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Some Diatoms in Lacustrine Sediments of Pillsbury and Sylvan Lake Beds in Northwest Iowa

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Synopsis. Diatom populations in two cores of lake sediments from Northwest Iowa have been analyzed as part of an investigation into the history of postglacial sediments in this region. The three member strata sequence of sediments indicate lacustrine diatoms were deposited in the upper two members. Diatoms and macroscopic organisms are scarce to non-existent in the deepest member. Evidence indicates that the level where diatom populations were first established represents the original bottom of the lake. Pollens, particularly spruce pollen, found immediately below the upper two members were possibly blown in and mixed with sediments from the receding glacier.

The beds of two drained prairie lakes in Northwest Iowa were selected for lacustrine diatom study as part of a continuing ecological study of lake sediments (Hungerford 1969).

These lakes were drained in 1915, and the land has been in agricultural production since then. However, the sediments below the plough line are essentially unmodified. Names and locations of the two lakes are given in Figures 1 & 2.

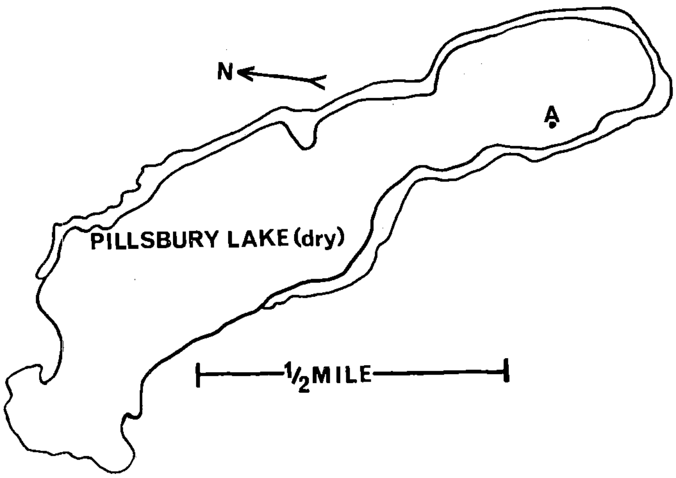

Fig. 1. Map of Pillsbury Lake Bed, (A) core site (Sections 5 and 6, T98N, R37W).

Materials and Methods

The following procedure was used to prepare diatoms in the sediments for microscopic analysis. A core was obtained in each lake bed by use of a Swedish Hiller type corer and divided into 10 cm lengths. Descriptive notes on the appearance of the sediments at each level were recorded in the field at the time of collection. One-half of each sample was separated for future study. The other half was first treated with Schultze's reagent (Brown 1960) to a volume approximately equal to four times that of the sediment, mixed to a slurry and allowed to stand without heating for twelve hours, stirring occasionally. The danger of corrosive gas released from boiling nitric acid in a frequently used diatom cleaning procedure was thereby avoided.

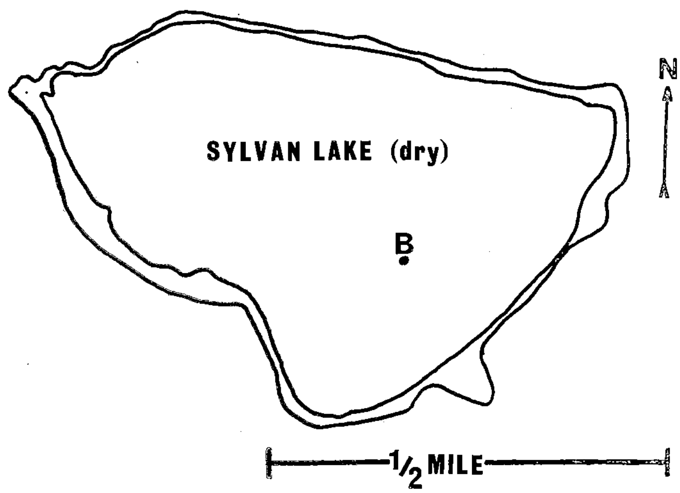

Fig. 2. Map of Sylvan Lake Bed, (B) core site (Sections 30 and 31, T99N, R37W).

The 600 ml beakers with the samples were then filled with distilled water. The supernatant fluid was decanted after settling and replaced with distilled water. After decanting again, ammonium hydroxide was added in an amount equal to three times the volume of the sediment. Actual ammonium hydroxide concentration was at least 20% by volume. The samples were immersed in the ammonium hydroxide for no more than three hours. The beaker was then filled with distilled water and decanted after twelve hours. Sometimes a dark supernatant formed but no diatoms remained suspended in it. The sediments were washed with distilled water two or more times. Half of each cleaned sample was separated for preparation of diatom slides by the usual method of drying on coverslips and mounting in Hyrax. The diatom specimens appeared brilliantly clean and undamaged. The other half of the sample was treated with 48%

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hydrofluoric acid (HF) in plastic beakers to dissolve diatoms and sand particles. HF was added in an amount equal to three times the volume of the sediment. The reaction proceeded at room temperature under a hood and samples were treated from two to twelve hours, depending on the sample. The beakers, no more than ⅓ full, were then filled with distilled water, allowed to settle, and decanted at least twice. The pollen was then stained with 1% aqueous safranin, washed and stored in Cellosolve.

The above schedule is a reversal and modification of one sometimes used in preparation of fossil pollen (personal communciation from Ruth Webster and J. D. Dodd). It has not yet been published in detail.

RESULTS

An analysis was made of the distribution of diatom populations in core samples from each lake bed. The 7 meter Pillsbury core (Table 1) and the 8.2 meter Sylvan core (Table 2) contained a three part stratification, as was noted by Conger (1939) in the sediments of Wisconsin's Crystal Lake. The diatom sediments have been deposited in the upper zones since the approximate date of 10,100 years before the present. This represents the radio-carbon date of the Pillsbury sediments at the 300-325 cm level at the core site and corresponds to the date for Hixton Pond sediments (Andrews 1966). Both lakebeds have the snail layer (Hungerford 1969). The Pillsbury core site was selected to get as much deposit as possible under the snail layer (5.9 meters) while the Sylvan core site was selected to include as much of the entire snail layer as possible (2.1 meters). Below the 2.10 meter level in Pillsbury and the 5.4 meter level in Sylvan lacustrine diatoms were non-existent. The occurrence of *Gyrosigma acuminatum* Reimer at the 660-670 cm level in Sylvan is an exception. *Tabellaria fenestrata* (Lyngbe) Kutz. was found in the lowermost diatomaceous deposits, i.e. 500-540 cm in Sylvan.

TABLE 1. STRATIGRAPHY OF THE PILLSBURY CORE

Depth interval (cm)	*General description*
0-150	Dark black muck, diatoms, pollen
150-160	Dark soupy muck, diatoms, pollen
160-175	Light brown, calcium carbonate, diatoms, pollen
175-210	Light brown, calcium carbonate, snails, numerous diatoms, pollen
210-250	Olive green, no diatoms, pollen
250-300	Light olive green, no diatoms, pollen
300-325	Carbon Date[1] 10,100 $\pm$240 years BP (8,150 BC)
300-440	Gray, no diatoms, pollen
440-510	Black, gravel, pollen, no diatoms
510-530	Loose sand, no diatoms, pollen
530-540	Corer empty
540-550	Sand
550-580	Corer empty
580-590	Black sand, no diatoms, pollen
590-600	Unconsolidated sand in clay, no diatoms, pollen
600-650	Sand in clay, unconsolidated, no diatoms, pollen
650-700	Less sand in clay, no diatoms, pollen
650-675	Carbon Date[1] 17,450$\pm$420 years BP (15,500 BC) Dating sample more than twice the volume of 300-325 sample in order to obtain enough carbon to make date possible[1]

[1] Isotope Inc., Westwood Laboratories, So. Van Buren Ave. Westwood, New Jersey 07675, April 2, 1968, W.O. #2-5535-112, Personal Communications to Author.

TABLE 2. STRATIGRAPHY OF THE SYLVAN CORE

Depth interval (cm)	*General description*
0-330	Muck, diatoms few, pollen
330-340	Transition to gray, snails, diatoms
340-485	Snail layer, shells, diatoms
485-500	Transition to brown, diatoms
500-510	Few snails, diatoms
510-520	Snails not present, brown soil, diatoms
530-680	Brown soil, no diatoms below 540 cm
680-815	Blue clay, no diatoms
815-820	Sand and gravel, gray color, no diatoms

A total of 150 taxa were encountered (Table 3). Proportionate counts in the samples were based on 850 individuals per sample in the Pillsbury material and 600 per sample in the Sylvan material. Greatest diversity (47 taxa) was encountered in the snail layer of Pillsbury in the samples from 1.6-2.1 m. The average number of taxa was 27 for the layer above the snail layer. Observations of the snail layer and the layers above in the Sylvan core showed similar difference.

TABLE 3. DIATOM TAXA FROM SEDIMENTS IN PILLSBURY AND SYLVAN LAKES[1]

Achnanthes conspicua A. Mayer P-C-1, 170-190, 200-210: S-C-1, 510-530 Calciumbiont.
A. exigua Grun. P-C-1, 170-190: S-C-2, 420-430, 480-490, S-C-1, 510-530 Calciumbiont.
A. hauckiana Grun. P-C-1, 200-210, Calciumbiont.
A. lanceolata (Bréb.) Grun. P-M-C-1, 20-30, 60-70, 100-110, 140-150, 160-170, 180-200, P-M-C-2, 200-210, 70-80, Coenophil.
A. linearis (W. Smith) Grun. P-C-9, 170-180, Calciumbiont.
Amphora ovalis var. *libyca* (Ehr.) Cleve P-C-M and S-C-M, usually less than 5% of every count, P-M-3, 20-30, 50-60, 70-80, P-M-4, 60-70, Coenophil.
A. veneta Kütz. P-C-M-1 and S-C-M-1, Coenophil.
Anomoenoneis sphaerophora (Ehr.) Pfitzer P-M-2, 30-40, P-M-1, 40-60, P-C-1, 150-160, 170-200, S-C-2, 330-360, S-C-1, 380-420, 440-460, 480-510, Calciumbiont.
A. sphaerophora var. *sculpta* O. Muller P-M-1, 20-30.
Caloneis bacillaris var. *thermalis* Grun. A.Cl. P-M-1, 10-20, Muckbiont.
C. lewisii Patr. P-M-C-1, 30-50, 130-160, 170-180, Coenophil.
C. limosa (Kütz.) Patr. P-M-C-1, 30-50, 100-130, 140-160, 170-210, S-C-1, 330-340, 350-380, 460-470, Coenophil.
Cocconeis placentula Ehr. P-M-C-1-2 all levels, P-M-C-3, 90-100. S-M-C, 2-5, Coenophil.

[1] Key to symbols: (C) $CaCO_3$ rich zone, "Snail layer", shell zone, (M) Muck, soil above "Snail layer", called Schlamn, (ooze) in present day lakes, (P) Pillsbury lakebed, (S) Sylvan lakebed.
(1) Less than 1% of relative abundance ratings diatom population, (2) 1-5% (3) 5-10%, (4) 10-20%, (5) 20-30%, (6) 30-40%, (7) 40-50%, (8) 50-70%, (9) not occurring in count but at level indicated.
Numbers 0-10, 10-20, etc. indicate centimeter depths of 10 cm samples.
Calciumbiont: A diatom characteristic of the calcium-rich ($CaCO_3$-Snail layer) area of the lake sediments.
Coenophil: A diatom not restricted to calcium-rich strata, found throughout the core.
Muckbiont: A diatom restricted to the area above the $CaCO_3$-rich deposit in the Muck type black soil sediment.

Cyclotella meneghiniana Kütz. P-C-1, 200-210, Calciumbiont. S-C-1, 480-500.
C. striata var. *bipunctata* Fricke P-M-C-1, 20-30, 60-70, 80-110, 120-140, 150-160, 170-180, 190-210, Coenophil. S-C-1, 330-340.
Cymatopleura angulata Greville P-M-1, 60-70, 190-210, Coenophil.
C. cochlea J. Brun. P-M-1, 60-80
C. elliptica var. *nobilis* (Hantzsch) Hust. P-M-C-1, 30-40, 60-120, 140-150, 160-170, Coenophil.
Cymatopleura solea (Bréb.) W. Smith, P-M-1, 30-40, 70-120, P-M-2, 60-70, Muckbiont.
Cymbella affinis Kütz. P-M-C-1, 20-30, P-M-C-2, 160-200, P-M-C-1, 200-210. S-C-1, 330-340, 350-360, 390-400, 450-460, 480-510, Calciumbiont.
C. aspera (Ehr.) Héribaud P-M-C-1, 30-40, 100-110, 200-210. S-C-1, 410-420, 450-460, Coenophil.
C. cistula (Ehr. in Hempr. and Ehr.) Kirchn. in Cohn P-M-C-2, 20-30, 150-160, P-M-C-1, 140-150, P-M-C-3, 160-170, 200-210, P-M-C-4, 170-200. S-C-1, 400-420, 430-440, 480-490, 500-510, S-C-2, 390-400, 440-450, 460-470, 490-500, 510-530, Calciumbiont.
C. cuspidata Kütz. P-C-1, 170-210, S-C-1, 360-380, 390-400, 420-430, 440-450, 490-500, P-C-2, 350-360, 400, 410, 470-480, 500-510, 520-540, Calciumbiont.
C. cymbiformis Agardh P-C-1, 170-210, S-C-1, 330-340, 380-390, 450-460, Calciumbiont.
C. inaequalis (Ehr.) Rabh. P-M-C-1, 20-40, 140-170, 190-210, P-M-C-2, 10-20, 70-80, 170-190. S-C-1, 400-410, 430-440, 450-460, S-C-2, 460-470, Coenophil.
C. gracilis (Ehr.) Kütz. P-M-2, 60-70.
C. helvetica Kütz. P-C-1, 160-200, S-C-1, 430-440, Calciumbiont.
C. laevis Naegeli P-C-1, 170-180, 190-200.
C. mexicana (Ehr.) Cleve P-C-1, 170-210, S-C-1, 440-450.
C. microcephala Grun. S-C-1, 330-350, 370-380, 440-450, 480-490, S-C-2, 360-370, 460-470.
C. muelleri Hust. P-M-C-1, 50-70, P-M-C-2, 170-180, S-C-1, 500-510.
C. sp. P-C-1, 160-170, 200-210, P-C-2, 170-200, Calciumbiont.
C. triangulum (Ehr.) Cl. P-C-1, 190-210, Calciumbiont.
C. turgida Gregory sensu Hust. 1930, P-M-C-1, 20-30, 160-170, 180-190, P-M-C-2, 170-180, 190-200, 200-210, S-C-1, 370-420, 430-460, 470-510. S-C-2, 350-360, 510-520, Calciumbiont.
Cymbella ventricosa Kütz. sensu Hust. 1930, 30-40, 100-210, P-M-2, 20-30, S-C-1, 380-390, 410-420, 430-440, 450-460, 470-500, S-C-2, 330-340, 370-380, 510-520, S-C-3, 340-350.
Epithemia turgida (Ehr.) Kütz. A fidelity of 100% throughout the P-M-C core, having the highest population percentage 20-30%, P-M-C-5, in the high calcium layer, 170-180, 190-210, P-M-C-4, 180-190, P-M-C-3, 150-170, P-M-C-2, 130-150, 110-120, 40-100, 0-20, P-M-C-3, 20-40, S-C-1, 330-350, 370-380, 410-420, 480-490, 530-540, S-C-2, 350-370, 390-410, 420-450, 460-470, 490-510, S-C-3, 380-390, 450-460, Coenophil.
E. turgida var. *granulata* (Ehr.) Brun P-C-1, 190-200
E. zebra var. *porcellus* (Kütz.) Grun. P-M-C-1, 30-50, 70-80, 120-150, 160-170, P-M-C-2, 0-30, 50-60, 90-120, 200-210, P-M-C-3, 150-160, 170-200. S-C-1, 470-490, 510-530, S-C-2, 330-380, 390-400, 410-420, 430-460, 500-510, 530-540, S-C-3, 380-390. Coenophil.
Eunotia arcus var. *bidens* Grun. P-C-1, 190-200, P-M-1, 20-30, S-C-1, 500-510.
E. curvata (Kütz.) Lagerst P-C-1, 150-160, S-C-1, 430-440.
E. flexuosa Bréb. ex Kütz. P-C-1, 190-200.
E. formica Ehr. P-C-1, 150-160.
E. sp. P-M-1, 110-120.
E. valida Hust. P-M-9, 80-90.
Fragilaria brevistriata Grun. P-M-C-1, 40-50, 60-130, P-M-C-2, 0-10, 20-40-, 130-150, P-M-C-3, 160-190, 200-210, P-M-C-4, 190-200. Coenophil S-C-3, 360-370, 380-390, 500-510, S-C-4, 330-360, 370-380, 390-410, 520-530, S-C-5, 420-450, 510-520, 530-540, S-C-6, 460-470, 480-500, S-C-8, 470-480. Coenophil.
F. capucina var. *melsolepta* Rabh. P-M-1, 30-40, 60-70, P-M-2, 80-100. Muckbiont. S-C-1, 340-350, 370-410, 420-430, 460-490, 500-510, S-C-2, 330-340, 440-460.
Fragilaria construens (Ehr.) Grun. 100% Fidelity. P-M-C-3, 50-60, 80-100, P-M-C-4, 20-30, 40-50, 60-80, 100-110, 150-160, 180-210, P-M-C-5, 0-10, 30-40, 120-130, 170-180. S-C-3, 340-350, 400-410, S-C-4, 330-340, 350-360, 380-400, 410-420, S-C-5, 360-370, 440-480, S-C-6, 490-510, S-C-7, 420-430, 480-490, 510-530, S-C-8, 530-540, S-C-1, 380-490, Coenophil.
F. construens var. *binodis* (Ehr.) Grun. P-M-9, 50-60.
F. construens var. *venter* (Ehr.) Grun. P-M-1, 20-30, 110-120.
F. crotonensis Kitton S-C-1, 370-380.
F. lapponica Grun. P-M-1, 20-30.
F. pinnata Ehr. P-M-C-1, 100-110, 170-200, P-M-C-2, 200-210.
Fragilaria vaucheriae (Kütz.) Peters. P-M-C-1, 60-70, 80-90, 110-130, 170-200, P-M-C-2, 130-140, 200-210.
Gomphoneis eriense (Grun.) Stoermer P-M-1, 130-140.
G. acuminatum var. *coronata* (Ehr.) W. Smith P-M-C-1, 30-40, 160-170, P-M-C-2, 170-310. S-C-1, 380-400, 440-450, S-C-2, 400-410, 490-500, Calciumbiont.
Gomphonema angustatum (Kütz.) Rabh. P-M-C-1, 0-10, 60-70, 80-130, 140-170, 180-190, 200-210, P-M-C-2, 30-50, 170-180, P-M-C-3, 50-60, 70-80, Coenophil.
G. augur Ehr. P-C-9, 180-190.
G. constrictum Ehr. P-M-C-1, 20-40, 60-70, 80-90, 100-120, 140-170, 200-210, P-M-C-2, 90-100, 170-200. S-C-1, 480-490, S-C-2, 360-420, 430-470, 500-520, 530-540, S-C-3, 330-360. Coenophil.
G. intricatum Kütz. P-M-C-1, 10-20, 330-360, 90-140, 200-210, P-M-C-2, 20-30, 60-70, 80-90, 140-150, 160-170, 190-200, P-M-C-3, 170-190. S-C-1, 470-490, 530-540, S-C-2, 360-370, 380-390, 420-430, 500-510, 520-530, S-C-3, 360-370, 380-390, 420-430, 500-510, 520-530, S-C-3, 340-360, 390-420, 440-460, S-C-4, 510-520. Coenophil.
Gomphonema lanceolatum Ehr. P-M-C-1, 20-30, 80-90, 160-170, 190-200, S-C-1, 370-380, 410-420, 470-490, S-C-2, 340-350, 360-370, 380-400, 440-450, 460-470, 490-500, 530-540, S-C-3, 330-430.
G. longiceps var. *gracilis* Hust. P-C-1, 190-210, P-C-2, 170-190, S-C-1, 370-380, 460-490, 510-540, S-C-2, 500-510, S-C-3, 450-460. Calciumbiont.
G. parvulum (Kütz.) Grun. P-M-9, 90-100, S-C-1, 390-400, 450-470, 480-490, S-C-2, 350-360, 370-380, S-C-3, 340-350.
G. sp. 1 S-C-1, 350-360, 400-420, 450-460, S-C-2, 370-400.
G. sp. 2 P-C-9, 190-200, S-C-1, 370-380.
G. sphaerophorum Ehr. P-M-C-1, 60-70, 160-200, S-C-1, 370-380, 390-410, 470-510, S-C-2, 380-490, 410-420, 440-450, 460-470.
G. subtile Ehr. P-C-1, 170-200, S-C-1, 440-450, Calciumbiont.
G. ventricosum Greg. P-M-1, 80-90.
Gyrosigma attenuatum (Kütz.) Rabh. P-C-1, 200-210.
Hantzschia amphioxys (Ehr.) Grun. P-M-1, 20-40, 50-70, 80-130, 140-150, P-M-2, 10-20, 70-80, S-C-1, 400-410, 430-440, 470-480. In Pillsbury a Muckbiont. S-C-1, 410-420.
H. amphioxys (Ehr.) var. major Grun. P-M-9, 70-80.
Mastogloia sp. P-C-1, 180-200, Calciumbiont.
M. grevillei W. Smith P-C-1, 170-190, 200-210.
M. smithii var. *lacustris* Grun. P-M-C-1, 30-40, 190-210, P-M-C-2, 170-190.
Melosira granulata (Ehr.) Ralfs P-M-C-7, 0-50, 70-160, P-M-C-8, 50-70, P-M-C-5, 160-170, P-M-C-4, 200-210, P-M-C-3, 170-200. Coenophil with highest population percentage in Muck. S-C-1, 430-470, S-C-2, 330-430. May indicate mesosaprobic-eutrophic-biont.
Meridion circulare (Grev.) Agardh P-M-C-1, 80-90, 130-140, 200-210.
Navicula anglica Ralfs P-M-C-1, 90-100, 180-190, 200-210.
Navicula capitata Ehr. P-M-C-1, 50-60, 90-100, 170-180.
N. capitata var. *hungarica* (Grun.) Ross P-M-C-1, 80-100, 170-180.
N. capitata var. *luneburgensis* (Grun.) Patr. P-M-1, 100-110.
N. cryptocephala Kütz. P-M-1, 90-100.
N. cuspidata (Kütz.) Kütz. P-M-C-1, 20-60, 80-90, 110-120, 140-170, 180-210, P-M-C-2, 60-80, 90-110, 130-140. S-C-1, 330-340, 420-440, 430-470, 480-490, 500-540, S-C-2, 340-400, 420-430. Coenophil.
N. elginensis (Greg.) Ralfs P-M-C-1, 90-100, 160-190. S-C-1, 350-360, 370-380, 400-420, 430-460, 500-520, S-C-2, 340-350, 360-

370, 380-400, 420-430.
N. heufleri Grun. P-M-1, 110-120.
N. laevissima Kütz. P-M-C-1, 90-100, 160-170. S-C-1, 340-350, 450-460.
*N. meniscul*us var. *upsaliensis* (Grun.) Grun. P-M-1, 50-60, 70-80, S-C-1, 440-450.
N. mournei Patr. S-C-1, 500-510.
N. mutia Kütz. P-M-C-1, 80-90, 130-140, 160-170, 180-190, 200-210. S-C-1, 450-460, S-C-2, 480-490.
N. oblonga (Kütz.) Kütz. P-M-C-1, 0-40, 160-170, P-M-C-2, 200-210, P-M-C-3, 170-200. S-C-1, 350-360, 400-410, 430-440, 460-470, 480-490, 510-540, S-C-2, 330-350, 360-400, 410-430, 440-460, 500-510. Coenophil-Calciumbiont.
N. perrotettii var. *enervis* Hust. P-C-9, 160-170.
N. protracta Grun. P-C-9, 200-210.
N. pseudoventralis Hust. P-C-1, 200-210, S-C-1, 430-440, 450-460, 490-510, 520-530, S-C-2, 510-520.
N. pupula Kütz. P-M-C-1, 20-40, 50-60, 80-110, 120-160, 170-210, S-C-1, 410-440, 460-490, 500-510, 520-530, S-C-2, 330-400, 450-460, 490-500, 510-540. Coenophil.
N. pupula var. *rectangularis* (Greg.) Grun. P-C-9, 200-210.
N. radiosa Kütz. P-M-C-1, 20-50, 110-120, 150-180, P-M-C-2, 60-110, 120-130, 140-150, 190-200. S-C-1, 370-410, 430-450, 480-500, S-C-2, 330-340, 350-360, 410-420, 450-470, 500-510. Coenophil.
Navicula schadei Krasske P-C-1, 200-210, S-C-1, 500-530. Calciumbiont.
N. scutelloides W. Sm. ex Greg. S-C-1, 520-540.
N. secreta var. *apiculata* Patr. P-C-1, 200-210.
N. seminuloides Hust. P-C-1, 160-170.
N. sp. P-M-C-1, 110-120, 200-210. S-C-1, 500-510.
N. tuscula Ehr. P-M-C-1, 140-150, 180-210, P-M-C-2, 170-180, S-C-1, 400-410, 430-440, 460-470, 500-510, S-C-2, 450-460. Calciumbiont.
N. wittrockii (Lagst.) Cleve-Euler P-M-1, 70-80, S-C-1, 420-430, 430-440.
Neidium affine (Ehr.) Pfitz. P-M-1, 90-140, S-C-1, 390-410.
N. affine var. *undulatum* (Grun.) Cl. P-M-1, 50-60, 80-100.
Neidium distincte-punctatum Hust. P-M-9, 50-60, 120-130.
N. iridis (Ehr.) Cl. P-M-C-1, 0-40, 100-110, 130-160, 170-190, 200-210. S-C-1, 304-350, 390-420, 440-470.
N. iridis var. *amphigomphus* (Ehr.) A. Mayer P-M-9, 180-190.
Nitzschia amphibia Grun. P-M-C-1, 0-10, P-M-C-2, 30-40, 50-60, 70-90, 190-210, P-M-C-3, 40-50, 60-70, 90-110, 130-140, 150-160, P-M-C-4, 110-130, 140-150, 160-170. S-C-2, 430-440, 470-490, 530-540, S-C-3, 390-400, 410-430, 440-470, 500-530, S-C-4, 330-360, 370-390, 400-410, 490-500, S-C-5, 360-370. Coenophil.
N. angustata (W. Smith) Grun. P-M-2, 60-70.
N. hungarica Grun. P-M-1, 80-90.
N. sigmoidea (Nitzsch) W. Smith P-M-1, 80-100, 130-140, P-C-1, 180-190, S-C-1, 370-380.
N. sp. P-M-1, 90-100.
N. thermalis (Ehr.) Auers. P-M-C-1, 0-10, 20-40, 50-60, 80-100, 110-140, 180-190, P-M-C-2, 40-50, 60-70.
N. tryblionella Hantzsch in Rabh. S-C-1, 430-440.
Pinnularia biceps Greg. P-C-1, 200-210.
P. borealis Ehr. P-M-9, 40-50.
Pinnularia borealis var. *rectangularis* Carlson P-M-1, 10-20.
P. clevei Patr. P-M-1, 30-40, 70-80, 100-110, 120-130. Muckbiont.
P. legumen Ehr. P-C-1, 200-210.
P. microstauron (Ehr.) Cl. P-M-1, 0-10, 20-40, 60-70, 80-90, 120-150, 160-170, 200-210, P-M-2, 90-120. S-C-1, 340-360, 370-410, 430-440. Coenophil.
P. streptoraphe Cl. P-C-1, 190-200.
P. subcapitata var. *paucistriata* (Grun.) Cl. P-M-1, 80-100, 110-130.
P. viridis (Nitz.) Ehr. P-M-C-1, 40-50, 60-70, 80-90, 110-130, 180-200, P-M-C-2, 20-30, 90-110, 140-180, 200-210. S-C-1, 340-350, 370-390, *S-C-2, 330-340.* Coenophil.
P. viridis var. *commutata* (Grun.) Cl. P-9, 150-160.
Rhopalodia gibba (Ehr.) O. Muller P-M-C-1, 0-30, 70-90, 100-140, 150-160, 170-210. S-C-1, 340-350, 370-450, 460-480, 490-530, S-C-2, 530-540. Coenophil.
R. parallela (Grun.) O. Muller P-C-1, 160-210, S-C-1, 360-370, 380-390, 410-420, 450-470, S-C-2, 400-410. Calciumbiont.
Stauroneis acuta Wm. Smith P-M-C-1, 20-30, 90-100, 130-140, S-C-1, 450-460, 500-510.
S. anceps f. *linearis* (Ehr.) Hust. P-M-C-1, 20-30, 60-70, 120-130.
S. phoenicenteron (Nitz.) Ehr. P-M-C-1, 40-60, 130-140, 170-180, 190-210. S-C-1, 410-420, 460-470. Coenophil.
Stephanodiscus astraea (Ehr.) Grun. P-M-1, 0-20, P-C-1, 160-170, 190-210, P-C-2, 20-80, 130-160, P-C-3, 80-120. This diatom seems to favor the environment above the calcium rich layer, i.e. higher percentage of the population in counts above the calcium rich layer. However, it may just be of higher percentage because other diatoms have not been in the counts above the calcium rich layer and this diatom took their place in the counts. Eutrophic-meso-saprobic indications.
Stephanodiscus dubius (Fricke) Hust. P-M-1, 80-90.
Surirella augusta Kütz. P-M-1.
S. biseriata var. *bifrons* (Ehr.) Hust. P-M-1, 20-40.
S. brightwellii W. Smith P-M-1, 90-100.
S. linearis W. Smith S-C-1, 500-510.
S. ovata var. *pinnata* (W. Smith) Hust. P-M-C-1, 40-60, 90-100, 120-140, 180-190, P-M-C-1, 60-90. S-C-1, 490-500.
Synedra acus Kütz.
S. amphicephala Kütz. P-M-1, 40-60.
S. capitata Ehr. S-C-1, 340-350, 370-390, 400-430, 440-470, 490-500, 520-530, S-C-2, 390-400, 430-440, 500-510, 530-540.
S. delicatissima W. Smith P-M-1, 100-110, S-C-1, 340-350, 370-380, 390-400, 410-420.
S. parasitia (W. Smith) Hust. P-C-9, 180-190.
S. rumpens Kütz. S-C-1, 340-350, 370-380, 390-400, 410-420.
S. ulna var. *longissima* (Wm. Smith) Brun P-M-C-1, 10-20, 30-60, 80-100, 110-130, 140-150, 160-170, 180-190, 200-210, P-M-C-2, 70-80, 170-180, 190-200. Coenophil. S-C-1, 340-360, 420-470, 490-500, 530-540, S-C-2, 330-340, 370-400, 500-510.
Tabellaria fenestrata (Lyngb.) Kütz. S-C-1, 510-520, 530-540, S-C-2, 500-510.

Vertical distributions of selected common diatom species are shown in figure 3, along with relative $CaCO_3$ contents and relative organic matter contents.

The presence or absence of pollen was noted for each of the samples examined. Many common arboreal and non-arboreal types were recognized, but it was not the intent of this study to undertake a pollen analysis.

DISCUSSION

Hutchinson (1958) suggested that *Cymbella cistula, Epithemia turgida, Fragilaria brevistriata* and *Navicula oblonga* prefer alkaline and shallow standing water. They are abundant in the relatively high $CaCO_3$ percentage zone, and above this level, where $CaCO_3$ percentage is considerably less, their population percentage decreases (Fig. 3). However, this relative decrease in population may have been due to the proportional increase of *Melosira granulata* (Fig. 3) which is presently common in warm water habitats locally. *Fragilaria construens* (Fig. 3), widely distributed in the temperate United States, may indicate the lakes were always shallow. Alkalinity changes and temperature changes in the ecosystem may be the two main factors in population shift at the 1.6 m level in Pillsbury and the 3.3 m level in

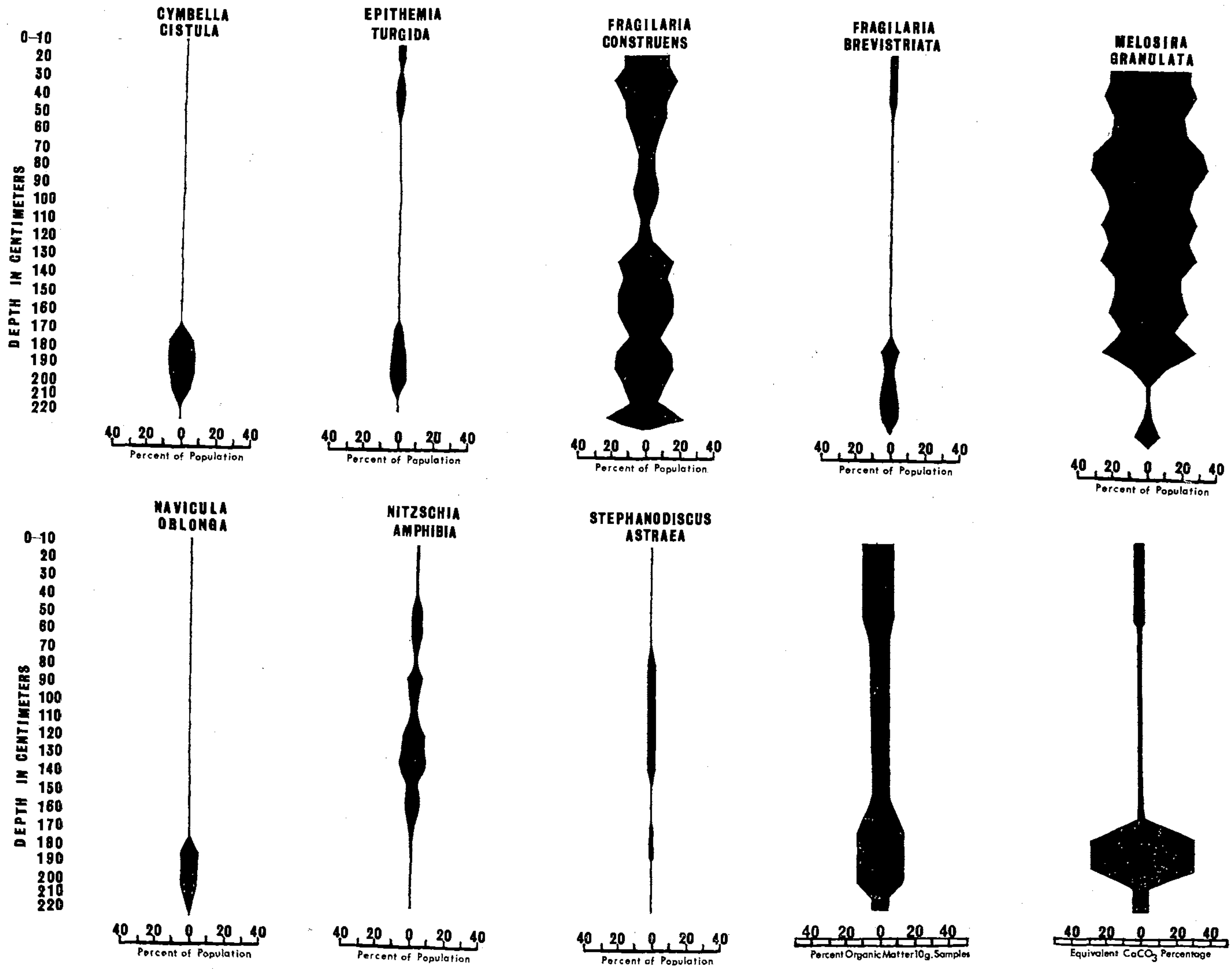

Fig. 3. Diagrams of Pillsbury core from 0-220 cm showing selected diatoms, organic matter and equivalent calcium carbonate.

Sylvan. The presence of *Fragilaria brevistriata*, *Nitzschia amphibia* and *Cocconeis placentula* also may indicate increasing shallowness of the lakes. Pillsbury data (Fig. 3) indicate that *Cymbella cistula* and *Navicula oblonga* may prefer the high $CaCO_3$ percentage zone. *Cymatopleura* spp., *Stephanodiscus astraea, Nitzschia thermalis, Surirella ovata,* and *Hantzschia* spp. prefer the muck or lower $CaCO_3$ zone above the 160 cm level. *Amphora* spp., *Caloneis limosa* and *Nitzschia amphibia* appear indifferent to calcium concentrations while *Epithemia turgida* seems to favor calcium-rich water.

Using the terminology of Fjerdingstad (1950) to interpret the lacustrine sediments studied, it appears that aquatic life started in Pillsbury and Sylvan lakes under eutrophic oligosaprobic conditions and populations changed through time as the lakes became eutrophic mesosaprobic.

The evidence suggests a three-phase history of the formation of these lake beds. The depressions were formed and filled as the glacial ice melted about 10,100± years B.P.

Diatoms present in the earliest sediment deposition suggest a cool climate with a rich nutrient and calcium supply. The evidence also indicates, by the diatom taxa population changes, that the climate may have become warmer after about a quarter of the diatom sediment was deposited. Extrapolation from known radiocarbon dates indicate this change to have occurred about 7,500± years B.P.

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