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Diatoms from the Shelton Mastodon Site

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Abstract

A fairly diverse and abundant diatom flora is associated with remains of *Mammut americanum* at the Shelton Mastodon Site in northern Oakland County, Michigan. The most abundant elements of this flora are species commonly recorded from late-glacial deposits in North America and Europe. The nearest modern analogues of this flora are assemblages deposited in small lakes in the high arctic and present day periglacial environments. Based on the diatoms present, the most probable depositional habitat was the margin of a moderately alkaline (pH > 7.0) and moderately productive pond which existed under arctic conditions.

Introduction

Diatoms preserved in lake sediments have been widely used to infer past conditions. It is often possible to recover relatively large numbers ($10^5 - 10^7 \cdot \mathrm{gm}^{-1}$ dry sediment) of specimens representing diverse (typically >100 species) floras. The ability to recover statistically reliable samples, combined with the fact that the growth requirements and distribution of many diatom species are relatively well known make them particularly useful for inferring past aquatic conditions. Examples of successful applications include determination of marine incursions, lake trophic history (Battarbee, 1987), and historic trends in lake acidification (Smol *et al.,* 1986). Examples of regional studies using diatoms to infer past aquatic conditions include studies of post-glacial development of Vestaburg Bog (Collingsworth *et al.,* 1967), Barney's Lake (King & Hohn, 1972), Fox Lake (Robbins & Hohn, 1972), and the post-glacial (Stoermer, 1977) and post-settlement (Andresen, 1976) history of Douglas Lake. Diatom analysis has also been widely employed in reconstructions of the trophic history of the Great Lakes (Duthie & Sreenivasa, 1971; Frederick, 1981; Harris & Vollenweider, 1982; Thayer *et al.,* 1983; Stoermer *et al.,* 1985a,b,c; Stoermer *et al.,* 1987).

Interest in the remains of the Pleistocene megafauna has also led to attempts to use diatoms to infer conditions under which these fossils were deposited (e.g. Patrick, 1938). In the following we report the diatom flora associated with the remains of extinct large mammals in southeastern Michigan.

Materials and methods

The Shelton Mastodon Site is located in northern Oakland County, Michigan (Brandon Township, SE 1/4 of SE 1/4 of Section 26, T5N R9E). A complete description of the site is given in Shoshani *et al.* (in press).

We examined a total of 6 samples from the site. Raw sediment samples were first dispersed in water without further treatment and examined at 400 × to determine gross characteristics. Samples were then cleaned by oxidation in concentrated nitric acid and potassium dichromate (Patrick & Reimer, 1966). Oxidation byproducts and excess acid were removed by settling and decantation of distilled water rinses. Cleaned material was then dried on cover glasses and mounted in Hyrax. Observation and identification of cleaned material was done with a Leitz Othholux microscope fitted with an optical system which provides numerical aperture of 1.30^{+} at ca. 1200 ×.

Only one of the samples examined contained abundant diatoms. The sample (grid reference C-4, sample no. 1, Soshani *et. al.* in press) consisted of very fine clayey sand with considerable organic matter which was associated with a cranium of *Mammut americanum*. According to Soshani *et al.* (in press), this material is of Twocreekan age (radiocarbon date approximately 11500 yrs BP) and most likely deposited at a pond margin during re-expansion of a previously existing water body.

Five slides of this material were examined. Relative abundance estimates were derived from the average of specimens counted on 11 mm transects on two slides. All five slides were then scanned for species present in lesser abundance. Vouchers have been deposited at the Great Lakes Research Division, University of Michigan (Stoermer Collection), the Cranbrook Institute of Sciences, and the Diatom Herbarium of the Academy of Natural Sciences of Philadelphia.

Results

Relative abundance of most abundant species is given in Table 1. Diatoms are the most abundant siliceous microfossils present, although cysts of chrysophycean algae constitute slightly over 1% of the total assemblage. Seventeen taxa occur at frequencies over 1% of the total assemblage and these taxa constitute over 95% of the specimens observed.

Table 1. Siliceous microfossils constituting more than 1.0% of the total assemblage present. Estimate is based on average of counts from transects of two slides.

Taxa	Relative Abundance
Cymbella diluviana	26.40
Fragilaria construens	20.57
Fragilaria brevistriata	10.85
Fragilaria pinnata	9.72
Fragilaria lapponica	7.80
Achnanthes exigua	2.83
Navicula minima	2.74
Fragilaria construens var. *pumila*	2.47
Fragilaria construens var. *venter*	1.96
Achnanthes basolettiana	1.57
Navicula subrotundata	1.51
Amphora perpusilla	1.49
Fragilaria leptostauron var. *dubia*	1.21
Navicula graciloides	1.17
Fragilaria brevistriata var. *inflata*	1.08
Chrysophyte cysts	1.02
Navicula modica	1.00
Total	95.39%

A listing of all diatom observed is given in Table 2. A total of 91 taxa are present, including representatives of 25 genera. In most cases it was possible to identify taxa to the species level, although fragmentary specimens of *Eunotia, Gyrosigma,* and *Surirella* were present in the sample which could not be assigned to species. The most widely represented genera are *Navicula* (15 species), *Cymbella* (14 species), *Fragilaria* (10 species), *Achnanthes* (9 species), *Gomphonema* (6 species), and *Cyclotella* (5 species).

Discussion

The diatom flora observed does not have any precise modern regional analogue known to us. Although all of the species present are still extant, the dominance pattern present is rarely, if ever, *Tabel 2.* Listing of all diatom taxa observed in the study.

Achnanthes biasolettiana (Kütz.) Grun.
Achnanthes exigua Grun. var. *exigua*
Achnanthes exigua var. *heterovalva* Krasske
Achnanthes lanceolata Brëb. *ex* Kütz.
Achnanthes microcephala (Kütz.) Grun.
Achnanthes minutissima Kütz.
Achnanthes stewartii Patr.
Achnanthes sublaevis var. *crassa* Reim.
Achnanthes flexella (Kütz.) Brun
Amphora michiganensis Stoerm. & Yang
Amphora perpusilla (Grun.) Grun.
Amphora thumensis (A. Mayer) Cleve-Euler
Anomoeoneis vitrea (Grun.) Ross in Patrick & Reimer
Caloneis limosa (Kütz.) Patr.
Caloneis silicula (Ehrenb.) Cleve
Cocconeis placentula Ehrenb.
Cocconeis thumensis A. Mayer
Cyclotella caspia Grun.
Cyclotella comta (Ehrenb.). Kütz.
Cyclotella michiganiana Skv.
Cyclotella ocellata Pant.
Cyclotella operculata (Ag.) Kütz.
Cymbella amphicephala Näg.
Cymbella cistula (Ehrenb.) Kirchn.
Cymbella cymbiformis Ag. var. *cymbiformis*
Cymbella cymbiformis var. *nonpunctata* Font.
Cymbella diluviana (Krasske) Florin
Cymbella hustedtii Krasske
Cymbella inaequalis (Ehrenb.) Rabh.
Cymbella incerta (Grun.) Cleve
Cymbella laevis Näg.
Cymbella microcephala Grun.
Cymbella minuta Hilse var. *minuta*
Cymbella minuta var. *silesiaca* (Bleisch ex Rabh.) Reim.
Cymbella minuta f. *latens* (Krasske) Reim.
Cymbella norvegica Grun.
Diploneis marginestriata Hust.
Diploneis ovalis (Hilse) Cleve
Epithemia reichelti Fricke
Epithemia turgida (Ehrenb.). Kütz.
Eunotia sp.
Fragilaria brevistriata Grun.
Fragilaria brevistriata var. *inflata* (Pant.) Hust.
Fragilaria construens (Ehrenb.) Grun.
Fragilaria construens var. *pumila* Grun.
Fragilaria construens var. *venter* (Ehrenb.) Grun.
Fragilaria lapponica Grun
Fragilaria leptostauron (Ehrenb.) Hust. var. *leptostauron*
Fragilaria leptostauron var. *dubia* (Grun.). Hust.
Fragilaria pinnata Ehrenb.
Fragilaria pinnata var. *intercedens* (Grun.) Hust.
Gomphoneis herculeana (Ehrenb.) Cleve
Gomphonema acuminatum Ehrenb. var. *acuminatum*
Gomphonema acuminatum var. *pusillum* Grun.
Gomphonema angustatum (Kütz.) Rabh.
Gomphonema intricatum Kütz
Gomphonema subtile var. *sagitta* (Schum.) Cleve
Gomphonema truncatum Ehrenb.
Gyrosigma sp.
Hantzchia amphioxys (Ehrenb.) Grun.
Mastogloia grevillei W. Sm.
Mastogloia smithii var. *lacustris* Grun.
Navicula aurora Sov.
Navicula cocconeiformis Greg.
Navicula cryptocephala Kütz.
Navicula explanata Hust.
Navicula graciloides A. Mayer
Navicula laevissima Kütz.
Navicula minima Grun.
Navicula modica Hust.
Navicula oblonga (Kütz.) Kütz.
Navicula pupula Kütz. var. *pupula*
Navicula pupula var. *rectangularis* (Greg.) Grun.
Navicula radiosa Kütz.
Navicula subrotundata Hust.
Navicula tuscula Ehrenb.
Navicula vitabunda Hust.
Neidium affine (Ehrenb.) Pfitz.
Neidium bisulcatum (Lagerst.) Cleve
Neidium iridis (Ehrenb.) Cleve
Nitzschia denticula (Grun.
Nitzschia dissipata (Kütz.) Grun.
Nitzchia paleacea Grun.
Nitzschia sinuata var. *tabellaria* (Grun.) Grun.
Pinnularia viridis (Nitz.) Ehrenb.
Rhopaladia gibba (Ehrenb.) O. Müll.
Stauroneis anceps Ehrenb.
Stauroneis phoenicenteron (Nitz.) Ehrenb.
Surirella sp.
Synedra demerarae Grun.
Tabellaria fenestra (Lyngb.) Kütz.

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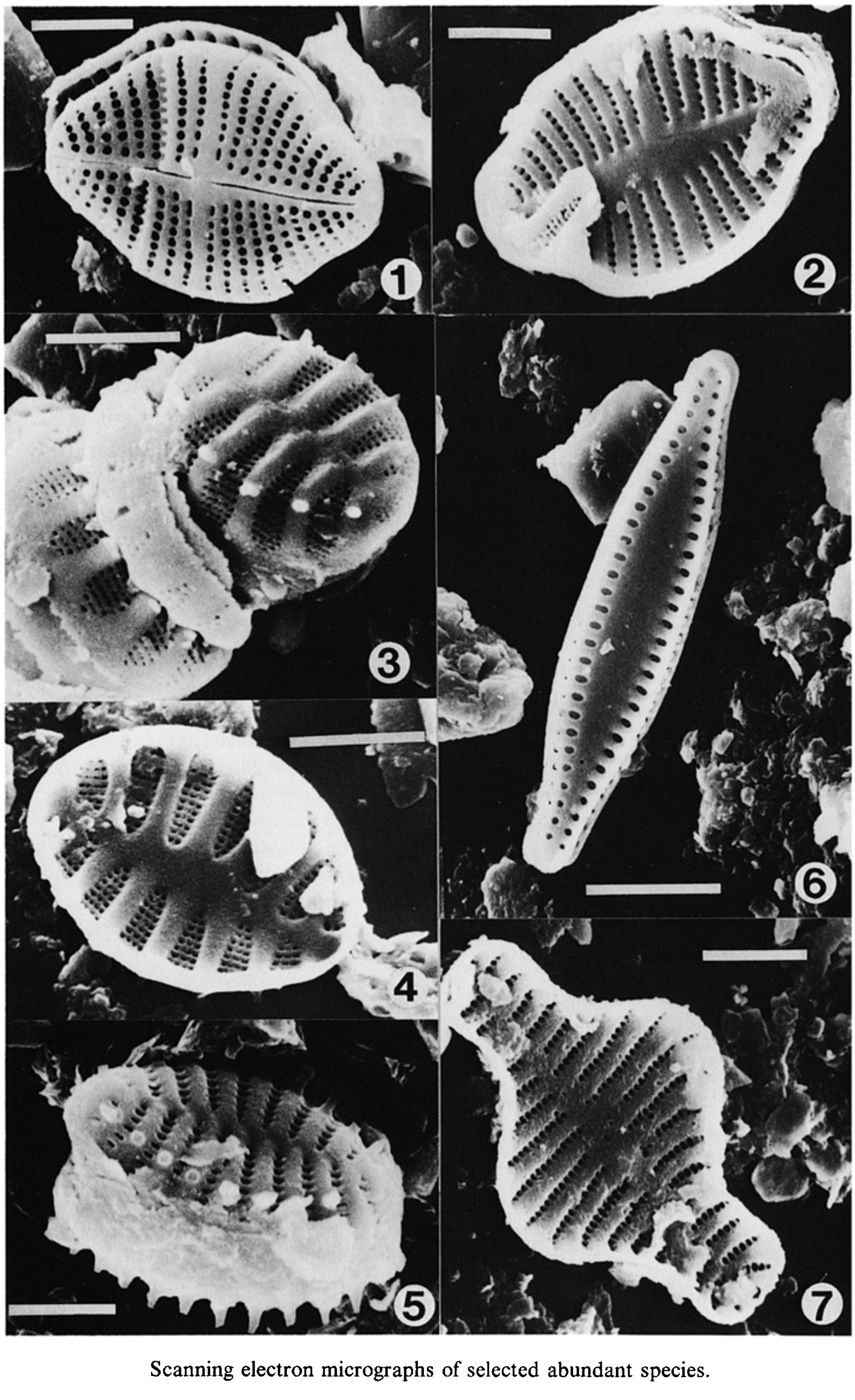
found in modern collections from Michigan or the surrounding area. The nearest modern analogues we have observed are psammon communities found in seepage and spring habitats which maintain low and constant water temperatures and relatively constant nutrient conditions. The community is, however, strikingly similar to late-glacial diatom assemblages reported by several authors and to modern assemblages accumulated in the sediments of small lakes in pertiglacial localities (Bradbury & Whiteside, 1980) and ponds and lakes in the high arctic (Smol, 1983, 1988). High relative abundance of the *Fragilaria*



Scanning electron micrographs of selected abundant species.

Fig. 1, 2. Achnanthes exigua. Fig. 1, External view of raphe valve. Scale bar = 2.5 μm. Fig. 2, Internal view of rapheless valve. Scale bar = 2.5 μm.

Figs 3, 4. Fragilaria pinnata. Fig. 3, External view. Scale bar = 2.5 μm. Fig. 4, Internal view. Scale bar = 2.5 μm.

Fig. 5. Fragilaria construens var. *pumila*. External view. Scale bar = 2.5 μm.

Fig. 6. Fragilaria brevistriata. Internal view. Scale bar = 5 μm.

Fig. 7. Fragilaria construens. Internal view. Scale bar = 2.5 μm.

species present in our sample almost universally characteristic of late glacial assemblages (Florin, 1970; Haworth, 1975, 1976). *Fragilaria brevistriata* et var., *F. construens* et var., *F. lapponica* and *F. pinnata,* are 4 of the 5 most abundant species in our sample. *Fragilaria leptistauron* var. *dubia,* another taxon abundant in many late-glacial assemblages, also constitutes more than 1% of specimens observed. Patrick (1938) found *F. brevistriata, F. construens,* and *F. leptostauron* associated with mommoth bones in her study of the Clovis Site.

The most unusual characteristic of the diatom flora preserved at the Shelton Site is the high abundance of *Cymbella diluviana.* This species was originally described (Krasske, 1933 – as *Navicula diluviana*) from a diatomite, possibly of late-glacial age. Florin (1971) gives an extended discussion of the systematics of this unusual species. She (Florin, 1970) found it in abundance, although not dominant as in our sample, at the Kirchner Marsh Site in Minnesota, and this species was observed in abundance from late-glacial sediments of Sioux Pond, Ontario (Björck & Keister, 1983). Florin (1970) also noted that her specimens from Kirchner Marsh were likely conspecific with specimens reported as *Cymbella similis* by Patrick (1943) from the basal sediments of Linsley Pond, Connecticut. This opinion was later confirmed by Patrick & Reimer (1975). Occasional specimens of *C. diluviana* are found in modern collections from the Great Lakes region, particularly in benthic collections from the Great Lakes themselves, but it is rarely abundant and, in our experience, never dominant.

Like *C. diluviana,* the majority of other taxa found at the Shelton Site are most abundant in benthic communities in modern collections. More specifically, the majority of these taxa are particularly abundant in psammon communities in modern boreal lakes. Some (e.g. *Navicula explanata*) were originally described from fossil localities (Hustedt, 1948) and are relatively rare in modern collections. High overall abundance of benthic taxa seems to be a consistent characteristic of late-glacial diatom assemblages. Although few studies are available, dominance by benthic species also appears to be characteristic of some modern lakes in the high arctic. Based on his study of a small lake on Ellesmere Island, Smol (1983, 1988) has postulated that the high relative abundance and diversity of benthic diatoms in such localities results from the fact that most of the lake surface remains frozen throughout the year. Under such conditions most diatom production takes place in the littoral zone of the lake which melts first or may be the only part of the lake to melt during any given season.

Planktonic diatoms are rare in both numbers and species in our sample. The majority of planktonic species present, *Cyclotella comta, C. michiganiana, C. ocellata, C. operculata,* and *Tabellaria fenestrata,* are still abundant in oligotrophic lakes in the region and are also found in boreal and arctic lakes. A striking exception is the presence of *Cyclotella caspia,* a species usually found in brackish water or marine habitats (Hustedt, 1930). The presence of this species at an inland site is puzzling, but it should be noted that Florin (1970) also found *C. caspia* in late-glacial strata at the Kirchner Marsh Site and gives an extended account of her efforts to verify her identification. In any case, the rarity of planktonic species is a common characteristic of diatom communities developed under glacial or arctic conditions. Smol (1983) hypothesizes that growth of planktonic diatoms in arctic lakes is limited by lack of wind-driven mixing of the water column due to persistent ice cover. Most planktonic diatoms are non-motile and rely upon turbulent mixing of the water column to remain suspended. Under conditions of low turbulence planktonic chrysophytes have competitive advantage, since most chrysophyte species have flagellae and are actively motile in their vegetative condition. Thus Smol's hypothesis could explain both the relative paucity of planktonic diatoms and the relative abundance of chrysophyte cysts found in the sediments of modern high arctic lakes and in the preserved remains of late-glacial communities.

Overall, the diatom flora at the Shelton Site is most similar to assemblages reported from other late glacial localities. Accounting for obvious synonyms, 71% of the taxa present in our samples were also found at the Kirchner Marsh Site (Florin, 1970), and 76% of those present were also found in samples from late-glacial levels at sites in Scotland (Haworth, 1976). Although some species, notably the small *Fragilaria,* are common to all localities the Shelton Site flora is slightly less similar to assemblages accumulated in the sediments of small lakes in modern periglacial localities (Bradbury & Whiteside, 1980) or to assemblages deposited in small lakes in the high arctic (Smol, 1983).

Conclusions

The diatom evidence is completely consistent with the hypothesis that the original site of deposition of this material was a small pond which existed under conditions similar to modern arctic and periglacial environments. The flora preserved is most similar to assemblages reported from late glacial deposits. On the basis of the diatom evidence it is not possible to make any more specific age determination. All of the species present are still extant today and probably existed throughout the Pleistocene.

The actual site of deposition was most likely the margin of a pond or small lake. The diatom assemblage is strongly dominated by species which grow in benthic habitats, particularly psammon communities. Such communities are found at significant depths only in highly transparant lakes. It is thus most likely that the site was in relatively shallow water. The presence of some strictly planktonic diatoms and fairly numerous cysts of chrysophyte species indicates that there was water of sufficient depth to develop a typical lake plankton community within the confines of the lake or pond where the material we examined was deposited.

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