PLEISTOCENE MOLLUSCAN FAUNAS OF THE SOUDER LAKE DEPOSIT, FRANKLIN COUNTY, OHIO

JOHN CORNEJO[1]

Location of Deposit

The Souder Lake deposit is located at 82° 50' 09" west longitude and 40° 00' 10" north latitude in Jefferson Township, Franklin County, Ohio; Westerville Quadrangle, section 3, approximately 2.4 miles southeast of Gahanna, Ohio and 0.3 mile northwest of the intersection of Taylor Road and Taylor Station Road (See Fig. 1).

Methods of Investigation

The north side of a small island in the approximate west center of Souder Lake was the most favorable location for fossil collecting. Here, a hole 7 X 4 X 5 feet was excavated; a vertical column 1 X 1 foot was collected in two-inch layers; this thickness was varied (collections 1, 2, 19) to prevent a collection crossing a stratigraphic boundary. Collections (two-inch layers) were made to the bottom of the column, a non-fossiliferous gravel. Fossils too far down to remove by digging were recovered with a bayonet auger. The collections were carried and stored in plastic bags. Later, they were washed in a series of sieves of 2.5, 9, 20, and 40 mesh. The remaining material was dried and stored in pint containers.

The volume of each collection was reduced with the aid of the Jones splitter. A representative fraction of the total collection was taken and its volume measured in cubic centimeters, labeled and placed in containers for further use. One thousand shells were then picked from randomly selected portions of each representative fraction and the volumes of the sorted and unsorted material were recorded. Collections 15 to 19 did not contain 1,000 shells. By adding the volume of sorted and unsorted material and then subtracting this figure from the volume of the total fraction, the volume occupied by the shells was obtained. The shells were identified to species and the total number of shells in the whole collection (before splitting) was determined. The volume occupied by the shells and organic material in the total collection was also noted. The percent of abundance of each species determined on the basis of total individuals sorted in a particular collection was also recorded.

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1 Formerly Department of Geology, Ohio State University, now Department of Geology, Iowa State University, Iowa City, Iowa. This paper is based on a M.S. thesis in the Department of Geology, Ohio State University.

Stratigraphy

The Souder Lake deposit is situated within an area of till which forms gently rolling topography. At present the area is sparsely vegetated and is used primarily for farming. The till covers a complex system of glacial deposits which overlie bed rock of shale or sandstone (Schmidt, 1958, p. 39). The glacial deposits vary from a few feet to over 90 feet in thickness. The general drainage of the area is to the west into Big Walnut Creek.

The Souder Lake deposit lies within a shallow asymmetrical kettle hole which rests on gravel. The maximum length of the deposit is 1,850 feet in a north-south direction, and the width is 850 feet in an east-west direction. The area covered is approximately 27.7 acres with a depth of 30 feet. However, the water in the lake was never 30 feet deep at any one time; rather, it gradually attained that thickness as the lake filled, causing the water to rise slowly. The lake was fed by precipitation and surface runoff from the surrounding area. A persistent layer of clay initially deposited over the bottom of the lake prevented any inflow of groundwater. When the lake first filled, it had an outlet flowing to the southwest into Big Walnut Creek; then, as the lake ponded, the original outlet was dammed and another outlet was opened several hundred feet to the south. This outlet drained the area for only a short time before it too became dammed, possibly by encroaching vegetation. The lake deposits dip sharply away from an island-like mound just west of the center of the lake. This island formed somewhat of a barrier between shallow and deep waters, even though its center was only a few feet across. The lithologic units of the Souder Lake deposits vary in thickness from section to section. Generally, most of the units are discontinuous; they thin out and grade into one another. The peat, clay, and humus units are continuous and occur throughout the deposit. The peat unit is the least fossiliferous, but it is by far the most extensive and thickest, reaching a thickness of approximately one foot. At most points this unit rests directly on gravel. The humus layer varies from a thickness of a few inches to more than one foot. The humus is noticeably disturbed in places, but it rests on undisturbed humus of the same nature. The most fossiliferous unit of the deposit is the peaty clay. This unit generally attains a thickness of 2 feet, but in many sections it is less. The other units vary greatly in thickness and in abundance of shell material. Most of these units appear to be lenticular and of no great significance.

Measured Section

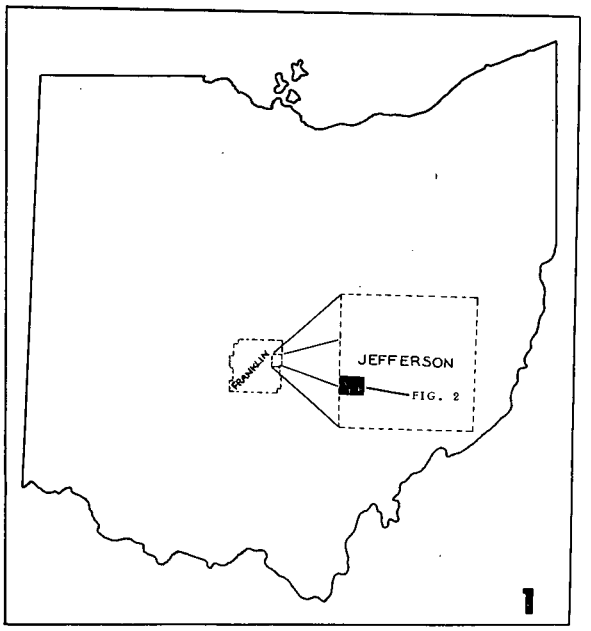
All sections were sampled by means of a bayonet auger with the exception of section 1, the main collecting station (M.S. on fig. 2), where detailed sampling was done at two-inch intervals. Other collections were made at regular intervals on four traverses radiating from section 1; therefore, only section 1 is described in detail, while all other sections are graphically depicted in figure 2.

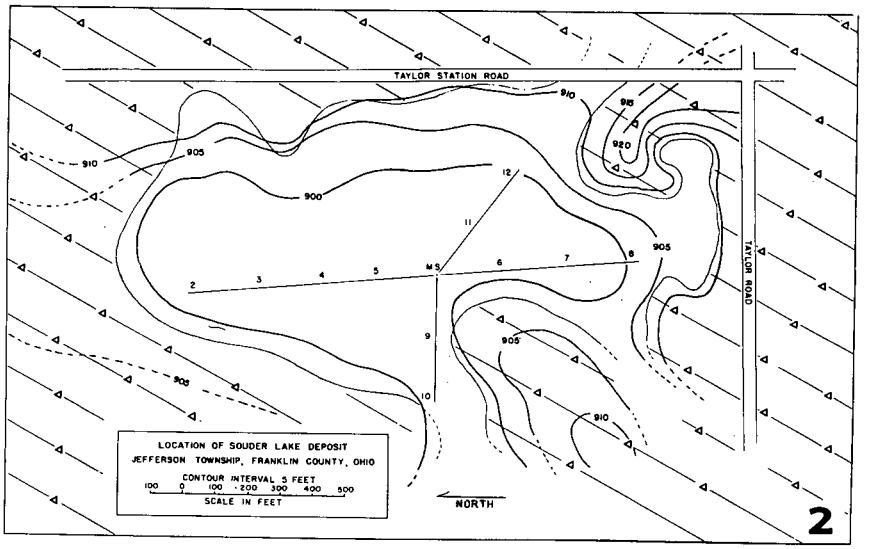
DESCRIPTION OF FIGURES 1-3, OPPOSITE PAGE

Fig. 1 Index Map showing the location of the Souder Lake Deposit.

Fig. 2 Map of the Souder Lake Deposit.

Fig. 3 Approximate total number of individuals in each collection of the Souder Lake Deposit.





Unit	Coll. No.	Thickness (inches)	Total No. Individuals	Comparative Abundance	Graphic Representation of Comparative Abundance (Thousands) 10 20 30
7	19	3	758	758	
6	18	2	287	287	
	17	2	103	103	
5	16	2	27	27	
4	15	2	775	775	
	14	2	19,200	19,200	
3	13	2	19,440	19,440	
	12	2	28,800	28,800	
	11	2	19,090	19,090	
	10	2	15,580	15,580	
	9	2	30,000	30,000	
	8	2	19,040	19,040	
	7	2	20,370	20,370	
	6	2	16,300	16,300	
	5	2	16,800	16,800	
	4	2	17,140	17,140	
	3	2	29,140	29,140	
2	2	1	7,870	15,740	
1	1	1	1,370	2,740	

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Section 1

Unit	Description	Thickness (inches)
7	Humus, black, disturbed, fossiliferous	3
6	Humus, black, undisturbed, fossiliferous	4
5	Humus, blackish brown, undisturbed, fossiliferous	2
4	Peat, light to dark brown, fossiliferous	4
3	Peat, clayey, dark brown to black, fossiliferous	22.25
2	Clay, peaty, bluish gray with lenses of light brown color, fossiliferous; unit wedges out laterally; the thickest portion is	1.25
1	Clay, blue gray, fossiliferous, resting on gravel; unit wedges out laterally; the thickest portion is	2
0	Gravel, bluish gray, no fossils found, forms base of section and is of undetermined thickness.	

Quantitative Distribution

The Souder Lake deposit consists of seven fossiliferous units containing 28 species of Mollusca. These species include pelecypods and both aquatic and terrestrial gastropods. An examination of other sections collected within the deposit does not reveal any outstanding variations in variety or number of species as compared with the collections made at the main collecting station (section 1); therefore, only the specimens found in the collections of section 1 will be referred to in the remainder of this paper.

Variation in Numbers

The approximate numbers of shells present in the various collections are listed in figure 3. Although all collections taken were of uniform area, collections 1, 2, and 19 were of varying thicknesses; therefore, the comparative abundance of shells present has been listed and the numbers have been adjusted for the various collections.

Unit 1 (fig. 3), a blue clay, contains 15 species which include both pelecypods and gastropods, but not in great numbers; however, one species, *Valvata tricarinata*, makes up over 50 percent of the entire unit. Unit 2, which is composed of peaty clay, shows an increase in the number of species present and in their abundance. Unit 3 (collections 3 to 13), consists of clayey peat and is by far the largest and most fossiliferous. The first collection of unit 3 (collection 3) shows an increase in numbers over unit 2 (collection 2). There is a gradual and fluctuating decrease to collection 4; then a gradual increase to collection 7, in which the number and abundance of species reaches a maximum for the entire section. It is in collection 7 that the one terrestrial species (*Euconulus* cf. *E. fulvus*) occurs. From this collection (7) to the last one (13) the number of individuals fluctuates from 15,580 (collection 10) to 19,200 (collection 13).

Units 4, 5, and 6 composed respectively of peat, blackish brown humus, and black humus, show a distinct decrease in the number of species present and in their abundance. Unit 7, which is composed of disturbed black humus, continues to show a decrease in the number of individuals. Even though this unit is disturbed, it serves to establish a general trend for the abundance of individuals.

Comparative Abundance of Groups

The various groups discussed include gastropods (freshwater pulmonates, gill-breathers, and a terrestrial species) and pelecypods (Sphaeriidae).

The freshwater pulmonates are common throughout the seven units of section 1. This group composes 16.2 percent of unit 1 (collection 1), and it gradually increases to 22.9 percent (collection 9) in unit 3. The group then shows a gradual decrease to 16.9 percent (collection 19) in unit 7. The freshwater pulmonates include 11 of the 15 species of gastropods present in the Souder Lake deposit; however, their optimum environmental conditions were never fully attained as indicated by the greatest percentage attained, a mere 22.9 percent in unit 3.

The gill-breathers include only three species of gastropods; however, these make up the greatest percentage of population wherever present. In unit 1 (collection 1) the gill-breathers compose 80.6 percent of the total population. The group then gradually decreases to unit 3 (collection 9) where it only composes 55.3 percent of the population. In collection 10 of unit 3, the percentage increases to 67.7 percent, but it continues to decrease to 46.1 percent in unit 7 (collection 19). Although represented by only three species, this group flourished in the highly favorable environment provided by the Souder Lake waters.

The only land gastropod found in section 1 of the deposit occurs in unit 3 (collection 15). This species is represented by only one broken specimen and is discussed later.

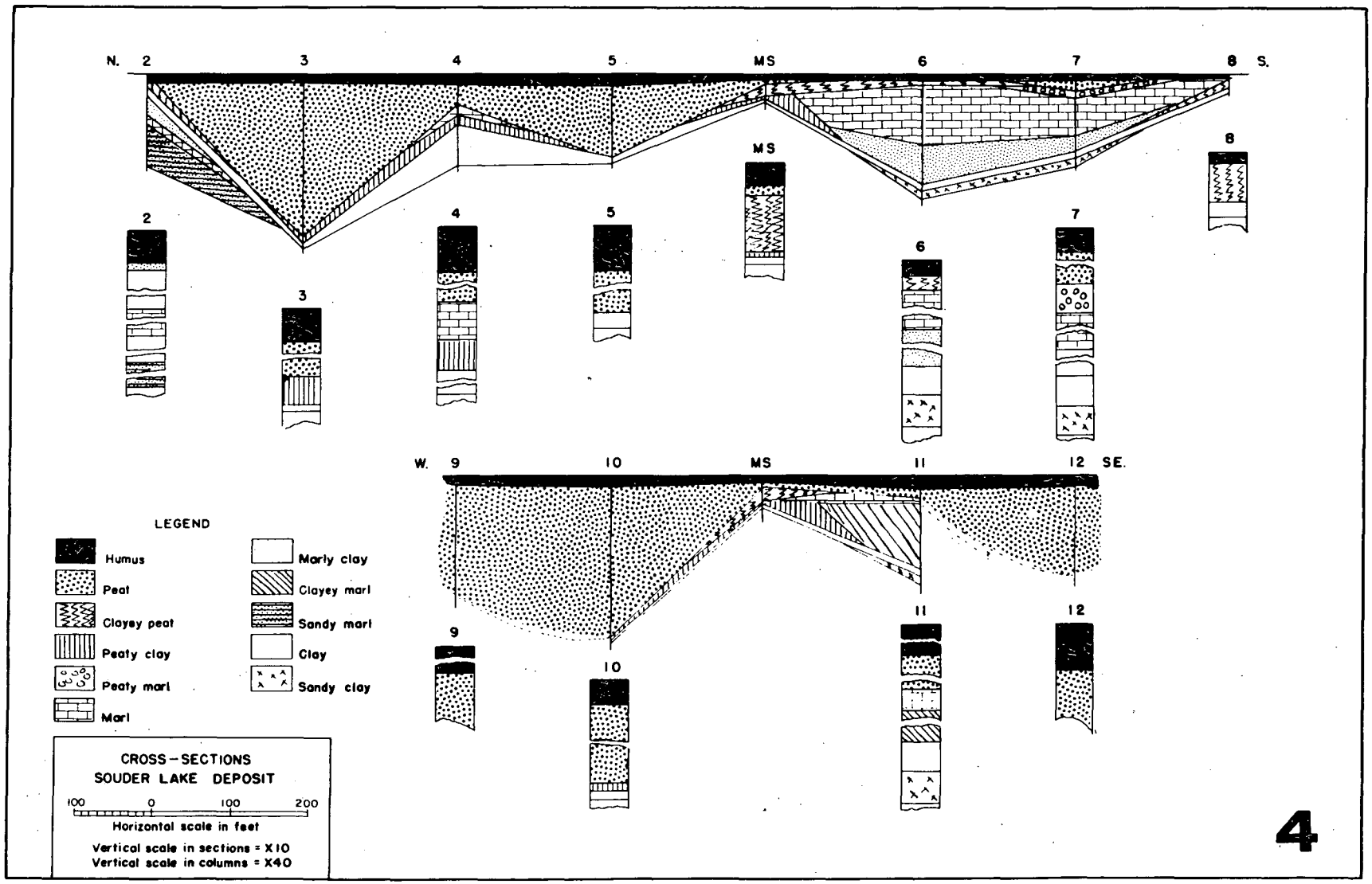
The Sphaeriidae, which include species of *Pisidium* and *Sphaerium*, are present in every collection of the deposit but they are not particularly abundant and only attain a maximum of 14.0 percent in collection 10. The species identified were, in many cases, represented only by separate valves rather than by whole specimens.

Comparative Abundance of Species

INDIGENOUS SPECIES. Eleven species of aquatic pulmonates are present in section 1 of the Souder Lake deposit; only one of these, *Gyraulus altissimus* (F. C. Baker), is considered significant. This species is present in all collections, rarely making up more than 19.0 percent or less than 15.0 percent of any one collection. The greatest percentage attained is 19.9 percent in unit 3 (collection 7), the lowest is 0.4 percent in unit 5 (collection 16). From unit 5, the percentage increases to 16.8 percent in collection of unit 7 (See fig. 8).

DESCRIPTION OF FIGURE 4, OPPOSITE PAGE

Fig. 4 Cross-sections of the Souder Lake Deposit.


N.
2
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MS
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12
SE.
LEGEND
Humus
Peat
Clayey peat
Peaty clay
Peaty marl
Marl
Marly clay
Clayey marl
Sandy marl
Clay
Sandy clay
CROSS-SECTIONS
SOUDER LAKE DEPOSIT
100 0 100 200
Horizontal scale in feet
Vertical scale in sections = X10
Vertical scale in columns = X40

4

All three species of gill-breathers present in section 1 are considered significant since they make up the major portion of any one collection or unit. The three species are Valvata tricarinata (Say), Amnicola leightoni F. C. Baker, and A. lustrica Pilsbry. Valvata tricarinata (Say) composes 50.6 percent of the population in unit 1 (collection 1). Units 2, 3, and 4 show a fluctuating decrease to unit 5 (collection 16) where the species is represented by only 1.4 percent. Units 6 and 7 show an increase to 18.1 percent in collection 19 of unit 7. Comparative abundance of this species is shown in figure 5. Amnicola leightoni F. C. Baker first appears in collection 6 of unit 3 where it composes 0.8 percent of the population. From collection 6 (unit 3) to 15 (unit 4), the species shows a gradual increase to 20.4 percent; next, the species suddenly decreases to 0.2 percent in collection 16 of unit 5. Finally, the abundance gradually increases to 7.2 percent in collection 18 of unit 7 (see fig. 6). Amnicola lustrica Pilsbry makes up 30.0 percent of unit 1 then gradually increases to 40.5 percent in collection 14 of unit 4. The species then decreases to a low of 0.3 percent in unit 5 (collection 16) and again gradually begins to increase to 20.5 percent in collection 19 of unit 7 (See fig. 7).

Although 13 species of Sphaeriidae are present in the Souder Lake deposit, only three of them, Pisidium compressum Prime, P. nitidum nitidum Jenyns, and P. nitidum pauperculum Sterki, are considered significant. Pisidium compressum Prime is present in every collection of section 1, even if not in abundance. In unit 1, collection 1, the species composes 1.65 percent of the population. The species decreases to 0.55 percent in collection 8 (unit 3), increasing to 2.7 percent in collection 14 (unit 4). From this point the species decreases to unit 5, where it is represented by only 0.02 percent. From collection 16 to 19 the species gradually increases to 1.6 percent. Pisidium nitidum nitidum Jenyns occurs in all collections except 16, and it is the most abundant species of Sphaeriidae present in section 1. In unit 1 the species makes up 2.95 percent of the individuals, gradually increasing to 9.5 percent in unit 3 (collection 10). From this collection, the species decreases to collection 16 where no specimens were found. From collections 16 to 19, the species begins a slight increase to 3.1 percent in collection 19 of unit 7. Pisidium nitidum pauperculum Sterki occurs in all units except collection 1. In unit 2 the species is represented by 0.01 percent, gradually increasing to 1.7 percent in collection 13 of unit 3. Units 3 to 7 show a numerical variation between 5.55 (collection 14) and 0.1 percent (collection 17).

INTRUDERS. The species in this category occur in such small numbers or so sporadically that they are considered to be insignificant intruders. Although the aquatic pulmonates display the greatest number of species, ten of the eleven identified are considered intruders. These are Fossaria obrussa obrussa (Say), F. obrussa decampi (Streng), Physa gyrina Say, Promenetus exacuous (Say), Helisoma anceps striatum (F. C. Baker), H. campanulatum (Say), H. trivolvis (Say), Gyraulus crista (Linnaeus), Ferrissia parallela (Haldeman), and Acella haldemani ("Deshayes" Binney). Fossaria obrussa obrussa (Say) occurs only in units 3 and 4 of section 1. In four of the collections (8, 10, 11, 14) where it occurs, it composes only 0.1 percent of the total population. In collection 13 (unit 3) it makes up 0.2 percent of the individuals; however, in collection 15 (unit 4) it reaches a maximum of 0.8 percent. F. obrussa decampi (Streng) occurs in only two collections; in both of these collections, the species is represented by only one specimen. Physa gyrina Say occurs in units 1 (collection 1), 2 (collection 2), 3 (collections 3 to 8, 10 to 13), 4 (collection 14), and 7 (collection 19). The percentage of this species ranges from 2.9 in collection 11 of unit 3 to a low of 0.3 in collection 15 of unit 4; all other occurrences fall between these. Promenetus exacuous (Say) is present in all collections except 16 (unit 5). Though present in many collections, this species only attains a high of 2.4 percent in collection 4 of unit 3 and ranges to a low of 0.1 percent in collection 17 of unit 6. Helisoma anceps striatum

(F. C. Baker) exists in all collections except 16 (unit 5). This persistent species ranges from a high of 2.9 percent in collection 6 (unit 3) to a low of 0.1 percent in collections 17 and 18 (unit 6). H. campanulatum (Say) is present in collections 3 to 7 and 12 of unit 3. Its highest percentage attained is only 0.4 in collection 7, then it falls to 0.2 in collections 5, 6, and 12. H. trivolvis (Say) is a little more abundant and occurs in units 3, 4, 6, and 7. Its percentage ranges from 0.5 (collection 12) to 0.1 (collections 4, 9, 13, 14, 18, 19). Gyraulus crista (Linnaeus) is present only in one collection of section 1. It is represented by two specimens in collection 6 of unit 3. The species Ferrissia parallela (Haldeman) is present in all collections except 16 and 17. This species is consistent in its abundance, generally making up about 0.4 percent of any one population. The percentages for this species range from 1.5 in collection 6 to 0.1 in collection 1. The delicate species Acella haldemani ("Deshayes" Binney) only occurs in units 2, 3, and 4. Most of the specimens found were immature forms or pieces of adults. The percentages range from 0.4 in collections 4, 5, and 10 to 0.1 in collections 2, 6, 12, 13, and 14.

The only land snail, Euconulus cf. E. fulvus (Müller), occurs in section 1 and forms less than 1.0 percent of the population in which it occurs (collection 15, unit 4); therefore, it is considered to be insignificant.

The following Sphaeriidae are considered to be intruders: Pisidium adamsi Prime, P. casertanum (Poli), P. ferrugineum Prime, P. obtusale ventricosum Prime, P. mainense Sterki, P. variabile Prime, P. walkeri Sterki, Sphaerium lacustre (Müller), S. lacustre ryckholti (Normand), and S. rhomboideum Say. P. ferrugineum is present in collections 2 to 15 and 19. The species occurs in collection 2 where it makes up 0.4 percent of the individuals, and it fluctuates to 1.0 percent in collection 11. From this point, the species decreases to 0.3 percent in collection 14. P. obtusale ventricosum Prime is present in all collections except 1 and 16. The highest percentage attained is 1.4 in collection 5, and the lowest percentage is 0.1 in collection 17. All other species of Sphaeriidae form less than 1.0 percent of the collection in which they occur; therefore, no particular significance is attached to their presence, and they are only noted in passing.

Paleoecology

GENERAL STATEMENT. The information on ecology presented here has been condensed, modified and paraphrased from the literature. To simplify this paper only those species which are considered indigenous and numerically important are discussed. Data on the remaining species has been summarized in figures 10, 11, and 12.

DESCRIPTION OF FIGURES 5-8, OPPOSITE PAGE

Fig. 5 Quantitative distribution of Valvata tricarinata (Say) in the Souder Lake Deposit.

Fig. 6 Quantitative distribution of Amnicola leightoni F. C. Baker in the Souder Lake Deposit.

Fig. 7 Quantitative distribution of Amnicola lustrica Pilsbry in the Souder Lake Deposit.

Fig. 8 Quantitative distribution of Gyraulus altissimus (F. C. Baker) in the Souder Lake Deposit.

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS (10 20 30 40 50)
19	184	18.4	
18	151	15.1	
17	56	5.6	
16	14	1.4	
15	131	13.1	
14	118	11.8	
13	119	11.9	
12	74	7.4	
11	75	7.5	
10	68	6.8	
9	112	11.2	
8	112	11.2	
7	102	10.2	
6	101	10.1	
5	180	18.0	
4	280	28.0	
3	308	30.8	
2	279	27.9	
1	506	50.6	

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COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS (10 20 30 40 50)
19	72	7.2	
18	20	2.0	
17	12	1.2	
16	2	0.2	
15	204	20.4	
14	151	15.1	
13	137	13.7	
12	92	9.2	
11	59	5.9	
10	66	6.6	
9	59	5.9	
8	53	5.3	
7	31	3.1	
6	8	0.8	
5	0	0.0	
4	0	0.0	
3	0	0.0	
2	0	0.0	
1	0	0.0	

6

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS (10 20 30 40 50)
19	205	20.5	
18	55	5.5	
17	12	1.2	
16	3	0.3	
15	173	17.3	
14	405	40.5	
13	394	39.4	
12	470	47.0	
11	526	52.6	
10	543	54.3	
9	482	48.2	
8	524	52.4	
7	493	49.3	
6	489	48.9	
5	381	38.1	
4	378	37.8	
3	406	40.6	
2	416	41.6	
1	300	30.0	

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COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS (10 20 30 40 50)
19	168	16.8	
18	42	4.2	
17	14	1.4	
16	4	0.4	
15	147	14.7	
14	161	16.1	
13	185	18.5	
12	196	19.6	
11	163	16.3	
10	161	16.1	
9	192	19.2	
8	162	16.2	
7	199	19.9	
6	189	18.9	
5	194	19.4	
4	197	19.7	
3	166	16.6	
2	168	16.8	
1	122	12.2	

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Pelecypods

The "fingernail clams" (Sphaeriidae) are of such complex morphology that few workers have attempted to identify their shells. Most identifications are generic only and they completely ignore the ecological aspects of the animals. As a result, relatively little information is available concerning the ecology of the many species of Sphaeriidae. Some approximations can be made by comparing those species on which little or no information is available with closely related species of known ecology, then drawing inferences from the latter.

Some species of Sphaeriidae are present in almost every body of water, except those in which conditions are so unfavorable that nothing could live. Some members of this family are known to live in bodies of water that dry up during part of the year. These species escape desiccation by burrowing into the substratum, but even then, few survive, and those that do are usually the young.

Under favorable conditions the adults burrow into the bottom, while the young actively crawl over the vegetation. The animals feed on algae, plant debris and microscopic organisms. They in turn are food for such freshwater fish as the Whitefish, Common Bullhead, Freshwater Killy, Pumpkinseed, and Sheepshead.

Pisidium compressum Prime. This animal is almost entirely restricted to creeks and rivers; it is rarely listed as living in lakes and ponds. The species can live on a variety of bottoms which include mud, clay, sand, and gravel and occurs most commonly in water up to 3 m. deep. The most frequently associated plants are Scirpus, Pontederia, Castalia, Nymphaea, and Potamogeton. The pH varies from 7.0 to 8.37 with a fixed carbon dioxide ratio of 9.3 to 30.56 p.p.m. (See figs. 10, 11, and 12).

Pisidium nitidum nitidum Jenyns. This species is known from small bodies of shallow water from 1 to 6 m. deep. It has been reported from a variety of bottoms including mud, sand, gravel, and boulders. The pH and fixed carbon dioxide ratio of the species are not listed but those of its synonyms are here given (see figs. 10, 11, and 12): P. minusculum: pH varies from 7.48 to 7.64 with a fixed carbon dioxide ratio of 12.96 to 18.87 p.p.m.: P. splendidulum: pH is 6.32 with fixed carbon dioxide ratio of 1.98 p.p.m.

Pisidium nitidum pauperculum Sterki. This subspecies, once considered a distinct species, is now believed to be a form of P. nitidum. This subspecies seems to prefer quiet, shallow water and mud or sand bottoms. Specific occurrences are: mud bottom, water 1.5 m. deep; sand and gravel bottom, water 1.5 to 1.7 m. deep; sandy mud bottom, water 1.2 to 3.4 m. deep; gravel bottom, water shallow; dredged from a marly clay bottom at depths of 10, 12.5, and 39.5 m. (animal dead). It has also been found in water containing algae such as Oedogonium and Cladophora. The pH varies from 7.0 to 8.0 and the fixed carbon dioxide ratio is 9.3 to 24.73 p.p.m. This subspecies probably parallels P. nitidum nitidum in its environment (see figs. 10, 11, and 12).

Freshwater Gastropods

Valvata tricarinata (Say). V. tricarinata is known from rivers, lakes, and permanent ponds, and from Pleistocene deposits. It exhibits a wide tolerance in its environmental requirements which have been summarized by Reynolds (1958, p. 160). (See figs. 5, 10, 11, and 12).

Amnicola leightoni F. C. Baker. This apparently extinct species was a lake inhabitant and is commonly found in the marl deposits of Michigan, Wisconsin, Illinois, Indiana, and Ohio. Though little is known of this species, its ecology can be inferred to some degree from a related living species, A. limosa, and a common associate A. limosa porata.

A. limosa Say. This most widely distributed species, and its lake form A. limosa porata, are found in lakes, streams, creeks, rivers, and fresh and brackish water lakes, or in any body of water where pollution or silt has not been an agent in prohibiting its existence. This species has been reported from waters varying in depth from 32 meters and from all types of bottoms. It occurs most abundantly in zones of vegetation such as Potamogeton, Utricularia, Vallisneria, Chara, Myriophyllum, Castalia, Nymphaea, Pontederia, and Elodea, and in areas where the water is relatively shallow. The pH is 7.95, and the fixed carbon ratio is 30.56 p.p.m. (see figs. 10, 11, and 12).

Amnicola lustrica Pilsbry. This common species is known from rivers and lakes. It has been collected from protected bays and on sandy bottoms in water ranging from 3 to 12 meters deep. It has also been less abundantly collected on marly bottoms and rarely on bouldery exposed points. In one occurrence, it is reported to have been dredged from 20 fathoms of water. This species commonly lives on vegetation such as Vallisneria, Potamogeton, and Chara, and is particularly abundant in filamentous algae. It lays its eggs on plants, most commonly on Vallisneria. This species probably feeds on the plants mentioned above, as well as on microscopic organisms and algae. The pH and fixed carbon dioxide ratio of this species are nowhere specifically stated, but it is possible to infer them from the values given for a close relative, A. lustrica decepta. The pH for this variety is 6.85 to 8.37, and its fixed carbon dioxide ratio varies from 9.3 to 30.56 p.p.m.; therefore, one can assume that the values for A. lustrica fall within the range of those listed for A. lustrica decepta.

Gyraulus altissimus (F. C. Baker). This once flourishing Pleistocene snail, which was believed to be extinct, is now known from at least two different areas in northern latitudes. However, there is insufficient information to determine the environment of this species. Therefore, its ecology will be inferred from a related species and from an assemblage in which it is a commonly occurring member.

In this deposit, as well as in others, G. altissimus is associated with Helisoma campanulatum, H. anceps striatum, Physa gyrina, and Fossaria obrussa decampi. These species all occur in ponds or small lakes, and their specific ecology is given elsewhere in this paper. In the above associations, it is interesting to note that few, if any, other species of Gyraulus are present wherever G. altissimus occurs. One species, G. parvus, does occur in some degree of abundance and has the same general pH and fixed carbon dioxide ratio as the rest of the associated assemblage.

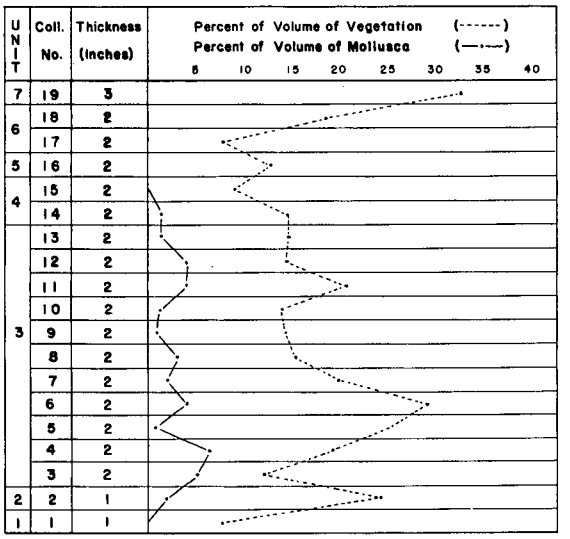
DESCRIPTION OF FIGURES 9-12, OPPOSITE PAGE

Fig. 9 Variation in relative abundance of vegetation and mollusks.

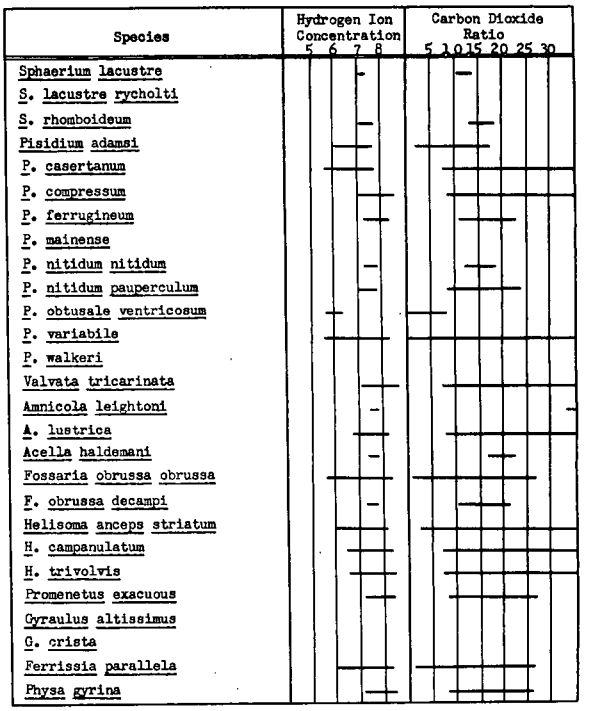
Fig. 10 Relation of Mollusca to water conditions.

Fig. 11 Relation of Mollusca to nature of water body.

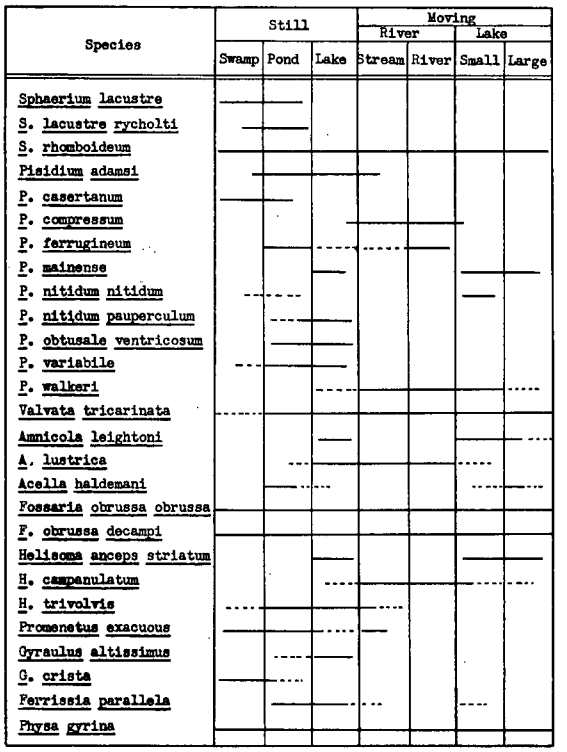
Fig. 12 Relation of Mollusca to character of bottom and depth of water.


UNIT
Coll. No.
Thickness (inches)
Percent of Volume of Vegetation (------)
Percent of Volume of Mollusca (—·—)
5 10 15 20 25 30 35 40
7 19 3
6 18 2
17 2
5 16 2
4 15 2
14 2
3 13 2
12 2
11 2
10 2
9 2
8 2
7 2
6 2
5 2
4 2
3 2
2 2 1
1 1 1

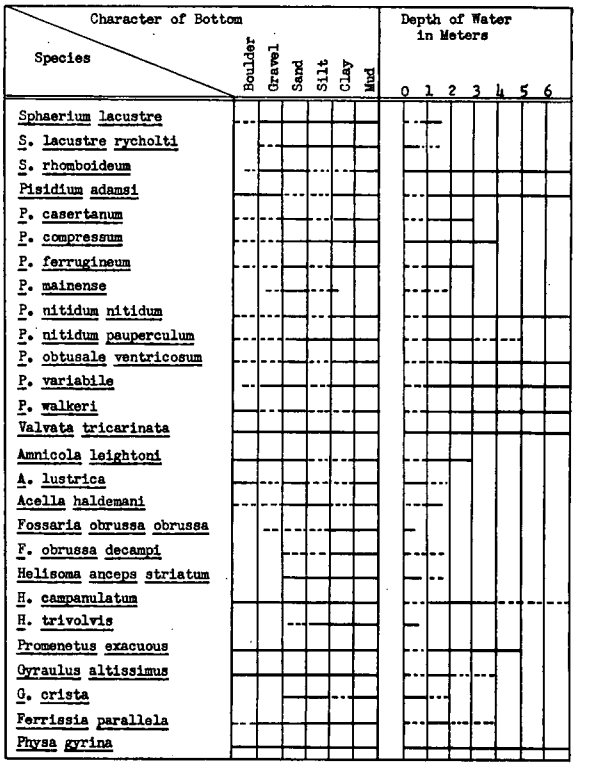
9


Species
Hydrogen Ion Concentration
5 6 7 8
Carbon Dioxide Ratio
5 10 15 20 25 30
Sphaerium lacustre
S. lacustre rycholti
S. rhomboideum
Pisidium adamsi
P. casertanum
P. compressum
P. ferrugineum
P. mainense
P. nitidum nitidum
P. nitidum pauperculum
P. obtusale ventricosum
P. variabile
P. walkeri
Valvata tricarinata
Amnicola leightoni
A. lustrica
Acella haldemani
Fossaria obrussa obrussa
F. obrussa decampi
Helisoma anceps striatum
H. campanulatum
H. trivolvis
Promenetus exacuous
Gyraulus altissimus
G. crista
Ferrissia parallela
Physa gyrina

10


Species
Still
Swamp Pond Lake
Moving
River
Stream River
Lake
Small Large
Sphaerium lacustre
S. lacustre rycholti
S. rhomboideum
Pisidium adamsi
P. casertanum
P. compressum
P. ferrugineum
P. mainense
P. nitidum nitidum
P. nitidum pauperculum
P. obtusale ventricosum
P. variabile
P. walkeri
Valvata tricarinata
Amnicola leightoni
A. lustrica
Acella haldemani
Fossaria obrussa obrussa
F. obrussa decampi
Helisoma anceps striatum
H. campanulatum
H. trivolvis
Promenetus exacuous
Gyraulus altissimus
G. crista
Ferrissia parallela
Physa gyrina

11


Character of Bottom
Species
Boulder Gravel Sand Silt Clay Mud
Depth of Water in Meters
0 1 2 3 4 5 6
Sphaerium lacustre
S. lacustre rycholti
S. rhomboideum
Pisidium adamsi
P. casertanum
P. compressum
P. ferrugineum
P. mainense
P. nitidum nitidum
P. nitidum pauperculum
P. obtusale ventricosum
P. variabile
P. walkeri
Valvata tricarinata
Amnicola leightoni
A. lustrica
Acella haldemani
Fossaria obrussa obrussa
F. obrussa decampi
Helisoma anceps striatum
H. campanulatum
H. trivolvis
Promenetus exacuous
Gyraulus altissimus
G. crista
Ferrissia parallela
Physa gyrina

12

The ecology of G. altissimus has been inferred from that of G. arcticus, which lives in small lakes with quiet water and abundant vegetation; however, this species is probably restricted to Greenland. Consequently, G. parvus, of which more is known and which is believed to be replaced by G. altissimus in Pleistocene deposits, is used to infer the environmental conditions of G. altissimus.

G. parvus. This is a common species of quiet, shallow water that is found on all types of bottoms in protected areas with an abundance of vegetation. Some specific occurrences are listed in bodies of water approaching pond conditions, in an open harbor, from an old pond, on mud bottoms and debris and on vegetation. In general, this species is restricted to water 1.8 to 3.0 m. deep and is associated with plants such as Myriophyllum, Potamogeton, Castalia, Nymphaea, Decodon, and Typha, and with algae such as Vaucheria, , Oedogonium, Spirogyra, or Cladophora. This species has the ability to burrow into the substratum to prevent desiccation and can remain out of water for long periods of time. This species probably feeds on algae, plant remains and microscopic organisms found on or near the plants.

Nature of Environment

GENERAL STATEMENT. All the information discussed in the following statements, and all conclusions made, refer to conditions at section 1, which was the only section in which control was possible. This section is located near the western shore of the lake; therefore, it gives only a limited picture of the events in the history of Souder Lake. Nevertheless, general inferences made from section 1 apply to the major events of the main area of the lake.

The Souder Lake deposit was formed in a small, shallow kettle hole lake that was fed by runoff water from the surrounding terrain and by rainfall. A list of the species found in section 1 shows 27 species of aquatic mollusks as compared to one land snail, thus indicating a freshwater aquatic environment.

After initiation (see figs. 4 and 9) the lake began to fill; first with sediments, then with vegetation. Soon, plants captured the entire area, reducing it first to pond-like, then to swamp conditions and finally to its present condition of a poorly drained farm field.

The ecology of the one land snail (Euconulus cf. E. fulvus) and its normal associations indicate that many more terrestrial species should be present. The lack of land snails is assumed to be due to the location of section 1.

Vegetation

Figure 9 shows the relationship between the abundance of mollusks and the amount of vegetation. Dawson (1911, p. 29) states that mollusks must have a moderate amount of vegetation for optimal environmental conditions. The plants aerate the water and they provide food and anchorage for many mollusks. The mollusks are destroyed when the vegetation becomes too luxuriant, except where there is deep water or some water above the vegetation.

The relationship between the mollusks and the vegetation of Souder Lake shows the above statement to be true in the deposit. The greatest occurrence of mollusks accompanies small to

moderate amounts of vegetation. This was near the bottom in all sections. As vegetation became more abundant in the upper units, the occurrence of snails progressively decreased until finally the lake was completely occupied by plants, and very few snails survived.

Probable Hydrogen Ion Concentration

The pH and fixed carbon dioxide ratio for this section varied slightly from unit to unit. The general pH range for the individual units is between 6.0 and 9.0. Hutchinson (1957, p. 690) states that this is the usual range of present-day lakes. The figures for the determination of the pH and fixed carbon dioxide ratio were derived from the significant species in each fossil bearing unit. The ranges for the individual units are presented in table form (see figs. 10-12) and are discussed in the environmental history of the lake.

Significant Species

The significant species are those which are considered to be indigenous and persistent and those whose numerical fluctuations reflect, to some extent, changes in environmental conditions. These include Valvata tricarinata, Gyraulus altissimus, Amnicola leightoni, A. lustrica, Pisidium compressum, P. nitidum nitidum, and P. nitidum pauperculum. Other species which probably could be considered indigenous, but which occur in such small percentages that little, if any, information can be gathered from their presence, include Physa gyrina, Ferrissia parallela, Promenetus exacuous, Helisoma anceps striatum, Pisidium ferrugineum, P. obtusale ventricosum, and Sphaerium lacustre, the latter mostly in the neplonic stage. Therefore, only those species will be used that occur in relatively large numbers and whose numerical variations reflect changes in the environment, namely Valvata tricarinata, Gyraulus altissimus, Amnicola leightoni, and A. lustrica.

Environmental History

UNIT ONE. The clay of this unit formed a favorable environment for the existence of mollusks and marked the greatest development of Souder Lake. During this time, water from the surrounding areas ran into the basin of the lake which was progressively filling with vegetation. As the vegetation became more abundant, it filled the lower portions of the basin; thus, the water level rose while the water depth decreased (see fig. 4).

After the initial invasion of mollusks into Souder Lake, 13 species occupied the bottom formed by the clay. The significant species were Valvata tricarinata, Gyraulus altissimus, and Amnicola lustrica. These species constituted over 92 percent of the total population, and Valvata tricarinata constituted over 50 percent of this total. Conditions at this time were very favorable for the existence of gill-breathers and were probably as follows: water shallow, approximately 2 m. deep, with a clay bottom on which little or no vegetation was growing; pH varied from 7.1 to 8.16 with a fixed carbon dioxide ratio of 6.8 to 8.0 p.p.m.

UNIT TWO. The lake soon reached its maximum extent and all lateral growth ceased. Then the vegetation, which had continued to fill the main portion of the lake, began to encroach upon the remaining open shore areas as indicated by the peaty clay of this unit. The prominent species of this unit were the same as those of unit 1, except that conditions were now more favorable for

the existence of large quantities of Amnicola lustrica which formed over 40 percent of the total population. The three significant species, previously listed, formed 86 percent of the total population. The approximate conditions of the water were: 1 to 2 m. deep, pH ranging from 7.0 to 8.37, fixed carbon dioxide ratio varying from 8.0 to 30.56 p.p.m.

UNIT THREE. Although this unit is by far the largest and most fossiliferous of the entire section, it does not have great areal distribution. This unit is composed of clayey peat and was deposited around the edges of the lake at the same time that luxuriant plant life was capturing the main body (see fig. 4). The lake by this time had approached pond-like conditions in which plants had become dominant. There was very little moving water except around the shores of the lake. This water washed in material from the surrounding hills to form unit 3 and to provide a great variety of habitats for many species of both gastropods and pelecypods.

The gill-breathers continued to be the dominant group in section 1, but a great variety of species from other groups began to appear. The three significant gill-breathers were Valvata tricarinata, Amnicola lustrica, and A. leightoni, which made up over 50 percent of any one collection within the unit. Within this group, V. tricarinata continued to show a decrease, while A. lustrica showed an increase to the point where it formed the main portion of individuals and was by far the most important species in the entire unit. The one significant pulmonate species, Gyraulus altissimus, showed very little fluctuation in abundance and continued to compose about 15 percent of any one collection. During this time, the pelecypods reached their greatest abundance, forming from 10 to 20 percent of most collections. The three significant species are Pisidium compressum, P. nitidum nitidum, and P. nitidum pauperculum, which formed over 10 percent of most collections within the unit.

The specific conditions of the lake water at this time were: water about 1 m. deep, great abundance of vegetation, pH from 7.0 to 8.37 with a fixed carbon dioxide ratio of 9.3 to 30.56 p.p.m.

UNIT FOUR. The peat of unit 4 and of equivalent units in other sections at the same elevation indicates that the vegetation had, by this time, completely captured the lake and that it had now become swampy. The habitat provided by the swamp was very limited and caused the total abundance of Mollusca to decrease suddenly. This was the final stage of the lake during which it still contained sufficient water to provide some sort of environment for aquatic snails. The occurrence of the one land snail found in the section might add further support to the belief that conditions were now becoming less favorable for aquatic snails and more favorable for land snails. The land snail, Euconulus cf. E. fulvus, even though washed in, could possibly have been the forerunner of a large land population which would eventually inhabit the area.

The gill-breathers, although still dominating the lake, showed a general decrease in abundance. Within the group, Amnicola lustrica, previously the most dominant species, decreases from 40 to 17 percent, while A. leightoni, heretofore occurring in minor percentages, increases to 20 percent. In the pulmonates, Gyraulus altissimus shows a sudden decrease from 14 percent to less than 1 percent. All other pulmonates either show decreases or completely die out. Many species of pelecypods, present in earlier units, do not occur here; meanwhile, the important species show a general decrease.

The conditions of the water at this time were probably as follows: water less than 1 m. deep, very heavy vegetation, pH from 7.0 to 8.0 with a fixed carbon dioxide ratio of 12.0 to 25.0 p.p.m.

UNITS FIVE AND SIX. These units have been grouped together to facilitate discussion since they are basically the same in lithology and are of equal importance in the information they add to the history of the lake.

These units of humus signified the beginning of the complete destruction of Souder Lake. By this time the process of desiccation had reduced the swampy area to isolated pools of standing water that provided a meager environment for a few of the hardier species. During this time desiccation continued, and more and more pools were destroyed. Only 8 of the 28 species found in this section occur in these units, and all the collections making up these units contain less than 300 individuals. The significant species in the units is *Valvata tricarinata* which forms over half of the individuals occurring.

The specific conditions of the water at this time are undeterminable since the conditions varied from pool to pool.

UNIT SEVEN. This unit has been disturbed by the farmer's plow, but it still has enough validity to contribute to the general trend of the history of this area. The formation of this unit of humus completely destroyed any remaining pools of water and brought the history of Souder Lake to a conclusion. The unit contains less than 300 individuals which may have been concentrated by erosion at the surface. *Valvata tricarinata* makes up over half of these individuals, and the remaining species occur in equally small numbers. Currently, the entire area of Souder Lake is covered by rich black humus which provides highly favorable soil for vegetable farming.

Age and Correlation of Deposits

A comparison of this fauna with others, both living and fossil, provides further information concerning the environmental conditions and relative age of the Souder Lake deposit. The faunas selected are briefly described in two groups, living and Pleistocene, and a comparison is made between them and the Souder Lake fauna.

Living Fauna

NORTH STAR LAKE, ITASCA COUNTY, MINNESOTA. An extensive study was made of this lake by Baker (1935) in which both the Mollusca and their environment were noted. North Star Lake is a deep glacial lake of some extent. It is surrounded by swamps and wooded areas; the adjacent country is covered with glacial deposits of varying thicknesses. The lake varies in depth and is as much as 25 m. at its deepest point. The molluscan fauna studied occurs abundantly in a zone of about 2 to 4 m. of water, rarely existing beyond this limit. Vegetation is abundant and forms zones along the shores, the most common being *Equisetum*, *Sparganium*, *Eleocharis*, *Scirpus*, and *Sagittaria*. In addition to the living species collected, one common Pleistocene fossil, *Gyraulus altissimus*, was collected from a marl bed under three feet of peat at Little North Star Lake. Baker (1935) concluded that many of the fossil faunas of the Illinoian Pleistocene, especially in the loess deposits, lived under conditions similar to those now found in northern Minnesota and southern Canada.

The North Star Lake fauna contains 46 species, 11 of which are present in the Souder Lake deposit. Here, they are listed as rare to uncommon with the exception of two, *Gyraulus altissimus* and *Valvata tricarinata*, which are recorded as common and very abundant,

respectively. Further, none of the extinct species found in the Souder Lake deposit, which are usually associated with deposits of Wisconsin age, are present in the North Star Lake fauna. Therefore, the Souder Lake fauna does not correspond with that of North Star Lake.

Pleistocene Faunas

RUSH LAKE, OHIO. This deposit is a post-Wisconsin marl bed located at the south end of Rush Lake, Logan County, Ohio (Baker, 1920, p. 440). The species collected and identified from this deposit indicated to Baker that the assemblage once lived in a larger Rush Lake, probably not long after the ice had disappeared from Ohio.

The fauna of this lake contains 26 species, 16 of which are present in the Souder Lake deposit. Both faunas contain many species of Sphaeriidae, although not in corresponding numbers; further, species of gastropods which are extinct and usually associated with Pleistocene deposits are present in both faunas. Therefore, their faunas correspond, at least in part.

JEWELL HILL LAKE DEPOSIT, LOGAN COUNTY, OHIO.[1] This Pleistocene deposit lies on a till sheet that covers a kame deposit (Mowery, 1958). The till has been assigned a "Late" Wisconsin age (Forsyth, 1956, p. 183) according to the explanation of the term by La Rocque and Forsyth (1957, p. 81).

The deposit consists of marl, peat, humus, and clay layers; the marl makes up the greatest portion of the deposit. The pH ranges from 6.0 to 9.0 and the fixed carbon dioxide ratio from 7.0 to 30.0 p.p.m. Thirty-seven species were collected and identified from the above deposit. The composition of the fauna points to a "Late" Wisconsin age for this deposit.

NEWELL LAKE DEPOSIT, LOGAN COUNTY, OHIO. The deposit occupies an area of about 30 square miles and rests upon a buried kame field and associated gravel features (Zimmerman, 1958). Till of varying thicknesses covers the gravel and a small esker forms a part of the west margin. The other sides are formed by till covered by an outwash plain and kame moraine.

The deposit is composed of layers of clay, humus, peat, and marl. The marl is essentially pure and is the most fossiliferous unit. On the basis of comparison with faunas of known age and the associated glacial deposits in and around the area, the age of the Newell Lake deposit is determined as "Late" Wisconsin. The Newell Lake assemblage contains 38 species, four of which, *Amnicola leightoni*, *Helisoma anceps striatum*, *Gyraulus altissimus*, and *Fossaria obrussa decampi*, are extinct.

The Newell Lake and Jewell Hill Lake deposits are both of late Wisconsin age. These deposits have a similar lithology consisting of peat, gravel, clay, and marl and contain essentially the same fauna. There is a close correspondence between the faunas of these deposits and that of Souder Lake; further, the lithologies of all three deposits are almost identical. Thus, it would seem that the faunas of these deposits lived in similar conditions in lakes with a somewhat similar history.

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[1] The Pleistocene fauna of this deposit is described in the paper by Mowery (this issue of Sterkiana, pp. 1-21) which of course was not available to Cornejo while preparing his manuscript. His references are to Mowery's M. S. thesis, referred to here as "Mowery, 1958."

URBANA, ILLINOIS. The deposit is in a kettle hole on the north side of the Champaign moraine and lies in a Champaign till sheet which is early Wisconsin in age (Baker, 1920, p. 660). Baker suggests that the mollusks may have inhabited the lake or pond when the late Wisconsin ice sheet briefly halted at the Valparaiso moraine. This deposit shows a similarity to the Souder Lake deposit in that both contain a large number of Pisidia.

HUMBOLDT DEPOSIT, ROSS COUNTY, OHIO. This "Early" Wisconsin deposit consists of superposed layers of gravel (lowest), till, sand, silts, marl, peat, and clay (highest). The fossiliferous layers are in the marl. Reynolds (1958) states that "The molluscan assemblage suggests a freshwater lake 2 to 10 feet deep with abundant vegetation. The high lime content of this lake was probably derived from nearby till and outwash. The pH varied from 7.0 to 8.0 and the fixed carbon dioxide ratio was approximately 24.0 p.p.m."

The Humboldt Lake and Urbana, Illinois deposits are early Wisconsin in age. Their faunas show close correlation with faunas of known early Wisconsin age and do not contain fossils usually associated with deposits of late Wisconsin age. The Souder Lake fauna agrees with the above faunas in that they all contain many species of Sphaeriidae, but they do not agree in the variety of gastropods present nor in their relative abundance.

Age of Deposit

The Souder Lake fauna can be assigned a Wisconsin age on the basis of comparison with faunas of known Wisconsin age. The presence of Gyraulus altissimus, Fossaria obrussa decampi, Amnicola leightoni, and Helisoma anceps striatum, species which are presently extinct in Ohio, further indicates a Wisconsin age.

The Souder Lake deposit rests on gravel which overlies till of late Wisconsin age. The till varies from 6 to 72 feet in thickness and overlies a sand and gravel layer of varying thickness. In no section was the till found to interfinger with the lacustrine deposit or to overlie the uppermost humus layer. The Souder Lake deposits are composed dominantly of peat and humus with some marl. In all sections the humus overlies the peat; further, the surface soil is made up dominantly of peaty material. This would indicate that the lake was formed after the last advance of the ice sheet during late Wisconsin time.

Therefore, on paleontological grounds, and because of its position over late Wisconsin till, the Souder Lake deposit is assigned a late Wisconsin age.

Acknowledgements

The writer would like to thank Dr. Aurèle La Rocque who suggested this problem and who gave invaluable assistance in preparing this paper. The writer gratefully acknowledges the valuable assistance given by Rev. Mr. H. B. Herrington, Westbrook, Ontario, Canada, in identifying the Sphaeriidae and providing pertinent information concerning them. Special thanks are given to M. B. Reynolds, J. R. Zimmerman, D. H. Mowery, and A. L. Clark, who did similar studies and who helped to develop the methods used in this study. The writer is indebted to the Ohio Division of Geological Survey and its chief, Mr. R. J. Bernhagen, for supplying the plates for this paper.

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ERRATUM

STERKIANA NO. 4 (this issue) p. 30, line 1, insert "late" at the beginning of the line.