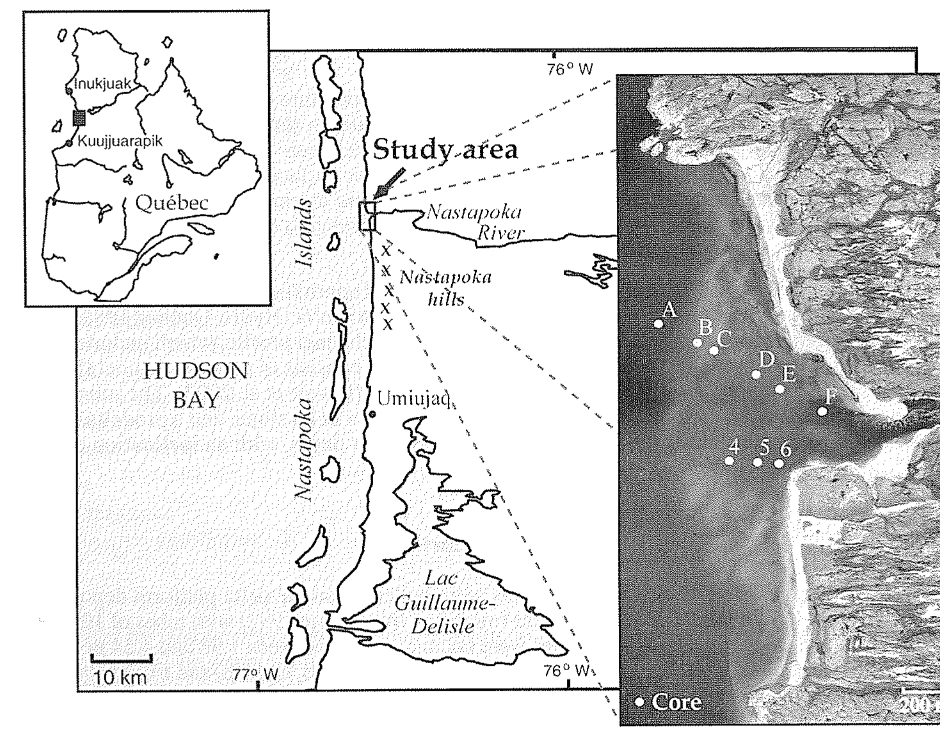


Fig. 1. Location map of the Nastapoka River delta on the eastern coast of Hudson Bay (airphoto by Hydro-Québec 1990) and location of percussion cores 98 A-F and 98 4-6.

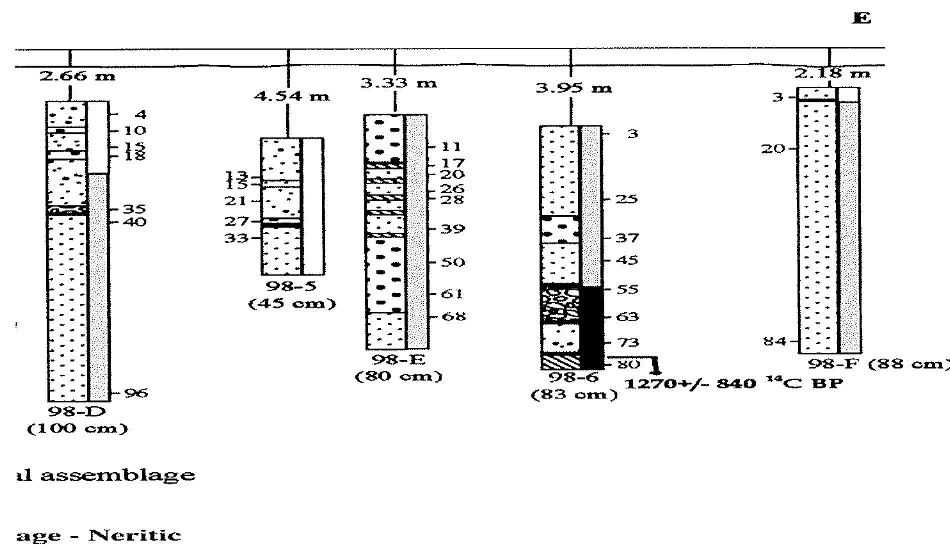


Fig. 2. Cores from the delta platform of the Nastapoka River showing core length, levels where the sediment samples were taken, grain-size results, and paleoenvironmental influence (Water column depths are measured from the surface of the ice). For location see Fig. 1.

The regional climate is characterized by a mean annual air temperature of -5.7°C (Environnement Canada 1993). The mouth of the Nastapoka River has open water in summer and a continuous ice cover in winter. On 18-25 April 1998 ice thickness varied between 1.35 and 2.06 m over the submarine delta platform. During the ice-free season, the deltaic surface is influenced by seasonal freshwater floods that cause salinity decreases and by oceanic storms that are responsible for brackish water intrusions into the mouth of the river. The tidal range is estimated at < 1 m (Lavoie et al. 2002).

The Nastapoka River is 187 km long and drains a catchment of approximately 13,360 km^2 (Hydro-Québec 1993). The mean monthly discharge of the river is 268 m^3/s (Hydro-Québec 1982). The bedrock topography controls the river floor morphology and channel profile, which includes sills characterized by rapids and waterfalls. The estuarine segment consists of a single channel floored by coarse sand and some gravel with a subaqueous sandy levee (Lavoie et al. 2002). The submarine environment of the delta consists of a shallow water platform, a delta slope, and a prodelta basin. The 800 m wide platform extends to approximately 6 m water depth, with an inclination of less than 1°.

Materials and methods

Coring: Eleven cores along 2 east-west transects were collected on the delta platform deposits in April 1998 (Fig. 1). We used a percussion corer (modified from Nesje 1992) with tubes of 10 cm in diameter and 1 m in length. The core samples were taken at depths between 1.98 and 4.54 m below the winter ice surface (Fig. 2). The cores of the northern transect (A, B, C, D, E, and F) and southern transect numbered cores 4, 5, and 6 were split in half and visually distinct stratigraphic units were identified and sampled with a spatula. Within a total of 54 subsamples, grain-size, macrofossils and fossil diatoms were analyzed. Two organic-rich subsamples from the core bases 98-B and 98-6 (Table 1) were dated by the ^{14}C Accelerator Mass Spectrometry (AMS) method at Isotrace Laboratories of the University of Toronto (Table 2). Dates are presented in conventional or normalized ^{14}C

Table 1. Macrofossil list from Jacques-Rousseau Laboratory at the University of Montréal. A: Ephippium, B: Fragment of cone female bract, C: Leaf, D: Leaf fragmented, E: Gemma, F: Seed, G: Megaspore, H: Oospore, I: Sclerotia, J: Statoblast, and K: Stem with leaves.

Samples	98-6	98-B	
Type	**Quantity**		**Habitats**
Tree/Shrubs			
Picea mariana- D	1	1	Boreal
Salix - dwarf - branch	1	1	Tundra
Betula glandulosa - B		1	Boreal, lakes, and streams
Herb			
Carex (2 sides) - F		1	Wet environment
Vascular aquatic plants			
Isoetes echinospora - G	1	2	Shallow water (0-2 m)
Najas flexilis - F		1	Shallow water (0-2 m)
Charophyte aquatic			
Nitella - H	2		Shallow water (0-2 m)
Mosses			
Hygrohypnum molle - K	6	1	Wet rocks near streams
Pleurozium schreberi - K	2	2	Humus, grounds, and rocks
Drepanocladus uncinatus - K	2	4	Rocks, rotten wood, humus, and tree-base
Ptilium crista-castrensis - K	2		Humus and old trunks
Aulacomnium turgidum - K	1	1	Wet rocky environments, very widespread
Drepanocladus aduncus - K	1	3	Wet calcareous grounds
Pogonatum alpinum - K	1		Rocks, grounds, and humus
Calliergon sarmentosum - K	1		Rocks in mountain tundra
Barbula unguiculata - C	1		Calcareous grounds and rocks
Drepanocladus vernicosus - C		1	Wet environment, marsh, and calcareous fens
Type *Mylia anomala* - K		1	Peats
Bryum pseudotriquetrum - C		1	Wet grounds
Tortula norvegica - C		1	Grounds and rocks, often calcareous
Sphagnum sp. - C		200	Peats
Aquatic others			
Eunapius fragilis - E	1	5	In pondside waters
Ephydatia fluviatilis - E	6		In pondside waters
Cristatella mucedo - J	16	18	In pondside waters
Daphnia sp. - A		1	In lake waters
Ostracode - valve		3	In lake waters
Others			
Wood fragment	1		Wood remains
Cenococcum graniforme - I	3	3	Ground supporting trees/shrubs

(corrected for isotope fractionation by normalizing to -25‰) and calibrated (cal years BP) by using the Calib 5.0.1 program (Stuiver & Reimer 1993, Stuiver et al. 2005) with calibration data set IntCal04 (Reimer et al. 2004).

Sample preparation and diatom counts: The same 54 subsamples used for grain size studies were also analyzed for diatoms. The sediments were prepared according to standard procedures (Veres et al. 1995). First, they were treated with hydrogen peroxide (H_2O_2, 25-35%) to digest the organic material, rinsed three times, evaporated onto coverslips, and mounted onto microscope slides in

Table 2. Conventional and calibrated AMS ages (98.3% - 1σ confidence limits).

Lab No.	Depth (cm)	Material dated	Age (yr ^{14}C BP)	Age (yr cal BP)
TO-8339	79 cm	*Sphagnum* leaves	1100 ± 100	928 (1012) 1096
TO-8340	82 cm	*Sphagnum* leaves	1270 ± 840	504 (1287) 2069

Naphrax® resin. A minimum of 300 valves on each slide were identified to the lowest possible taxonomic level and counted along random transects with a Leica DMRB microscope (1000× oil immersion objective). Taxonomic determinations were made with reference to floras described by Germain (1981), Poulin et al. (1984a-b-c, 1987, 1990), Cardinal et al. (1984, 1986), Bérard-Therriault et al. (1986, 1987), Krammer & Lange-Bertalot (1986, 1988, 1991a-b), Lange-Bertalot & Krammer (1989), Simonsen (1992), Lange-Bertalot (1993), Snoeijs (1993), Snoeijs & Vilbaste (1994), Witkowski (1994), Cumming et al. (1995), Snoeijs & Potapova (1995), Lange-Bertalot & Metzeltin (1996), Snoeijs & Kasperovičiene (1996), Cremer (1998), Reavie & Smol (1998), Snoeijs & Balashova (1998), Campeau et al. (1999), Witkowski et al. (2000), and Pienitz et al. (2003). A total of 325 diatom taxa representing 41 genera were identified.

The ecology of the modern diatom species, including their life-form and salinity preference, was used to qualitatively infer nearshore environments at the time of deposition. The salinity classes of diatoms are largely based on the system of Hustedt as presented in Campeau et al. (1999) and defined as polyhalobian (marine - about 30-35‰), mesohalobian (brackish-water - about 0.5-30.0‰), oligohalobian-indifferent (freshwater with salinity about 0.5-5.0‰), and halophobian (freshwater 0‰) species. The life-form is defined by planktonic, benthic, epiphytic (attached to plants), epilithic (attached to rocks), epipelic (unattached forms on silty sediment), and epipsammic (forms attached to sand grains) species. We tried to distinguish between allochthonous (transported from elsewhere by water or wind before burial) and autochthonous (accumulated *in situ*) species that more accurately reflect environmental conditions at the time of sediment deposition. They are distinguished on the basis of a number of diatom and non-diatom criteria proposed by Vos & de Wolf (1988). The results of classifications according to salinity preference, habitats, and common species were expressed as a percentage of the total diatom valves counted (Figs 3, 4 and 5). Six photographic plates illustrate the most common taxa found within the different assemblage types.

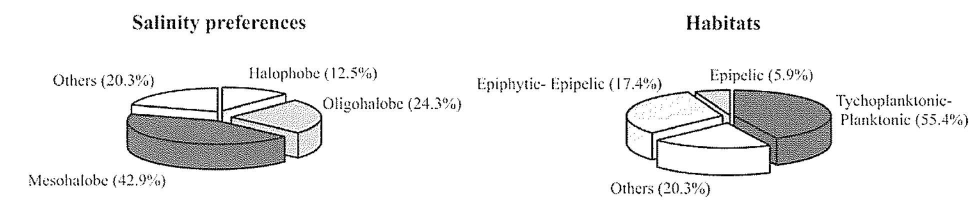
Results

At the mouth of the Nastapoka River, the geometry of the deltaic platform, tidal currents, and fluvial inputs have governed the accumulation of sediments under a significant progressive fall of RSL during the Holocene period. The sediment structures, grain size, macrofossils, and diatom analyses form the basis for distinguishing the processes that were active at the time of the sediment deposition.

In fact, common observed diatoms defined by their salinity preference and life-form have been taken into consideration to determine the 3 distinct assemblages presented below. No signs of physical and biotic perturbation were visible in the sediments. The results of the diatom analysis have been synthesized in the form of percentage diagrams for the salinity and life-form groups, as well as percentage diagrams of the dominant species.

Mixed marine-terrestrial assemblage

This assemblage was found in the basal parts of cores 98-6 and 98-B (Fig. 2) which were characterized by black, poorly sorted coarse silt containing transported



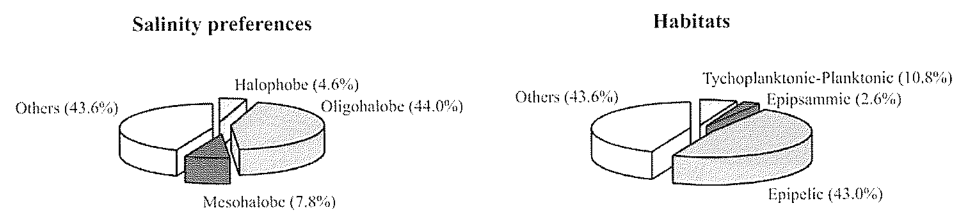
Common species

Thalassiosira sp.1	41.3%
Tabellaria flocculosa	12.5%
Achnanthidium minutissimum	5.9%
Eunotia pectinalis	5.6%
Encyonema cf. *silesiacum*	3.3%
Eunotia implicata	2.6%
Fragilariforma virescens var. *exigua*	2.6%

Fig. 3. Example of salinity preference, habitats, and common species from the mixed marine-terrestrial assemblage in core 98-B (at 79 cm).

macroscopic plant remains. At the base of the core 98-6, the diatom assemblage was characterized by the high occurrence of the marine-littoral planktonic species *Thalassiosira* sp.1 (Pl. 1, Figs 24-25) which accounted for up to 50% of the total number of diatoms. Other important taxa were some epiphytic mesohalobian species, such as *Achnanthidium minutissimum* (Kützing) Czarnecki (Pl. 1, Figs 1-4), as well as the tychoplanktonic freshwater species *Fragilariforma virescens* var. *exigua* (Grunow) Poulin (Pl. 1, Figs 19-20) and *Tabellaria flocculosa* (Roth) Kützing (Pl. 1, Fig. 23). *Chaetoceros* resting spores (Pl. 1, Figs 7-9) and marine remains were also found and the remaining species included individual abundances of less than 1.5%, accounting for 25-30% (Others group). Diatom preservation was very good except for elongate *Tabellaria flocculosa* frustules that had a high percentages of broken valves. The macrofossil assemblage in 30 g of material consisted of moss leaves, twigs of *Hygrohypnum molle* (Hedwig) Loeske, *Pleurozium schreberi* (Bridel) Mitten, and *Drepanocladus uncinatus* (Hedwig) Warnstorf from a forest or shrub environment, as well as other plant species from peatlands and ponds (Table 1). This plant material yielded an AMS ^{14}C date of 1287 cal. BP (TO-8340) (Table 2).

Diatoms in core 98-B sediments were also dominated by a large number of *Thalassiosira* sp.1 species making about 41% of the total (Fig. 3). We counted more abundant epiphytic freshwater species, such as *Eunotia pectinalis* (O.Müller) Rabenhorst (Pl. 1, Fig. 18), *E. implicata* Nörpel, Lange-Bertalot & Alles (Pl. 1, Fig. 17), and *Encyonema* cf. *silesiacum* (Bleisch) D.G.Mann (Pl. 1, Figs 15-16), with some coastal epipelic taxa. *Tabellaria flocculosa* was more abundant (12.5%) while the Others category accounted for ca. 20%. The macrofossils in 15 g of material were similar to those found at the base of core 98-6, but were relatively rich in *Sphagnum* moss leaves from peat bogs and wetlands (Table 1). This material yielded an AMS ^{14}C date of 1012 cal. BP (TO-8339) (Table 2).



Common Species

Achnanthidium minutissimum	8.9%
Psammothidium levanderi	6.9%
Psammothidium subatomoides	6.6%
Psammothidium chlidanos	5.2%
Achnanthes pusilla	5.2%
Cavinula pseudoscutiformis	5.2%
Tabellaria flocculosa	4.6%

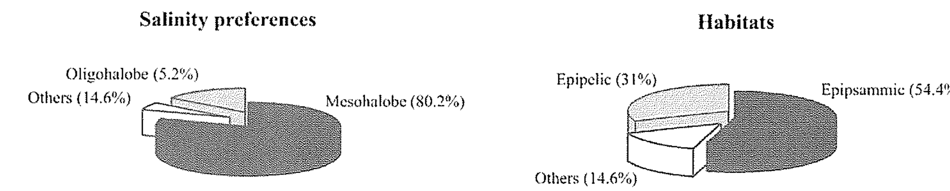
Fig. 4. Example of salinity preference, habitats, and common species from the estuarine assemblage in core 98-E (at 49 cm).

Estuarine assemblage

This estuarine diatom assemblage was found at the top of core 98-4, between 0-54 cm depth in 98-6, 23-100 cm in 98-D, 5-88 cm in 98-F, and throughout the 98-E sediment sequence (Fig. 2). In general, the sediments consisted of poorly to well-sorted sand and gravel. Pennate (elongate) benthic diatoms were dominant and well preserved in these subsamples characterized by the high abundance of epipelic coastal and freshwater-brackish taxa, such as *Achnanthidium minutissimum* which was slightly more abundant than in the mixed marine-terrestrial assemblage, *Psammothidium levanderi* (Hustedt) Siver & Hamilton (Pl. 4, Figs 12-14), *P. subatomoides* (Hustedt) Bukhtiyarova & Round (Pl. 4, Figs 15-16), *P. chlidanos* (Hohn & Hellermann) Lange-Bertalot (Pl. 4, Figs 9-11) and *Cavinula pseudoscutiformis* (Hustedt) D.G.Mann & Stickle (Pl. 2, Figs 20-21) with some tychoplanktonic-planktonic and epipsammic species (Fig. 4). The relative abundance of diatoms in the Others group generally fluctuated between 30.6-59.1% of the assemblage.

Shallow marine assemblage - Neritic

This marine assemblage was found between 0-75 cm depth in core 98-B, 6-56 cm in 98-4, 0-23 cm in 98-D, at the top of the core 98-F, and throughout cores 98-A, -C, and -5. The sediments were characterized by well-sorted stratified sand and gravel deposits. The diatom flora was dominated by small brackish-water epipsammic species attached to or living within the sediments, such as *Navicula perminuta* Grunow (Pl. 5, Figs 18-20), *Planothidium hauckianum* (Grunow) Round & Bukhtiyarova (Pl. 6, Figs 14-15), *P. delicatulum* (Kützing) Round & Bukhtiyarova complex (Pl. 6, Figs 4-9), *Achnanthes* sp.1 (Pl. 5, Figs 3-5) and *A. lemmermannii* Hustedt (Pl. 5, Figs 1-2) (Fig. 5). The relative abundance of Others was lower with ca. 20% of the diatom assemblage.



Common species

Navicula perminuta	19.5%
Achnanthes lemmermannii	18.6%
Planothidium hauckianum	12.4%
Planothidium delicatulum complex	10.4%
Planothidium delicatulum	5.5%
Achnanthes sp.1	4.6%
Navicula cf. *phyllepta*	3.3%

Fig. 5. Example of salinity preference, habitats, and common species from the shallow marine assemblage in core 98-D (at 23 cm).

Discussion

The study of fossil diatom assemblages at the mouth of the Nastapoka River provides an insight into the variability of the hydrodynamic conditions that have prevailed during the formation of the delta and the related sedimentary processes. Marine and estuarine intertidal diatom populations exhibit patterns that relate to local differences in habitat types (Whiting & McIntire 1985). The first assemblage (mixed marine-terrestrial) was found only in silty organic-rich deposits at the base of two cores. The predominant *Thalassiosira*, typically found in relatively deep and low energy marine offshore environments, is interpreted as an allochthonous diatom. Epiphytic and tychoplanktonic freshwater diatom taxa directly associated with organic matter from peatlands located within the River drainage basin (Lavoie et al. 2002) are common interpreted as an allochthonous component. According to Vos & de Wolf (1988), in tidal environments influenced by fluvial input, allochthonous species are high and mainly defined by marine planktonic and tychoplanktonic taxa. The fossil diatom compositional pattern probably reflects strong currents at the time of deposition which have transported allochthonous species. Moreover, based on Vos & de Wolf (1993), a dominance of transported planktonic and tychoplanktonic diatoms is often found, but not exclusively, in sediments of tidal channels and inlets. In this kind of environment, the conditions are unfavorable for the development of an autochthonous diatom population. Lavoie et al. (2002) suggest that the sediments were probably deposited in water depths less than 10 m.

The brackish taxa and salt-tolerant freshwater species in the second group associated with the estuarine assemblage reflected a period when the inner platform was an energetic environment with influence by freshwater. In this assemblage, the percentage of *Tabellaria flocculosa* decreased as compared to the first assemblage, whereas the percentage of *Achnanthidium minutissimum* increased. At this time, the delta platform was influenced by both freshwater inflow from the Nastapoka River and salt water from Hudson Bay. The sediments were thus deposited in an estuarine environment.

The third, wave-influenced, neritic diatom assemblage indicated that the outer platform was a high-energy environment dominated by wave action. Previous studies have shown that *Navicula perminuta, Achnanthes lemmermannii, Planothidium hauckianum,* and *P. delicatulum* have an affinity for sandy sediments in shallow marine and brackish estuarine environments with no significant inputs from freshwater sources (Sundbäck 1983, Whiting & McIntire 1985, de Jonge 1985, Vos & de Wolf 1988, 1993, Juggins 1992, Zong & Horton 1998, Campeau et al. 1999). Because of the highly energetic conditions in this environment where frequent resuspension of the diatoms from the sediments occurs, the allochthonous species component in this assemblage was small (Vos & de Wolf 1993). These small brackish-water epipsammic species can be considered as autochthonous diatom component in the third assemblage.

Based on Juggins' (1992) study, factors such as habitat type, environmental gradients, erosion, transport, and deposition influence the composition of estuarine surface sediment diatom assemblages. Hydrodynamic conditions, sedimentation patterns, and morphology changed during the evolution of the deltaic platform. In fact, sediments of cores 98-A, -C, and -5 were likely always influenced by a high-energy environment dominated by wave action. Sediments of core 98-B became wave

Legends to plate 1-3

Plate 1. Diatom taxa (1500×) from the mixed marine-terrestrial assemblage. 1-4 *Achnanthidium minutissimum*. 4-6 *Brachysira brebissonii* R.Ross. 7-8 *Chaetoceros furcellatus* (resting spore) Bailey. 9 *Chaetoceros* sp.1 (resting spore). 10-11 *Cocconeis hoffmannii* Simonsen. 12 *Cocconeis scutellum* Ehrenberg. 13-14 *Cymbella microcephala* Grunow. 15-16 *Encyonema* cf. *silesiacum*. 17 *Eunotia implicata*. 18 *Eunotia pectinalis*. 19-20 *Fragilariforma virescens* var. *exigua* Grunow. 21-22 *Gomphonema parvulum* (Kützing) Kützing. 23 *Tabellaria flocculosa*. 24-25 *Thalassiosira* sp.1. 26 *Thalassiosira* sp.2.

Plate 2. Diatom taxa (1500×) from the estuarine assemblage. 1 *Achnanthes depressa* (Cleve) Hustedt. 2-3 *Achnanthes lanceolata* ssp. *robusta* (Hustedt) Lange-Bertalot. 4-5 *Achnanthes oestrupii* (Cleve-Euler) Hustedt. 6-7 *Achnanthes pusilla* Grunow. 8-9 *Achnanthes suchlandtii* Hustedt. 10-11 *Achnanthes* sp.2. 12 *Achnanthes* sp.3. 13 *Amphora coffeaeformis* (C.Agardh) Kützing. 14 *Aulacoseira distans* var. *tenella* (Nygaard) Florin. 15 *Aulacoseira perglabra* (Østrup) E.Y.Haworth. 16-17 *Brachysira intermedia* (Østrup) Lange-Bertalot. 18-19 *Brachysira neoexilis* Lange-Bertalot. 20-21 *Cavinula pseudoscutiformis*. 22 *Cocconeis costata* W.Gregory. 23-24 *Craticula* sp.1. 25-26 *Cyclotella bodanica* var. *lemanica* (O.Müller ex Schröter) H.Bachmann. 27-28 *Cyclotella ocellata* Pantocsek. 29-30 *Cyclotella stelligera* (Cleve & Grunow in Cleve) Van Heurck.

Plate 3. Diatom taxa (1500×) from the estuarine assemblage. 1-2 *Cyclotella tripartita* Håkansson. 3-4 *Cyclotella* cf. *tripartita*. 5 *Cymbella cistula* (Hemprich) Kirchner. 6 *Cymbella descripta* (Hustedt) Krammer & Lange-Bertalot. 7-8 *Cymbella gaeumannii* Meister. 9 *Cymbella gracilis* (Ehrenberg) Kützing. 10 *Cymbella naviculacea* Grunow. 11 *Diploneis* cf. *coffaeiformis* (Schmidt) Cleve. 12 *Diploneis* cf. *parma* Cleve. 13-14 *Eunotia incisa* W.Gregory. 15-16 *Fallacia solutepunctata* (Hustedt) D.G.Mann. 17 *Fragilaria capucina* Desmazières. 18-19 *Fragilaria* cf. *parasitica* (W.Smith) Grunow. 20 *Fragilariopsis cylindrus* (Grunow) Krieger. 21 *Frustulia rhomboides* var. *saxonica* (Rabenhorst) De Toni. 22-23 *Karayevia laterostrata* (Hustedt) Round & Bukhtiyarova.

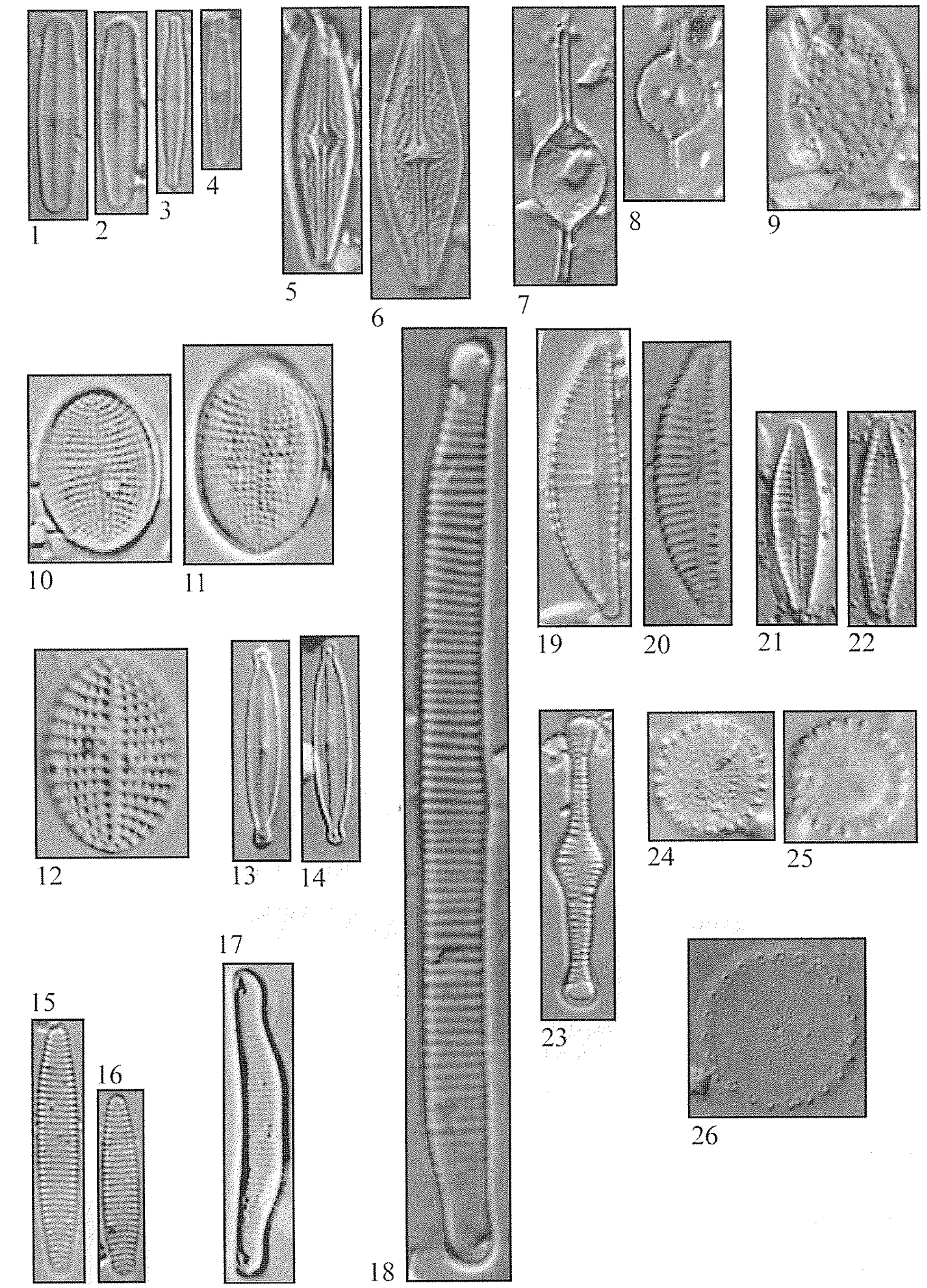


Plate 1

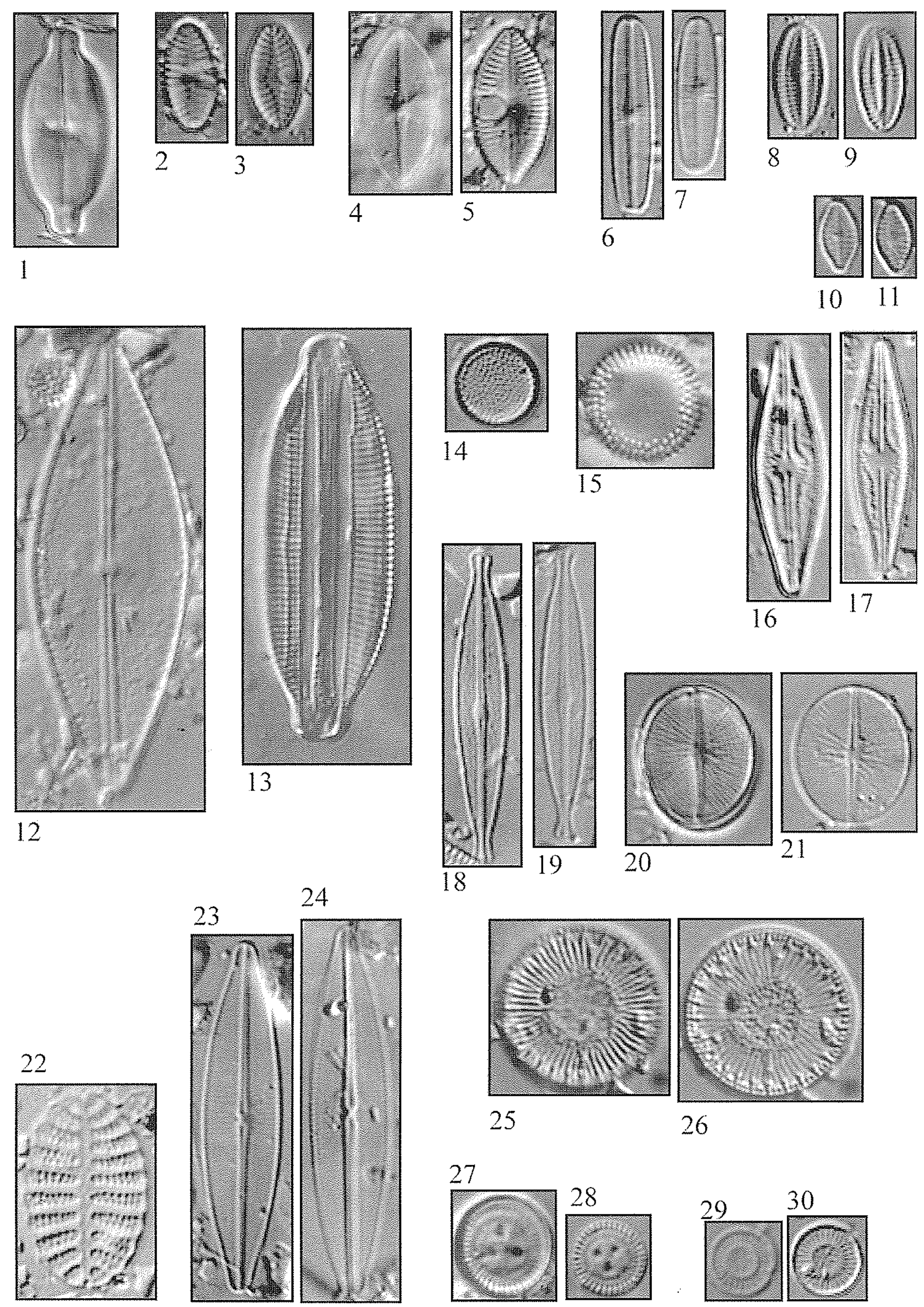


Plate 2

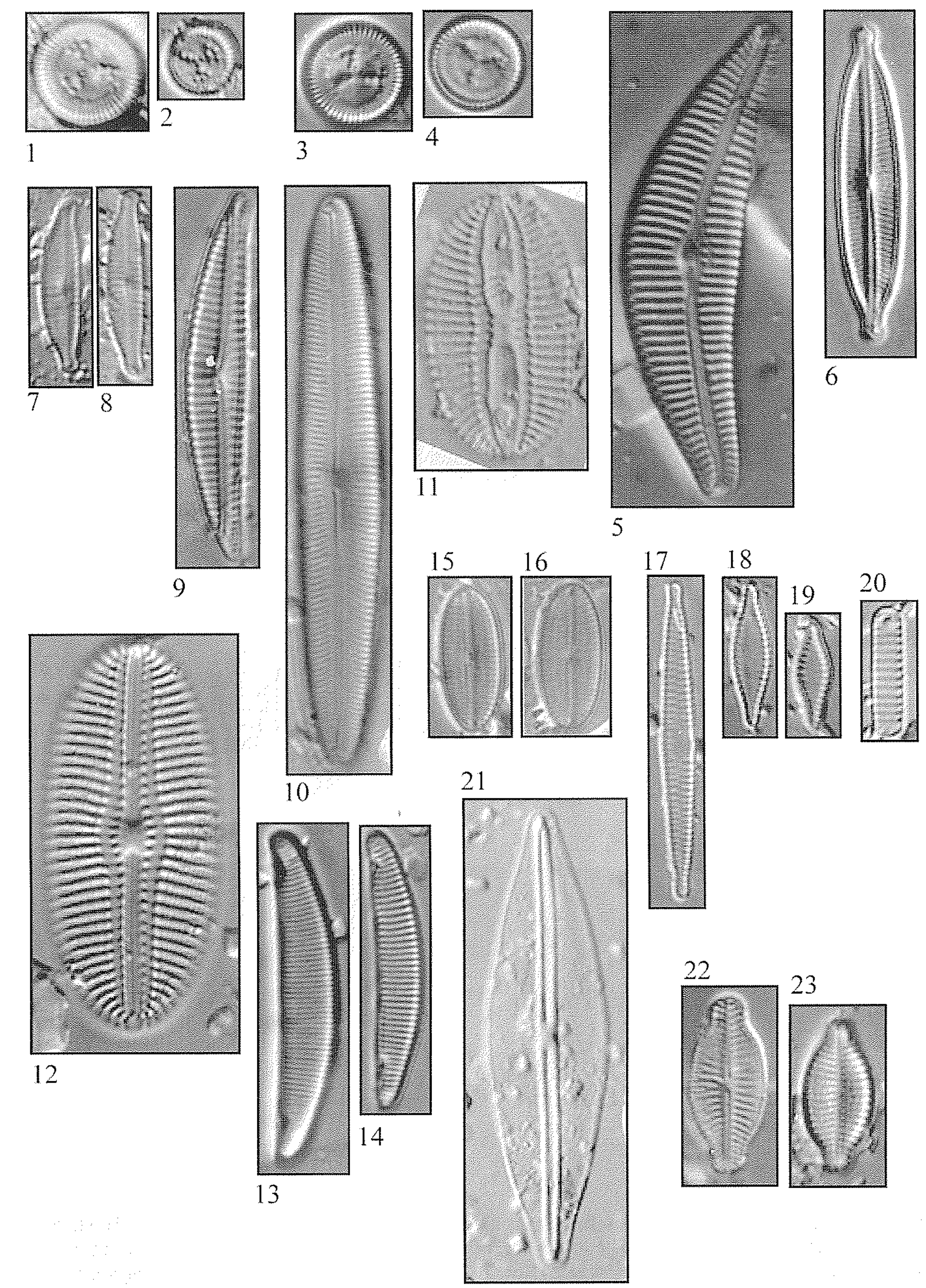


Plate 3

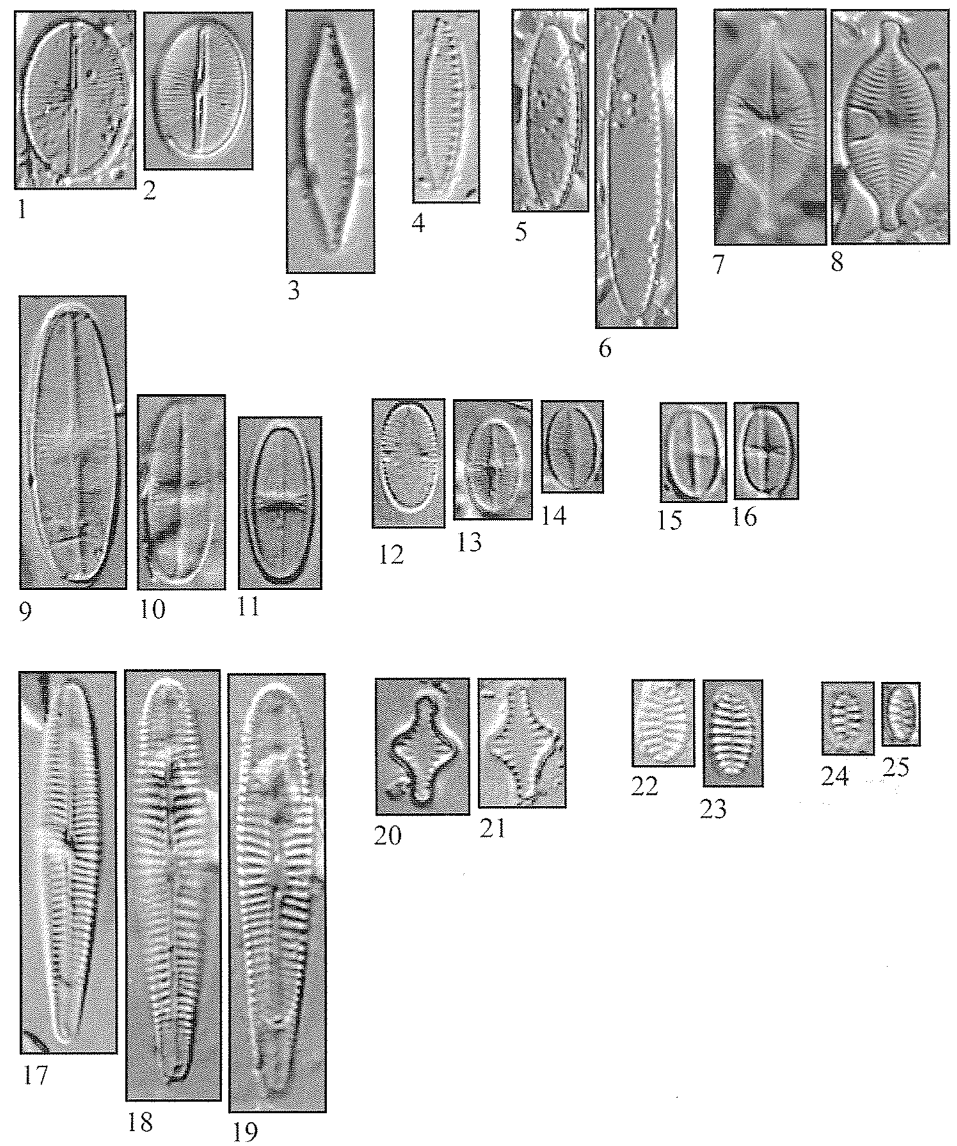


Plate 4. Diatom taxa (1500×) from the estuarine assemblage. 1-2 *Navicula jaernefeltii* Hustedt. 3 *Nitzschia bryophila* (Hustedt) Hustedt. 4 *Nitzschia liebetruthii* Rabenhorst. 5-6 *Nitzschia* sp.1. 7-8 *Planothidium peragalli* (Brun & Héribaud) Round & Bukhtiyarova. 9-11 *Psammothidium chlidanos*. 12-14 *Psammothidium levanderi*. 15-16 *Psammothidium subatomoides*. 17-19 *Rhoicosphenia curvata* (Kützing) Grunow. 20-21 *Staurosira construens* (Ehrenberg) D.M.Williams & Round. 22-23 *Staurosira construens* var. *venter* (Ehrenberg) Hamilton. 24-25 *Staurosira construens* var. *venter* complex.

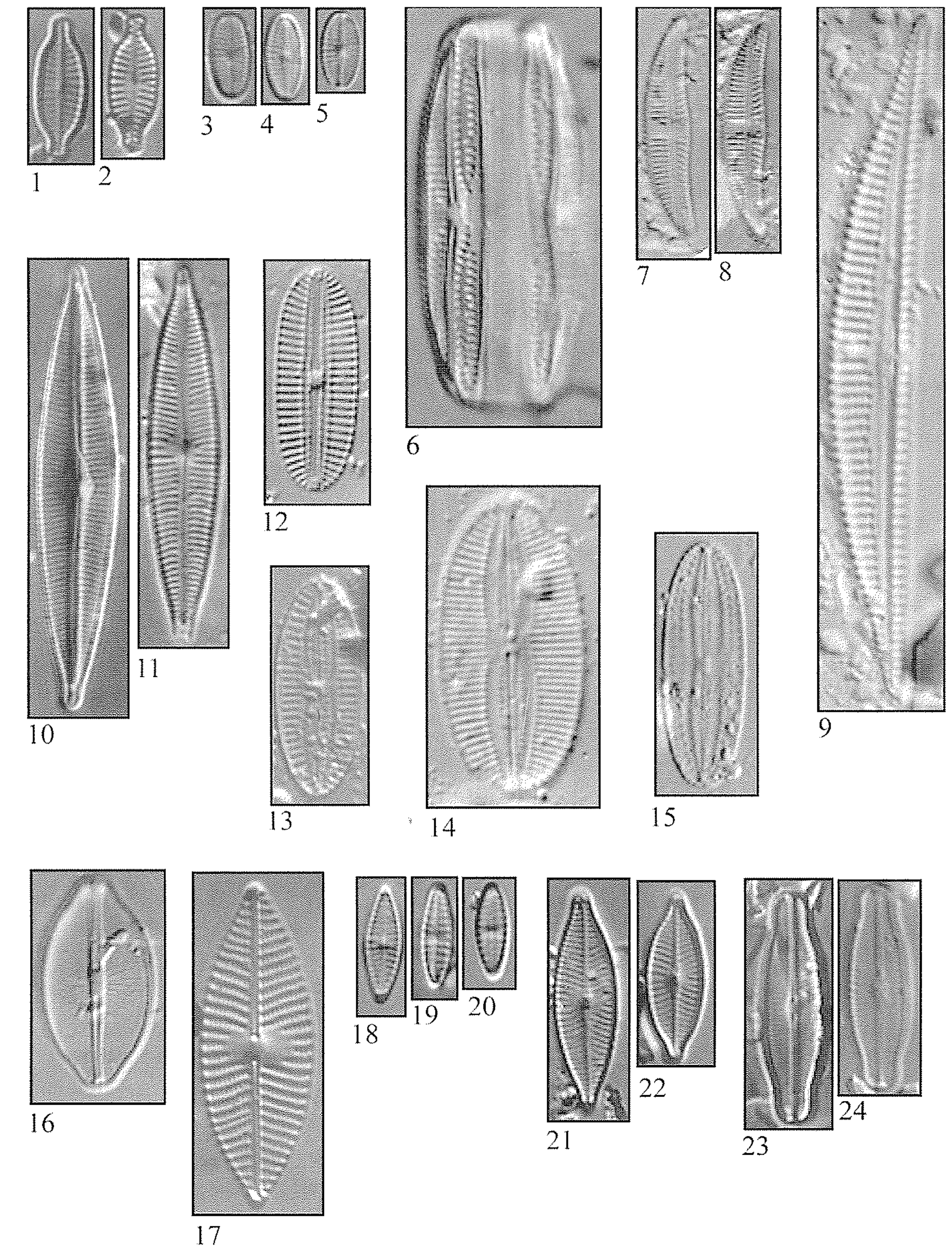


Plate 5. Diatom taxa (1500×) from the shallow marine assemblage. 1-2 *Achnanthes lemmermannii*. 3-5 *Achnanthes* sp.1. 6 *Amphora copulata* (Kützing) Schoeman & Archibald. 7-8 *Amphora inariensis* Krammer 9 *Amphora* sp.1. 10-11 *Cymbella cesatii* (Rabenhorst) Grunow. 12 *Diploneis* cf. *modica* Hustedt. 13 *Fallacia clepsidroides* Witkowski. 14 *Fallacia* cf. *pygmaea* (Kützing) Stickle & D.G.Mann. 15 *Fallacia tenera* (Hustedt) Stickle & D.G.Mann. 16 *Navicula cocconeiformis* W.Gregory. 17 *Navicula meniscus* Schumann. 18-20 *Navicula perminuta*. 21-22 *Navicula* cf. *phyllepta* Kützing. 23-24 *Navicula* sp.1.

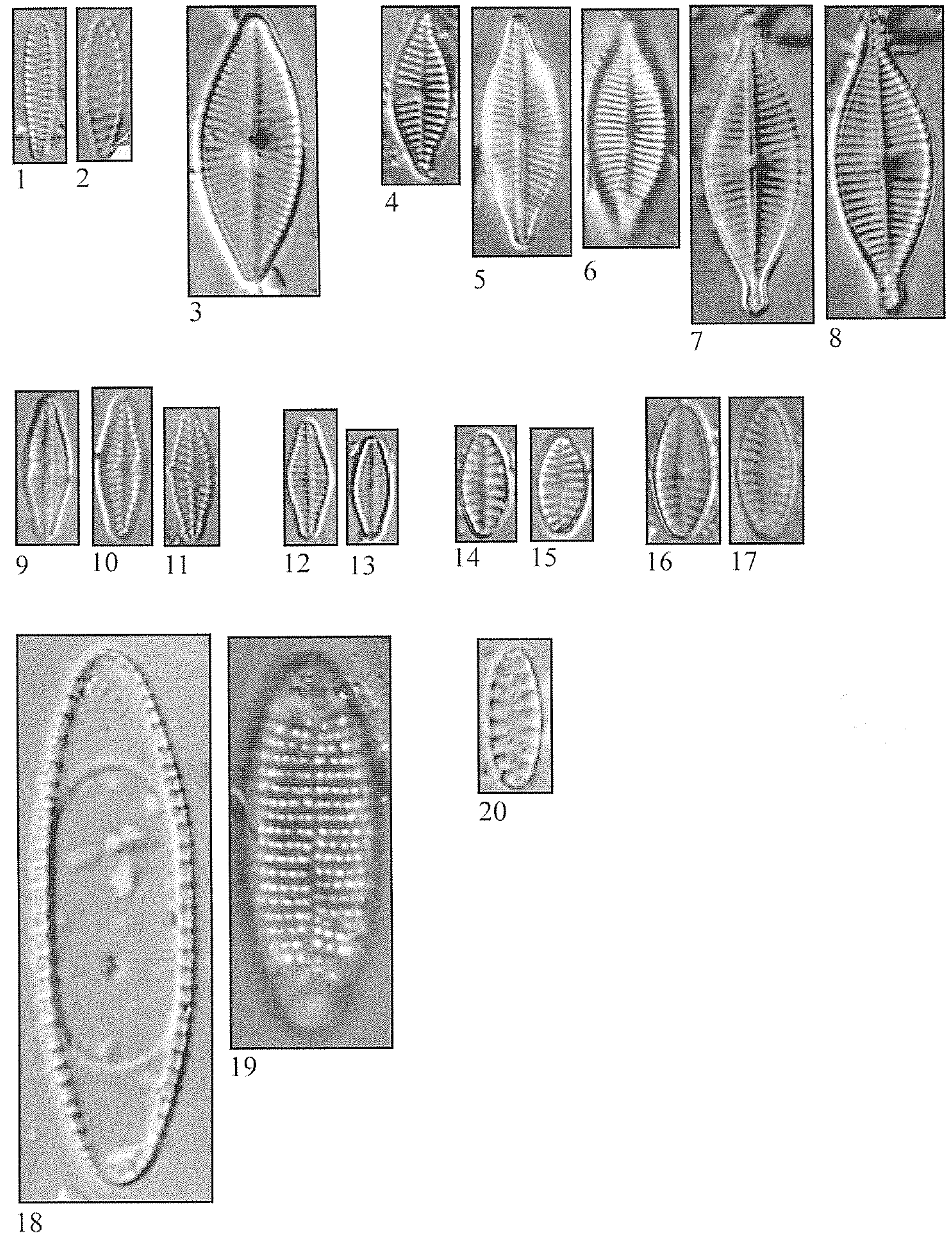


Plate 6. Diatom taxa (1500×) from the shallow marine assemblage. 1-2 *Opephora olsenii* Møller. 3 *Placoneis clementis* (Grunow) E.J.Cox. 4-9 *Planothidium delicatulum*. 10-11 *Planothidium delicatulum* complex. 12-13 *Planothidium delicatulum* fo.1. 14-15 *Planothidium hauckianum*. 16-17 *Planothidium* sp.1. 18-19 *Rhabdonema arcuatum* (Lyngbye) Kützing. 20 *Staurosirella lapponica* (Grunow in Van Heurck) D.M.Williams & Round.

dominated after the deposition of mixed marine-terrestrial deposit. However, cores 98-D and - F were influenced by estuarine conditions with freshwater inflow from the Nastapoka River before the onset of wave action. Estuarine influences are also observed in core 98-E and in the major part of core 98-6.

Conclusion

Allochthonous marine-littoral and epiphytic mesohalobian species dominate diatom assemblage 1. Epipelic coastal and freshwater-brackish diatoms dominate in the second estuarine assemblage, whereas the third assemblage is characterized by an autochthonous benthic community with predominance of small epipsammic taxa. In this study, we used fossil diatoms to reveal fluvial and marine processes that governed the sediment type and distribution over the shallow delta surface at the mouth of the Nastapoka River. This coastal system is characterized by an ongoing postglacial isostatic rebound and shoreline emergence with interesting applications for diatom-based investigations.

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