STERKIANA

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CONTENTS

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ANNOUNCEMENT

STERKIANA is named after Dr. Victor Sterki (1846-1933) of New Philadelphia, Ohio, famed for his work on the Sphaeriidae, Pupillidae, and Valloniidae. It is fitting that this serial should bear his name both because of his association with the Midwest and his lifelong interest in non-marine Mollusca.

The purpose of STERKIANA is to serve malacologists and paleontologists interested in the living and fossil non-marine Mollusca of North and South America by disseminating information in that special field. Since its resources are modest, STERKIANA is not printed by conventional means. Costs are kept at a minimum by utilizing various talents and services available to the Editor. Subscription and reprint prices are based on cost of paper and mailing charges.

STERKIANA accepts articles dealing with non-marine Mollusca of the Americas in English, French, or Spanish, the three official languages of North America. Contributors are requested to avoid descriptions of new species or higher taxa in this serial as the limited distribution of STERKIANA would probably prevent recognition of such taxa as validly published. Papers on distribution, ecology, and revised checklists for particular areas or formations are especially welcome but those on any aspect of non-marine Mollusca will be considered.

STERKIANA will appear twice a year or oftener, as material is available. All correspondence should be addressed to the Editor.

SUBSCRIPTIONS: 50¢ per number; subscriptions may be entered for not more than 4 numbers in advance; please make checks and money orders payable to the Editor.

STERKIANA est une collection de travaux sur les Mollusques extra-marins des deux Amériques, distribuée par un groupe de malacologues du centre des Etats-Unis. STERKIANA publie des travaux en anglais, en français et en espagnol acceptés par le conseil de rédaction. Prière d'adresser toute correspondance au Rédacteur.

ABONNEMENT: 50¢ le numéro, par chèque ou mandat payable au Rédacteur.

STERKIANA es una coleccion de trabajos sobre los Moluscos extra-marinos viventes y fosiles de las dos Americas, editada por un grupo de malacólogos de los Estados Unidos centrales. Contenirá en el porvenir trabajos en inglés, francés, y español que serán acceptados por la mesa directiva. La correspondencia deberá ser dirigida al Editor.

PRECIO: 50¢ el número.

PLEISTOCENE MOLLUSCAN FAUNAS OF THE JEWELL HILL DEPOSIT, LOGAN COUNTY, OHIO

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INTRODUCTION

Nature and Purpose of Investigation

This report is a paleontological study of the Pleistocene molluscan fauna occurring in a lacustrine deposit at Jewell Hill, Ohio. The paleoecology and quantitative distribution of the species yield information which has been used to reconstruct the environmental changes during the development of the lake. This study is one of several of the same nature, undertaken to provide data for correlation of Pleistocene freshwater deposits by the use of molluscan assemblages.

Location of Deposit

The Jewell Hill deposit lies in the western half of the southwest quarter of section 31, Liberty Township (see Fig. 1), Logan County, Bellefontaine Quadrangle, Ohio. The southwest corner of section 31 is at 83° 46' 45" west longitude and 40° 18' 15" north latitude.

Methods of Investigation

The geographical center of the lake deposit, as nearly as it could be determined, was chosen as the main collecting site. At this location a vertical column measuring 12 inches square was left in place on one side of an excavation approximately 6 x 6 x 6 feet. Most of the vertical column was sampled in successive two-inch layers. It was necessary, however, to vary the thickness of these layers to remain within a stratigraphic unit. The uppermost sample, collection 26, is 12 inches thick, and has been disturbed by the farmer's plow. Four other samples (collections 7, 9, 24, and 25) are each 2.5 inches thick and collection 8 is 3 inches thick.

A bayonet auger was used to sample below the excavation to obtain the lowermost fauna in the deposit. The stratigraphy and profile of the deposit were determined by the use of this auger.

Each sample was put in a plastic bag, sealed, and labeled with a collection number. The plastic bags retained the moisture in the samples; a few samples required additional soaking in beakers. Each collection was washed in a series of sieves of 2.5, 9, 20, 40, and 100 mesh. The material left after sieving was dried and placed in pint containers. The containers were carefully labeled to avoid mixing.

The volume of each collection of dry material left after sieving was reduced with a Jones sample splitter. A truly representative fraction could therefore be studied. The size of the fraction selected was dependent upon the abundance of fossils in each collection. After measuring the total volume of the fraction, portions of it were selected at random and sorted until 1,000 shells were counted. In two collections the entire sample contained less than 1,000 shells. The ratio of shells to other material in the fraction sorted was used to compute the total molluscan population and the relative amount of vegetation in each collection. The fossil shells were identified to species, and the percentage of each species was determined on the basis of total individuals sorted in a particular collection. In this way the quantitative distribution of the entire fauna could be evaluated in terms of paleoecological requirements of all species. These in turn permitted a reconstruction of the lake's history.

STRATIGRAPHY

Description of Deposit

The Jewell Hill lake deposit lies in two shallow depressions which are probably a kettle on a till (Forsyth, 1956, p. 137) that mantles a complex of buried kame moraines. (See Figs. 2 and 3). The two basins are almost separated by a kame ridge, and the northeastern bay is much smaller than the centrally located basin. The periphery of the lake deposit lies at an elevation between 1,140 and 1,145 feet as shown in Fig. 2. The longest dimension, which extends from the southwestern to the northwestern bays, measures approximately 2,100 feet and the average width of the lake deposit is about 260 feet.

The topography of the buried kame hills in the surrounding area indicates that Jewell Hill Lake did not have any apparent influent. There are two lower elevations in the direction of the projecting northwestern and southeastern bays of the lake (see Fig. 2). During periods of high water, the northwestern bay connected with another, smaller depression lake just northwest of Jewell Hill Lake.

DESCRIPTION OF FIGURES 1-5, OPPOSITE PAGE

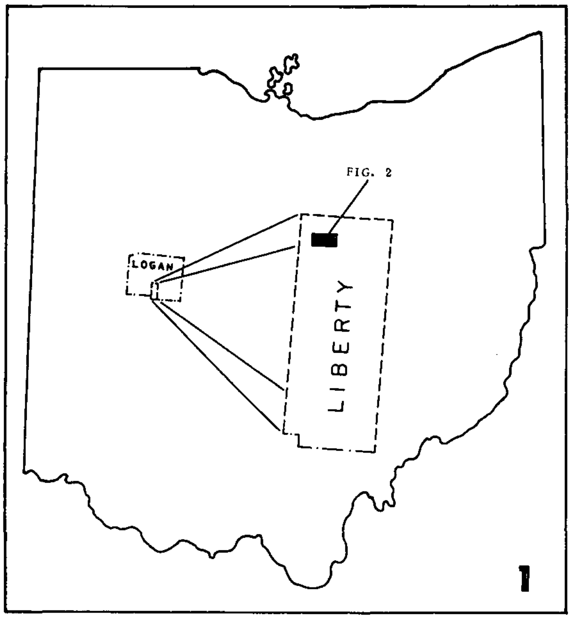
Fig. 1. Index map, showing location of Jewell Hill Deposit. The small rectangle represents the area of Fig. 2.

Fig. 2. Map of the area of the Jewell Hill Lake Deposit.

Fig. 3. Panel Diagram of the Jewell Hill Lake Deposit.

Fig. 4. Approximate total number of individuals in each collection of the Jewell Hill deposit.

Fig. 5. Quantitative distribution of Gyraulus altissimus (F. C. Baker) in the Jewell Hill deposit.



UNIT	COLL. NO.	THICKNESS (inches)	TOTAL NO. INDIVIDUALS	COMPARATIVE ABUNDANCE	GRAPHIC REPRESENTATION OF COMPARATIVE ABUNDANCE (Thousands) 10 20 30 40 50 60 70
	26	12	15,310	1,950	
7	25	2.5	1,420	947	
	24	2.5	501	332	
	23	2	8,480	8,480	
	22	2	78,820	78,820	
	21	2	79,270	79,270	
	20	2	59,230	59,230	
	19	2	53,740	53,740	
	18	2	41,610	41,610	
	17	2	51,260	51,260	
6	16	2	62,350	62,350	
	15	2	41,490	41,490	
	14	2	31,740	31,740	
	13	2	16,130	16,130	
	12	2	13,580	13,580	
	11	2	20,790	20,790	
	10	2	14,170	14,170	
	9	2.5	15,920	12,720	
5	8	3	50	33	
	7	2.5	10,640	8,520	
	6	2	19,190	19,190	
	5	2	23,610	23,610	
4	4	2	22,180	22,180	
	3	2	26,390	26,390	
	2	2	23,640	23,640	
	1	2	26,190	26,190	

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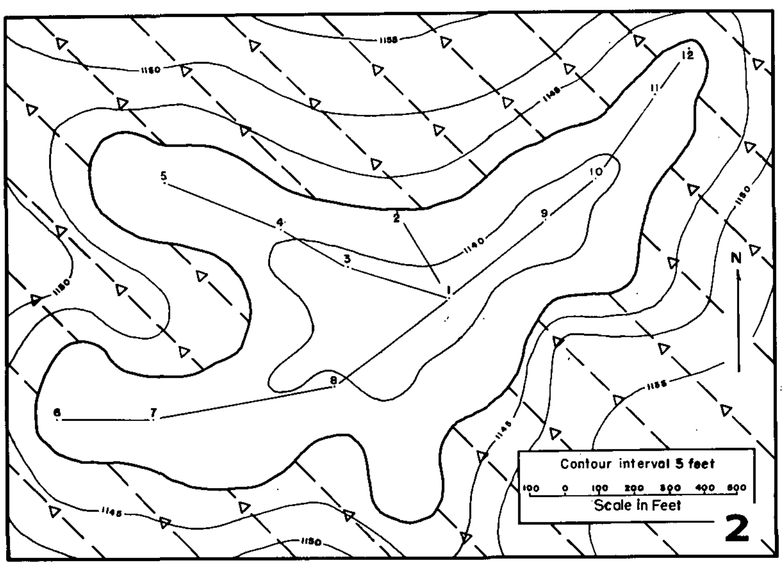

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 20 40 60 80 100
26	407	40.7	
25	428	42.8	
24	207	41.4	
23	123	12.3	
22	336	33.6	
21	271	27.1	
20	349	34.9	
19	473	47.3	
18	384	38.4	
17	461	46.1	
16	524	52.4	
15	589	58.9	
14	502	50.2	
13	565	56.5	
12	389	38.9	
11	172	17.2	
10	551	55.1	
9	633	63.3	
8	33	67.4	
7	424	42.4	
6	384	38.4	
5	229	22.9	
4	225	22.5	
3	191	19.1	
2	138	13.8	
1	139	13.9	

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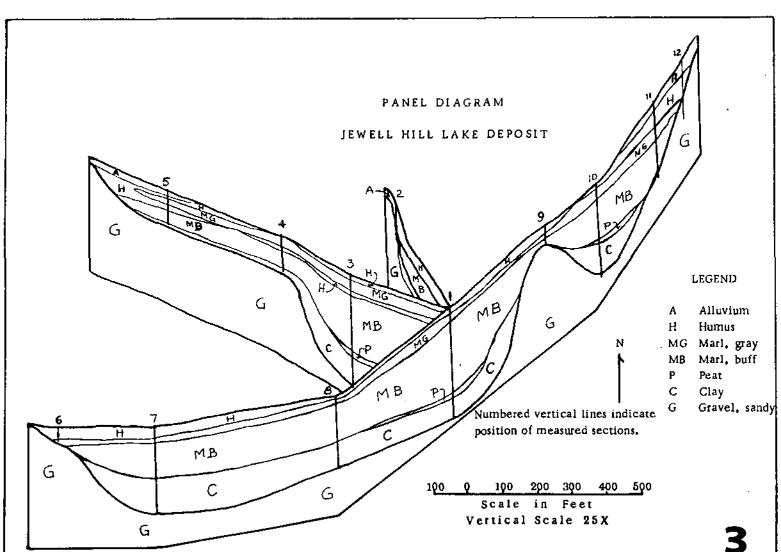

The southeastern bay, which points toward the lowest elevation in the immediate area, served as outlet and as migration route for mollusks into the lake. The superfluous water during the rainy season probably emptied into a lower marshy depression and on into McKee Creek, a part of the tributary system of the Miami and Ohio Rivers. The assumptions above concerning the spillway were deduced from augering the periphery of the lake deposit.

The gray blue lake clay covers both shallow basins and rests on sandy gravel, which is impenetrable by a bayonet auger. It ranges in thickness from a trace at the extreme margins and on the sides of the kame ridge to a maximum of 8 feet at section 7 (see Fig. 3). A marly peat layer overlies the lake clay in the central area of both basins and never exceeds a thickness of 14 inches. Most of the buff colored marl rests directly on the lake clay and a sharp contact exists between the two. This buff marl is essentially pure and contains some vegetation, which increases upward. The thickness of the buff marl ranges from a trace at the shore lines to a maximum of 17.5 feet in the central area of the larger basin. A lower humus layer overlies the western and southeastern bays. This black humus layer measures 13 inches at section 5 and 5.5 inches at section 1. A silty, medium light gray marl overlies both the lower humus layer and buff marl. There is a sharp contact between both marl units. The gray marl is highly impure, coarse, and contains many thin peat lenses. It ranges in thickness from a trace at the extreme margins to a maximum of about 3 feet. An upper humus layer covers the entire area of the lake deposits. The black humus is thickest, approximately 3 feet, at the margins of the deposits. At these sites, the humus grades into peat, a few inches thick to a maximum of one foot at section 12.

Measured Sections

Twelve sections measured in the course of the work showed only minor variations in stratigraphy. Section No. 1, which was sampled in detail for Mollusca, is given below. Correlation of the other 11 sections with Section No. 1 is shown in Table 1, page 4.

Section No. 1

Unit	Description	Thickness (inches)	Coll. No.
7	Humus, black, porous, blocky, fossiliferous, bottom 0.5 inch gray marl undulating up into humus; upper 12 inches brownish black, disturbed	19	23-25
6	Marl, medium light gray, calcareous, coarse, silty, fossiliferous, interbedded with many thin peat lenses	29	9-22
5	Humus, black, porous, blocky; upper 3 inches slightly fossiliferous, lower 2.5 inches fossiliferous, interstratified with dark gray marl .	5.5	7-8
4	Marl, buff, pure, very fine, calcareous, clayey, fossiliferous, a few scattered plant stems; some calcareous tufa tubes, the size of pencil lead; upper 2 inches, light gray marl, calcareous, slightly silty, interbedded with minute peat lenses . . . . (Collections 1 through 6 represent the uppermost foot of this unit).	206	1-6
3	Peat, light yellowish brown, marly, compact, unfossiliferous	13	
2	Clay, gray blue, very fine, compact, plastic, unfossiliferous . . .	49	
1	Gravel, sandy	6	

TABLE I. CORRELATION OF MEASURED SECTIONS

Lithology	Section and Unit Numbers 1	2	3	4	5	6	7	8	9	10	11	12
Alluvium	abs.	6	abs.	abs.	7	abs.	abs.	abs.	abs.	abs.	6	4
Clay, gray	abs.	5	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.	abs.
Humus	7	4	7	6	6	4	5	6	4	7	5	3
Marl, gray	6	3	6	5	5	3	4	5	3	6	4	2
Humus	5	abs.	5	4	4	abs.	abs.	4	abs.	5	abs.	abs.
Marl, buff	4	abs.	4	3	3	abs.	3	3	2	4	3	abs.
Peat	3	abs.	3	abs.	abs.	abs.	abs.	abs.	abs.	3	abs.	abs.
Clay, blue	2	2	2	2	2	2	2	2	abs.	2	2	abs.
Gravel	1	1	1	1	1	1	1	1	1	1	1	1

Location of Faunas

In the Jewell Hill Lake deposits there are four fossil-bearing units: the upper humus layer, unit 7; the medium light gray marl, unit 6; the lower humus layer, unit 5; and the buff colored marl, unit 4. Each of the three upper units has corresponding collections, 6 through 26, as indicated by the measured section at section 1. The uppermost foot of unit 4 corresponds to collections 1 through 6. The bottom foot of unit 4 was collected with a bayonet auger at section 1. The species listed in Table II are those of the lowermost fauna in this unit.

TABLE II. COMPOSITION OF LOWERMOST FAUNA

SPECIES	NUMBER OF SPECIMENS	PERCENTAGE OF TOTAL INDIVIDUALS
Valvata tricarinata	328	45.5
Amnicola leightoni	131	18.2
Amnicola lustrica	73	10.1
Fossaria obrussa	5	0.7
Fossaria obrussa decampi	2	0.3
Helisoma anceps striatum	26	3.6
Gyraulus altissimus	127	17.5
Physa gyrina	8	1.1
Pisidium sp.	21	2.9
Vertigo ovata	1	0.1
TOTAL	722	100.0

QUANTITATIVE DISTRIBUTION

General Statement

The four fossil-bearing units of the Jewell Hill Lake deposit contain 37 species, collected at section 1 (Fig. 3). They include eight "finger-nail" clams, sixteen freshwater gastropods, and thirteen terrestrial gastropods. Samples from the other sections (2 to 12, whose locations are given in Fig. 3, did not reveal any other forms. The interpretation of the distribution of all forms is given under Paleoecology.

Variation in Numbers

The approximate total number of individuals in each collection is given in Fig. 4. Only two collections, numbers 8 and 24, contain less than 1,000 individuals. The comparative abundance column has been added because of the difference in volume of the collections. In this column the figure given is that for a sample 2 X 12 X 12 inches. To obtain the figure, samples thicker than 2 inches have been reduced proportionately.

Figure 4 exhibits an almost constant population in the uppermost foot of the buff colored marl, unit 4. The population was reduced in unit 5, the lower humus layer, until it reached the minimum comparative abundance of 33 individuals in collection 8. Unit 6, consisting of interbedded peat members and silty, gray marl, shows an almost constant increase, with slight fluctuations, to a maximum of about 79,000 individuals in collections 21 and 22. In the upper humus layer, unit 7, the population was again reduced to comparatively small numbers in collection 23. The population continued to decrease but reached a somewhat constant number in the upper collections of this unit. Collection 26 has been disturbed, but it retains some validity as a sample; of the 21 forms occurring in this unit only one, Vallonia gracilicosta, does not occur in the lower collections.

Comparative Abundance of Groups

The freshwater pulmonate snails form a somewhat meager 23.2 percent of the individuals in the lowermost fauna in unit 4 at section 1. This group is dominant in all collections except numbers 3 and 11, in which they form 43.5 and 24.6 percent of the total individuals, respectively. The numerical abundance of the freshwater gill-breathing snails is greatest, 73.8 percent, in the lowermost fauna of unit 4. This group is less numerous than the freshwater pulmonates of the uppermost fauna of unit 4 and the lower collections, from 9 to 12, of unit 6. In unit 6, from collection 13 through 22, and unit 7 the gill-breathing snails are in such small numbers that they suggest intruders struggling to survive in an environment favorable to freshwater pulmonates. The small pelecypods are persistent in minor percentages throughout section 1. This group is only 2.9 percent of the lowermost fauna of unit 4 and attains the maximum of 11.3 percent in the uppermost fauna of unit 4. The land snails are persistent in smaller percentages than the pelecypods. The percentages of this group are high in collection 6, unit 4; collection 7, unit 5; and attain a maximum of 28 percent in the upper two collections of unit 7, the upper humus layer.

Comparative Abundance of Species

INDIGENOUS SPECIES. Each form in the various groups is discussed in order of abundance and the numerical variation is listed from bottom to top. The lowermost fauna in unit 4 (Table II, p. 4) exhibits significant changes in abundance with the uppermost fauna of the same unit, collections 1 through 6.

Of the thirteen aquatic pulmonates, seven are significant. These are Gyraulus altissimus, Fossaria obrussa, Fossaria obrussa decampi, Physa gyrina, Promenetus exacuous, Stagnicola umbrosa, and Helisoma trivolvis (See Table II).

INTRUDERS. The forms in this group either occur sporadically or are insignificant in percentages of total individuals.

The six freshwater pulmonate snails in this group are: Lymnaea stagnalis jugularis, Helisoma anceps striatum, Helisoma campanulatum, Planorbula armigera, Gyraulus crista, and Ferrissia parallela. L. stagnalis jugularis occurs as 0.1 percent in collections 11 and 14, 0.2 percent in collection 12, and 0.4 percent in collection 13. H. anceps striatum remains almost constant from the lowermost to the uppermost fauna, with a maximum of 4.4 in collection 1, in unit 4. From collection 1 it decreases and occurs in minor percentages where the form is present in the deposit. H. campanulatum reaches its maximum percentage of 1.5 in collection 1 and fluctuates in minor percentages, between 0.1 and 0.9 percent, where the species is present in a collection. P. armigera occurs as twelve individuals in collection 24 and composes about 2.4 percent of the total individuals in collections 25 and 26. G. crista attains a maximum of 2.7 percent in collection 16. It occurs sporadically and fluctuates between 0.1 and 1.8 percent where it is present in the other collections. F. parallela occurs as 0.4 percent in collection 6, 0.9 percent in collection 7, 0.1 percent each in collections 4 and 18, and 0.2 percent in collection 19.

Five pelecypods are considered intruders into the environment of the Jewell Hill lake. These are Sphaerium lacustre, Pisidium adamsi, P. ferrugineum, P. compressum, and P. nitidum pauperculum. S. lacustre is absent in the first 8 collections and increases from 0.1 percent in collection 9 to a maximum of 1.6 percent in collection 16, and then decreases to 0.2 percent in collection 25. Each of the other four pelecypods forms less than 1.0 percent of the total individuals in any one collection and no particular significance is attached to their sporadic occurrence in the deposit.

All of the land snails are considered as intruders. Succinea avara occurs as 0.5 percent in collection 23, fourteen specimens in collection 24, 2.2 and 2.4 percent in collections 25 and 26, respectively. Succinea ovalis is in all collections except 8 and 10. It attains a maximum of 6.5 percent in collections 23 and 26. In the other collections it varies between 0.1 percent and 5 percent. Gastrocopta pentodon reaches a maximum of 15.2 percent in collection 25 and occurs sporadically throughout the collections. Vertigo ovata is absent in collection 1, has a maximum percentage of 6.6 in collection 23, and varies between 0.1 and 4.1 percent in the other collections. It occurs as 0.1 percent in the lowermost fauna of unit 4. Carychium exile occurs as twelve specimens in collection 24, 2.1 and 2.2 percent in collections 25 and 26, respectively. No particular significance is attached to the occurrence of the following eight land snails: Stenotrema leaii, Euconulus fulvus, Retinella binneyana, Hawaiia minuscula, Strobilops labyrinthica, Pupoides albilabris, Vallonia gracilicosta, and V. pulchella. Each of the above species forms less than 1.0 percent of the total individuals in any one collection.

PALEOECOLOGY

General Statement

The following information concerning conditions of environment has been paraphrased from publications by the following authors: F. C. Baker, E. G. Berry, J. Dawson, R. W. Dexter, C. Goodrich, H. B. Herrington, A. La Rocque, A. B. Leonard, J. P. E. Morrison, J. Oughton, H. A. Pilsbry, L. S. Russell, and M. L. Winslow.

Pelecypods

FAMILY SPHAERIIDAE. Almost all fresh-water bodies are inhabited by some species of this family unless the environment is completely unfavorable. These mollusks even occupy pools that dry up for a long period of time during the year. In these places a few survive, mainly the young, by burrowing deeply into the mud. The food supply is mainly diatoms and vegetation. The "finger-nail clams" in turn are a source of food for freshwater fish. They are also attacked by parasitic worms which may modify the form of the shell.

For some of the Sphaeriidae, listed below, the specific conditions of environment are those given under synonyms in the literature; the names used here follow Herrington's (1954, p. 131) revision.

SPHAERIUM LACUSTRE (Müller) prefers swamps, ponds, lakes, or streams on a firm bottom of fine deep or hard packed mud, fine gravel, and hard clay, in water up to 0.6 m. in depth. The pH is 6.4 to 7.64; fixed carbon dioxide 9.3 to 18.87 p.p.m.

PISIDIUM ADAMSI (Prime) appears to prefer quiet water, about 3 m. deep, in small and some large lakes or slow moving streams. The bottom usually consists of mud which has occasional vegetation and in depths of water ranging from 0.3 to 13.5 m. The pH is 6.05 to 7.7; fixed carbon dioxide 2.75 to 18.36 p.p.m.

PISIDIUM CASERTANUM (Poli) is a lake or pond inhabitant on a clay, sandy clay, or mud bottom in shallow water, between 0.5 and 3 m. in depth. It also occurs in swamps or protected bays among vegetation. It is able to resist desiccation at least several months in a swampy area during dry periods. The pH is 5.8 to 7.95; fixed carbon dioxide 5.5 to 30.50 p.p.m.

PISIDIUM COMPRESSUM (Prime) is confined principally to rivers and creeks. It occurs on a sandy, sandy silt, or mud bottom in water up to 3 m. deep among vegetation. The pH is 7.0 to 8.37; fixed carbon dioxide 9.3 to 30.56 p.p.m.

PISIDIUM FERRUGINEUM (Prime) inhabits the mud, sand, or marly clay bottoms of ponds, lakes, and some rivers in water 1 to 3 m. deep. It is usually found among vegetation and algae. The pH is 7.23 to 8.14; fixed carbon dioxide 10.8 to 22.5 p.p.m.

PISIDIUM NITIDUM (Jenyns) is an inhabitant of ponds, small and large lakes in shallow water, from 1 to 6 m. deep. It lives on various bottoms such as sand, clay, mud, and gravel. The pH is 7.48 to 7.64; fixed carbon dioxide 1.98 p.p.m.

PISIDIUM NITIDUM PAUPERCULUM Sterki lives in habitats similar to those of P. nitidum, but is a distinct varietal form. It prefers the same bottom condition and has been recorded in depths of water from 1 to 39.5 m., although the more dense population would probably be in water from 1 to about 5 m. deep. The pH is 7.0 to 8.0; fixed carbon dioxide 9.3 to 24.73 p.p.m.

PISIDIUM OBTUSALE ROTUNDATUM (Prime) is an inhabitant of ponds, large and small lakes, and lagoons with various bottoms consisting of mud, marly clay, sand, and sometimes gravel. This species occurs in water consistently deeper than do the other Sphaeriidae. The depth of water ranges from shallow, 1.6 m., to more than moderately deep, 12 m. The pH is 5.8 to 6.2; fixed carbon dioxide 1.97 to 9.0 p.p.m.

Aquatic Gastropods

VALVATA TRICARINATA (Say) occupies a wide variety of habitats which include rivers, lakes, and permanent ponds. It occurs on various bottoms such as mud, silt, sand, gravel, mixtures of these materials, and in vegetation, especially algae. The species has been found in water a few cm. to depths exceeding 9 m., but is more abundant in situations approximately 2 m. deep. V. tricarinata has been observed feeding on plants and algae, chiefly Vaucheria. The pH is 6.8 to 8.6; fixed carbon dioxide 8.16 to 30.56 p.p.m.

AMNICOLA LEIGHTONI (F. C. Baker) occurs exclusively in marl deposits of Wisconsin, Michigan, Illinois, Indiana, Ohio, and Ontario. The species undoubtedly flourished in lakes of glacial origin for it has been recorded in abundance mostly from this type of environment. Since A. leightoni is an extinct species of late Pleistocene time, the ecology must be derived from its closely related living counterpart, the Amnicola limosa group. Both A. limosa limosa and A. limosa porata are gill-bearing operculates occurring in very quiet bodies of fresh or brackish water. The wide variety of environmental occurrences of A. limosa limosa include rivers, creeks, many lakes, and swamps. It occurs on all types of bottoms and in various vegetation. The depth of water ranges from 0.2 to 7.5 m., but is more abundant in water less than 2 m. deep. Habitats listed for A. limosa porata are mostly lake occurrences. It is found on various bottoms, usually in vegetation, in water 0.3 to 3 m. deep. The abundance of Amnicola depends largely on the presence of vegetation. The amnicolids have been reported to eat various plants in the absence of fixed carbon dioxide in order to build shell material; however, the plants act as hosts for vast colonies of diatoms which supply the food for the snails. The group as a whole are burrowers and may burrow beneath the substratum during stormy weather. Amnicola can be exterminated by unusually high summer water temperatures; but low temperatures have no effect except on those near the shore which may be frozen. The seasonal abundance of the group remains almost constant; it increases in July when the new generation is produced, and drops to the lowest ebb in mid-August when the adults die off rather suddenly after the egg-laying period. The young generation enlarges the population to a maximum by mid-September. A. limosa porata occurs in situations with a wide tolerance of pH which may vary from 5.68 to 8.37, and the fixed carbon dioxide varies from 1.2 to 30.56 p.p.m.; A. limosa has a stable pH value of 7.95 and fixed carbon dioxide ratio of 30.56 p.p.m.

AMNICOLA LUSTRICA (Pilsbry) inhabits vegetation and is most abundant in filamentous algae. The ecology of this amnicolid is similar to that of A. limosa with which it is often associated. It occurs on the same type of substratum in rivers and lakes. The shell of this species exhibits a characteristic form in river and lake environments. The type form is the river form and the lake form is an ecological variation, with a wide umbilicus. The A. lustrica of the Jewell Hill Lake deposit exhibits the wide umbilicus. The same conditions for food, pH of the water, and fixed carbon dioxide in parts per million, are assumed for A. limosa since the two are often associated.

LYMNAEA STAGNALIS JUGULARIS (Say) usually occurs about decaying vegetation in the more stagnant waters of ponds, lakes, rivers, or in open swamps. Although it may be found on floating driftwood or debris and on a sandy or pebbly bottom, the more favored habitat is among vegetation near the shore. It is found in a depth of water ranging from 0.2 to 1.2 m. In the larger lake bays and inlets it occurs in protected areas near shore during the spring, while in August or September it may be found in abundance floating in the open waters on or near vegetation. L. stagnalis jugularis has been observed frequently floating, among pond weeds and algae, with the shell pointed downward and the foot on the under surface of the water film. The usual food supply is vegetal, although it has been observed feeding upon dead animals. Instances are recorded of its attacking small living animals for food. The pH is 7.6 to 8.16; fixed carbon dioxide 15.8 to 23.0 p.p.m.

FOSSARIA OBRUSSA OBRUSSA (Say) normally inhabits small bodies of water such as ponds and medium sized lakes, but it may be found in creeks, sloughs, bays, overflow ditches, swamps, and marshy areas near river banks. It is a semi-amphibious inhabitant of shallow water, up to 1.0 m. and as much as 3.0 m. deep, living among vegetation and on sticks, stones, and any other debris in the water or near the edge. It is capable of remaining out of water for considerable periods of time on debris or moist mud flats. Its food consists normally of the stems of water plants, diatoms, desmids, and pond scums. It may become carnivorous according to circumstances or by choice. The pH is 5.86 to 8.37; fixed carbon dioxide 1.26 to 25.75 p.p.m.

FOSSARIA OBRUSSA DECAMPI (Streng) probably has the same ecology as F. obrussa obrussa and the same conditions of occurrence and diet are inferred. F. obrussa decampi is very abundant as a Pleistocene fossil, and was associated with F. galbana, an extinct species, in the icy waters of Pleistocene time. Its less abundant occurrence in the living fauna has been noted, possibly indicating its coming extinction. This species occurs mostly on vegetation in water 1 m. deep with a bottom of sandy silt or mud. It has been collected from many different water plants. The pH is 7.5; fixed carbon dioxide 10.65 to 18.87 p.p.m.

STAGNICOLA UMBROSA (Say) inhabits tranquil waters of pond-like areas thick with vegetation either near a river or in ponds and sloughs which may become more or less dry in the summer. Since the ecology of this species is poorly known, more specific conditions of environment must be inferred from the closely related form Stagnicola palustris elodes. The preference of the latter for bodies of still water in both clear and stagnant situations is in agreement with the character of the closing stages of the Jewell Hill Lake. S. umbrosa occurs only in the upper two units of the Jewell Hill Lake deposit as shown in Fig. 10. S. palustris elodes occurs in large or small water bodies on floating sticks, submerged vegetation, and muddy bottoms; it is rarely found out of water. The more natural habitats are along margins of rivers, protected bays of lakes, and ponds. The depth of water ranges between 0.3 and 1.0 m., but it is more abundant in water 0.3 m. or less deep near the pool edge. Its food supply is both animal and vegetal. The species is both omnivorous and a scavenger. The pH is 7.4; fixed carbon dioxide 21.0 p.p.m.

HELISOMA TRIVOLVIS (Say) inhabits quiet, more or less stagnant bodies of water in swamps, marshes, pools, sloughs, and ponds; it is virtually absent from flowing streams. Its occurrence in a fossil fauna is a good indication of ponded environment because of the restricted conditions of habitat. H. trivolvis generally favors a depth of water ranging from a few cm. to 1.3 m., a mucky bottom, and presence of mass vegetation and sometimes algae. It is more abundant in water less than 0.5 m. deep. In the above environment the species is always abundant and is found on debris, driftwood, among vegetation and sometimes on shore. By burrowing into the mud bottom of drying pools, it can survive long periods of drought. It feeds on water weed, algae, desmids, and diatoms. The pH is 6.6 to 8.37; fixed carbon dioxide 7.5 to 30.56 p.p.m.

HELISOMA ANCEPS STRIATUM (F. C. Baker), once believed extinct, is known from the living fauna of two lakes in northern Minnesota and probably occurs in other lakes in the northernmost regions of the United States and northward into Canada. H. anceps striatum appears to be more abundant as a fossil and living form in the northern localities and its presence as a fossil farther south probably indicates a lake form which reinvaded the cold waters immediately following the retreating ice. Colder water could be a limiting factor of distribution. This variety occurs in shallow, quiet waters almost always on the abundant vegetation growing on a mud or silt, sandy silt, and clay bottom. It inhabits a depth of water ranging between 0.3 to 1 m. The food of the planorbids is largely vegetal; however, little is known concerning the food supply. The pH and fixed carbon dioxide values for this variety may be inferred from its nearest relative, Helisoma anceps sayi which is also a lake form. The inferred values, pH 7.13 to 8.37 and fixed carbon dioxide 9.59 to 25.75 p.p.m., compare well with those of other species in the Jewell Hill Lake deposit.

GYRAULUS ALTISSIMUS (F. C. Baker) is abundant as a Pleistocene fossil and may still be living in northern lakes. Specimens, probably alive, were collected from a number of lakes in North Dakota (Winslow, 1921, p. 11) which Baker (1922, p. 54) identified as "apparently the same species." Baker (1928, p. 383) reverted to the concept of "apparently an extinct form peculiar to the Pleistocene period" and listed the ecology as unknown. Russell (1934, p. 35) reported G. altissimus as living in Fishing Lake, Wadena, southern Saskatchewan. Baker (1937, p. 116) concluded that "its status as a living member of the fauna is not well known" and that a closely related form, G. arcticus, is probably confined to Greenland (Baker, 1939, p. 98). The ecology of G. altissimus may be derived from the association of other mollusks in a particular deposit. After comparing various faunas, in which this species was abundant in Pleistocene deposits, species regularly associated with G. altissimus and of approximately the same high abundance were: Helisoma campanulatum, H. anceps striatum, Physa gyrina, and especially Fossaria obrussa decampi. Other species either occurred erratically with G. altissimus or were so much less abundant that they would be considered insignificant in the environment, mostly ponds or lakes, where all these species flourished. Species of the same genus usually were rare in the same deposit. Of those that do occur in the same deposit with any abundance is G. parvus, a closely related species, which has about the same pH and fixed carbon dioxide values as the species most often associated with G. altissimus in a deposit. All of the above species, except G. parvus, occur in the Jewell Hill Lake deposit and their ecology is given elsewhere in this paper.

G. parvus exhibits a partiality to vegetation, for it is rarely found in other situations. It occurs usually in quiet bodies of water, often of small size, in depths between 0.5 and 2.2 m. and with various bottoms supporting the plant growth. It also is found on debris near the top of the water. During periods of drought G. parvus has but a slight burrowing reaction when faced with desiccation. It can live for a time upon various substrata provided moisture is present. G. parvus has been observed eating leaves and algae of various kinds. The pH is 7.0 to 8.16; fixed carbon dioxide 8.16 to 30.56 p.p.m.

GYRAULUS CRISTA (Linnaeus) inhabits very shallow water of ponds or small lakes and creeks. In the small lake habitat it has been found sparingly on dead leaves in stagnant water. In another lake occurrence G. crista was living in shallow water, 0.3 to 1 m., among vegetation on a mud or silt bottom which in most places was mucky. In a creek it occurred in a few cm. of water under logs and bark. No pH or fixed carbon dioxide values are available.

PLANORBULA ARMIGERA (Say) lives in small stagnant lakes or ponds. This snail is also found at the edges of marshes, in ditches, and small streams. It prefers situations with abundant vegetation and a mud bottom in water between 0.3 and 1 m. deep, but is capable of remaining out of water and lying dormant in dried mud until the wet season of the year. The pH is 6.6 to 7.6; fixed carbon dioxide 7.5 to 16.7 p.p.m.

PROMENETUS EXACUOUS (Say) is another inhabitant of quiet, shallow water bodies of marshes, ponds, lakes and on mud flats of small mountain streams. Apparently P. exacuous seeks the cool waters, a very important factor in its dispersal. It occurs in protected weedy places on driftwood, plants, lily leaves, and dead leaves on almost all varieties of bottoms from 0.5 to 5 m. deep; however, it is most abundant in water a few cm. to 1 m. deep. The preferred habitat is on the luxurious growth of vegetation that affords shade, tending to lower the temperature of the water. Besides the plants, P. exacuous has been observed to live and feed on dust-fine detritus. The pH is 6.0 to 7.64; fixed carbon dioxide 9.3 to 22.5 p.p.m.

FERRISSIA PARALLELA (Haldeman) is usually an inhabitant of shallow, quiet water of ponds or lakes. The depth of water ranges from 0.3 to 2 m. in which the animal is usually found near the surface on plant leaves but may occur near the bottom on other plants. The distribution of the species is undoubtedly controlled by the presence of vegetation for any other occurrence is rare. The food supply is limited to plants, normally in a state of decay. The pH is 6.05 to 8.37; fixed carbon dioxide 2.75 to 25.75 p.p.m.

PHYSA GYRINA (Say) is found in situations that are characteristically swampy, slow moving, and stagnant with a preference for a mud bottom. The occurrences include overflows from large rivers, small ponds behind river and lake beaches, drainage ditches, and other temporary pools and ponds. Optimum conditions of environment are shallow water usually less than 0.3 m. deep; a minimum amount of shade; few or no enemies such as fish and some birds; a minimum amount of debris; protection from waves and currents; a moderate amount of water weeds; and well aerated water. P. gyrina is usually found on vegetation, mostly on the upper side of pond lily leaves. Physa demands practically the same environmental conditions in lakes and ponds as in streams. P. gyrina can live for a time upon almost any kind of substratum providing it is moist. They survive for a few months when their apertures are turned down and buried in clay, even though they do not form an epiphragm. However, in periods of long drought desiccation takes place for it has only a slight burrowing reaction to enable it to withstand these periods during summer months. Physa depends on plants for both food and aerated water. A great part of the life of Physa is spent in floating upon the surface water where it feeds upon particles of decaying vegetation. It feeds on a variety of animal and vegetable food either fresh or partly decayed. The pH is 7.1 to 8.37; fixed carbon dioxide 9.5 to 22.75 p.p.m.

Terrestrial Gastropods

STENOTREMA LEAII (Binney), occasionally in large colonies, usually inhabits quite damp areas near water such as the margins of ponds, streams, and marshes. It has been observed thriving in rather humid forests or occurring on seeping hillsides and flood plains of streams, under leaves, logs, and rocks.

EUCONULUS FULVUS (Müller) prefers damp situations in woodland areas, especially those of deciduous trees, among the forest debris. Here, it is abundant under started bark, under wet pieces of bark or wood of fallen logs, and rotting stumps of trees. Although it occurs among damp leaves or other vegetation in well-shaded situations, it may as easily occupy the drier, more open woods or fields.

RETINELLA BINNEYANA (Morse) inhabits the more damp situations of woodlands, especially those of deciduous trees. Here, it is common on the forest floor under debris, logs with started bark, at the base of stumps, and under brush. Another occasional occurrence is in sphagnum bogs.

HAWAIIA MINUSCULA (Binney) is a small snail which usually inhabits the moist woodland environment, but is able to withstand desiccation under semi-arid conditions. In woods it lives in leaf mold, on and beneath the bark of trees, among mosses, and under fallen logs. It also thrives along banks of streams and lakes in piles of moist drift or under a light layer of decaying vegetation.

SUCCINEA AVARA (Say) inhabits environments which are widely variable; however, it prefers the more moist situations. It has been found thriving in the following places: low swampy areas, crawling about on mud or living among the debris; along the wet margins of ponds, streams, and marshes; seeping hillsides, living under leaves, logs, sticks, or damp rocks which are limestone and moss-covered. It is also abundant on the grass and reeds near or above the water in roadside ditches.

SUCCINEA OVALIS (Say) inhabits the damp situations of woodlands, especially those of deciduous trees, but may just as easily occupy the drier, open woods or fields. This snail is able to avoid desiccation for a considerable period of time, some five to nineteen weeks. It occurs often among the shrubs and weeds of moist situations near ponds, swamps, and streams. It is also abundant along the floodplains of rivers living among grasses and hedges on mud flats.

STROBILOPS LABYRINTHICA (Say) is probably more or less confined to moist shaded woodland areas. Here, it may be found under loose bark of logs, in half-decayed wood, among dead leaves, crawling on old stumps and logs and other forest debris. The species also occurs abundantly under debris close to the water line of lakes.

GASTROCOPTA PENTODON (Say) lives on wooded hillsides, more abundant on the drier slopes; in well drained groves, among leaves in the underbrush; it also occurs in the more damp woodlands, especially those of deciduous trees. It is common among moss and grass in forests and on open slopes.

PUPOIDES ALBILABRIS (C. B. Adams) is unusual in its ability to dwell in both semi-arid or more than moderately wet regions. The wide range of occurrences includes limestone areas, where populations are denser; in woodlands, under leaf mold and loose bark of fallen logs; in dead grass of prairies; among roots of short grass in unshaded areas; moist grass of untimbered slopes; flood plains of creeks and rivers; beneath rocks in open country; and common on limestone ledges.

VERTIGO OVATA (Say) exhibits a preference for the more moist situations afforded by shaded slopes among vegetation in swampy areas, ponds, marshes, and on flood plains of creeks and rivers. In some regions the species is uncommon because of its failure to adapt itself to periodic droughts. It has been observed thriving in locally favorable habitats, such as marshes near springs, in an area where snails are generally absent or rare.

VALLONIA GRACILICOSTA (Reinhardt) is an inhabitant of situations where organic or rock debris offers protection. The animal may burrow into earth where the soil is not too compact. It usually occurs among vegetation, slightly damp humus, or rotting stumps of birch in wooded areas, and also under rocks and rotting logs on the flood plain of intermittent streams.

VALLONIA PULCHELLA (Müller) occupies the wetter margins along ponds, streams, and marshes; seeping hillsides; sandy flats which receive water by percolation; and occasionally inhabits the drier, more open woods and fields. It is able to withstand desiccation for periods of three to seventeen weeks. This snail is characteristic of lime-rich soils.

CARYCHIUM EXILE (H. C. Lea) is a minute land snail whose environmental conditions have not been extensively recorded in the literature. C. exile dwells in the more damp situations of woodlands, especially those of deciduous trees, and also inhabits the moist soil near streams. It has a preference for a more basic soil. C. exile inhabits the margins of swamps or marshes under decaying vegetation.

Nature of Environment

GENERAL STATEMENT. The environment occupied by the aquatic mollusks in the Jewell Hill Lake was a small, quiet body of water contained in the shallow basin of a kettle. This small lake offered a habitat around its margins for terrestrial snails and was shallow enough for the aquatic mollusks to occupy the entire area of the lake bottom. The successive quantitative distribution of the fauna in each collection of the four units reflects a small lake progressively filling, at first by sediments and later with the aid of encroaching hydrophytes.

The transformed area of the shallow lake to pond-like conditions became a more favorable habitat for the aquatic pulmonates. The invasion of Lymnaea stagnalis jugularis, Stagnicola umbrosa and Helisoma trivolvis and the change of dominant forms to the aquatic pulmonates indicates very shallow water, a soft mud bottom, and thick vegetation.

The increased numerical proportion of the land snails in both humus layers and the uppermost collection of unit 4, the buff colored marl, suggests a shifting shore line and the possible proximity of a deciduous forest. Oughton (1948, p. 93) concluded that the greater land snail population inhabits the damp deciduous woodlands and also the wet margins of small and large bodies of water. These snails thrive in leaf mold and under vegetable debris, inches thick, which remains moist. In this situation the eggs and young snails have a chance of survival against desiccation hazards.

VEGETATION. The relationship between the molluscan population and plant growth is intimately brought out in the deposits of the Jewell Hill Lake. Although the fauna depends on plant growth largely for food and aeration of the water, an increase of luxuriant plant growth beyond a certain point is disastrous for the aquatic mollusks. Dawson (1911, p. 29) also states that the population is greatest where there is a moderate amount of plants and organic debris. These conclusions are clearly demonstrated in the Jewell Hill Lake deposit. Twice in the history of the lake plant growth captured the quiet water and extremely reduced the molluscan population. This is well exemplified by comparing the total abundance in each collection, Fig. 4 and the volumetric data, Fig. 17.

PROBABLE HYDROGEN ION CONCENTRATION. The usual pH range for most present day lakes is between 6.0 and 9.0 (Hutchinson, 1957, p. 690). Both the pH and the fixed carbon dioxide values as determined from the indigenous species in the Jewell Hill Lake indicate a similarity to conditions in present day lakes. These values have been derived for each fossil-bearing unit and are discussed later in the environmental history of the lake.

Significant Species

Almost all of the freshwater mollusks discussed in this paper could be indigenous in present day small lakes. Ten aquatic mollusks in the Jewell Hill Lake deposit occur in very small numbers indicating their intrusion into the environment. All land snails, also intruders, occur in collections that are indicative of an aquatic habitat. These have been washed into the deposit or occur on old shore lines of the lake.

Other aquatic mollusks occurring in minor percentages but continuously throughout the deposit are considered indigenous. These are the small shelled forms such as Promenetus exacuous, Pisidium casertanum, P. nitidum, and P. obtusale rotundatum. In present day occurrences these mollusks live in a habitat usually in much less numbers as compared with others of the molluscan fauna.

In order to ascertain the probable environmental limiting factors of the Jewell Hill Lake, discussed later under Environmental History, the most significant species have been selected. These forms, which have the largest proportional abundance in numbers, exhibit pronounced fluctuations in the quantitative distribution according to repeated changes in favorable and marginal unfavorable environments. These species are Valvata tricarinata, both species of Amnicola, P. obrussa and G. altissimus. The changes in environmental conditions usually do not show as well in the less abundant indigenous species. Other significant species are those which occupy more actual volume because of the much larger shell of the animal. The large forms in this category are S. umbrosa, H. trivolvis, and at times P. gyrina, which often occurs as an immature shell.

Environmental History

GENERAL. This discussion is an attempt to outline the probable events in the development of the Jewell Hill Lake. Inferences are drawn from the information given under Paleoecology and the occurrence of mollusks collected at section 1. The conclusions, therefore, are limited to the immediate area of the collection site. With this reservation in mind, each fossil-bearing unit is presented separately.

UNIT FOUR, LOWERMOST FAUNA. Table II shows the fauna that lived in the lake just after the initial invasion of mollusks into Jewell Hill Lake. The significant species are V. tricarinata, G. altissimus, A. leightoni, A. lustrica, and H. anceps striatum. Water approximately 5 to 6 m. deep was present in which the fauna flourished. This depth of water at section 1, the deepest portion of the lake, corresponds very well to the known thickness, 5.2 m., of this unit, the buff colored marl. The above depth of water is the probable mean annual water level derived from the known ecology of the significant forms, especially V. tricarinata which lives in deeper water than the others listed. The pH of the water at this time may have been between limits of 7.1 and 8.16. V. tricarinata does not occur in water where the pH is lower than 6.8 or in water softer than 8 p.p.m. The probable limits of the fixed carbon dioxide are between 8.16 and 30.56 p.p.m.

UNIT FOUR, UPPERMOST FAUNA. From the lowermost fauna in the bottom foot of unit 4, up to collections 1 through 6, different species became significant. The change of significant forms indicates filling of the lake and gradual decrease in depth of water. V. tricarinata and A. leightoni decreased in numbers until in the upper part of this unit they assume an unimportant role. A. lustrica increased to about 32 percent in collection 1 and gradually decreased to 20 percent in collection 5. P. gyrina and Pisidium nitidum exhibit parallel conditions as they increase to 19 and 9 percent, respectively, in collection 1 and gradually decreased to 13 and 6 percent, respectively, in collection 5. Just before the time of accumulation of collection 1 and continuing through collection 5, the specific conditions inferred were as follows: small amount of water weeds with a corresponding minimum of shade and well aerated water about 1 m. or more deep. In collection 6 Pisidium nitidum, Physa gyrina, and Amnicola lustrica drop to an insignificant small number. Conditions here indicate the beginning encroachment of a luxuriant plant growth in very shallow water. The total population already shows a slight reduction in absolute numbers. The encroachment and continued shallowing of water, possibly less than 0.6 m. deep, produced a habitat most favorable for G. altissimus and F. obrussa, the semi-amphibious inhabitant of shallow water among vegetation and debris. These species account for 58 percent of the total individuals in collection 6.

The increase of land snails from 1.5 percent in collection 5 to 8.4 percent in collection 6 shows the possible inward shifting of the shore line. The pH values of about 7.0 to 8.16 are inferred from the significant species in the uppermost part of the unit. The fixed carbon dioxide value probably ranged between 9.5 and 25.75 p.p.m.

UNIT FIVE. Conditions continued to become more adverse for the molluscan population in unit five. In collection 7 the fauna had been reduced to less than half of the population by the continued encroachment of plant growth. In this environment Gyraulus altissimus increased in percentage of total individuals. However, it too was reduced to less than half of its total numbers in unit four, uppermost fauna. The upper part of collection 7 and all of collection 8 represent complete capture of the centrally located area of the lake deposits. In collection 8 the total population was reduced to 0.15 percent of the once vast population in unit four. The decomposition of peat to humus in unit five took place during periods when parts of the vegetal debris was out of water. Undoubtedly some shifting pools of water remained in the area of the lake and provided a source from which the surviving species later repopulated the lake.

In collection 7 the land snails such as S. ovalis, V. ovata, G. pentodon, R. binneyana, and E. fulvus occupied their preferred habitat along the same probable shore line as in collection 6 of unit four, uppermost fauna. Only one land snail, V. ovata, was found in collection 8. This could possibly mean that the shore area would be located elsewhere in the area of the lake deposit.

The pH and fixed carbon dioxide values are about the same as those given for the uppermost part of unit four.

UNIT SIX. A seasonal increase in rain, ending the drought-like or low-water-level period, began another cycle of sedimentation and plant growth in the lacustrine deposit. Again V. tricarinata, along with G. altissimus, became significant during the time of accumulation of collections 9 through 12. Both species of Amnicola are also significant in collections 10 through 12. The presence of these forms, during the accumulation of the lowermost part of this unit, indicated moderately thick vegetation, a level of water more than 1 m. deep, and a mud bottom.

Three species migrated into the pond-like environment during the accumulation of collections 9 through 11. Two of these, S. umbrosa and H. trivolvis, indicate pond conditions. The other, L. stagnalis jugularis, came into a favored habitat of stagnant water in collection 11 but lasted through only to collection 14.

Four species, S. umbrosa, F. obrussa, H. trivolvis, and G. altissimus, are indigenous and remain significant throughout the unit, from collections 13 to 22. Both species of Fossaria are especially valuable in interpreting the conditions. They gradually increase from about 25 percent in collection 13 to about 45 percent of the total individuals in collection 22. These species indicate very shallow water; however, there were times when the water deepened as shown in collections16 and 17. In collections 16 and 17 V. tricarinata and G. altissimus soar to combined percentages of 63 and 57 respectively.

This unit indicates prevailing pond conditions with shallow water and muddy bottom supporting thick pond weeds. The vegetation continued to increase throughout most of the unit as shown in Fig. 18, and a gradual decrease in depth of the already shallow water is inferred from the ecology of the indigenous species. The above inferred habitat is also exemplified by the stratigraphy of the interbedded peat and silty, medium light gray colored marl.

The influx of sediments from the surrounding kame hills was sufficiently great to bury the vegetal debris. The choking vegetation and organic debris so adverse to a flourishing fauna were held in check by the accumulation of sediments. The total population fluctuates in this unit, but increases steadily until a culmination is attained in collections 22 and 23 as shown in Fig. 4. Collections 22 and 23 and those immediately preceding them represent a habitat of optimum conditions for an abundant molluscan assemblage.

The pH value derived from the significant species ranges between 6.6 and 7.8. The fixed carbon dioxide value was probably 7.5 to 25.75 p.p.m.

UNIT SEVEN. The late stage of the lake probably developed as a result of insufficient influx of sediment to check the plant growth. The filling of the lake had raised to such a level that the influx of sediment no longer had much effect. The plant growth finally gained supremacy in the struggle to capture the quiet, shallow water. In this unit the only species to survive were those able to live in mass vegetation. These species include F. obrussa, which reached its highest percentage of 54 in collection 23; and G. altissimus, which attained a percentage of approximately 41 percent in the upper three collections of the unit. The pH and fixed carbon dioxide values would be approximately the same as those in unit six.

The land snails again probably followed the shrinking shore line where they occupied the cool, damp lower layers of vegetal debris. In collections 24 through 26 these land snails attained percentages from 26 to 28 percent of the total individuals. An aquatic habitat is still indicated, however, by the greater percentages of the aquatic mollusks.

AGE AND CORRELATION OF DEPOSIT

General Statement

The molluscan assemblage collected at section 1 is similar to various Pleistocene and living faunas recorded in the literature. In order to determine a probable age relationship based on mollusks, certain faunal occurrences have been selected to illustrate possible correlation. The dissimilarities between the fauna studied and others offer additional information to support a more complete conclusion. The Jewell Hill fauna is compared with one living and five fossil assemblages. In each faunal occurrence names have been brought up to date where necessary.

Living Fauna

NORTH STAR LAKE, ITASCA COUNTY, MINNESOTA. Baker (1935, p. 257) made exhaustive collections of freshwater mollusks in this deep glacial lake, and also of land snails in nearby forests and along the margins of the lake. The freshwater mollusks are largely confined within depths of water less than 4 m. deep. An extensive marl bed lies beneath three feet of peat and bog at Little North Star Lake. Baker (1935, p. 260) states that this deposit of marl "belongs to the time of greater expansion of the lake, probably in late Wisconsin time." Gyraulus altissimus occurred only in the marl bed and was associated with species still living in the lake.

The lake had 27 living freshwater species of which the following eleven also occur in the Jewell Hill deposit: Pisidium sp., Valvata tricarinata (Say), Lymnaea stagnalis jugularis (Say), Fossaria obrussa decampi (Streng), Helisoma anceps striatum (F. C. Baker), Helisoma campanulatum (Say), Planorbula armigera (Say), Promenetus exacuous (Say), Gyraulus crista (Linnaeus), Ferrissia parallela (Say), and Physa gyrina Say.

Seventeen species of land snails lived near the lake, of which 6, listed below, have been washed into the Jewell Hill deposit: Euconulus fulvus (Müller), Retinella binneyana (Morse), Hawaiia minuscula (Binney), Strobilops labyrinthica (Say), Vallonia gracilicosta Reinhardt, and Succinea ovalis Say.

Pleistocene Faunas

URBANA, ILLINOIS. Baker (1918b, p. 660) states that the Urbana deposit is in the Champaign till sheet, which is early Wisconsin in age. The deposit lies in a kettle hole on the north side of the Champaign moraine at the University of Illinois. He suggests that the mollusks may have inhabited the lake or pond when the late Wisconsin ice sheet was "resting at the Valparaiso moraine."

The fauna of the Urbana and Jewell Hill deposits show a dissimilarity in that Pisidia are more abundant in the former and comparison of quantitative data may be made for only a few species. Only eight are common to both deposits. These eight species, together with Baker's indications of abundance, are: Pisidium adamsi Prime - a single valve; P. nitidum Jenyns - the most abundant mollusk; P. ferrugineum Prime - next to P. nitidum the most abundant; Valvata tricarinata (Say) - not common; Fossaria obrussa decampi (Streng) - common; Helisoma trivolvis (Say) - not common, majority of individuals are immature; Gyraulus altissimus F. C. Baker - a few adult individuals and a number of young and immature specimens; and Physa gyrina (Say) - occurs in abundance; the greater number are immature.

RUSH LAKE, LOGAN COUNTY, OHIO. This marl deposit has been dated as post-Wisconsin in age since "Logan County is within the late Wisconsin drift border" (Baker, 1920, p. 440). Noting the absence of land snails and the presence of certain species that have a wide distribution in lakes, Baker concluded "the Ohio deposit may, therefore, be considered as having lived in a larger Rush Lake, perhaps not long after the ice had disappeared from Ohio."

The assemblages of the two deposits, Rush Lake and Jewell Hill Lake, are similar in character and comparative abundance of freshwater mollusks. The most abundant species are the same for both deposits except for one species, Fossaria obrussa. The list of the same species, together with Baker's indications of abundance, follows: Sphaerium lacustre (Müller) - a dozen odd valves; Pisidium casertanum (Poli) - 2 valves; P. compressum Prime - common; P. ferrugineum Prime - a score; P. nitidum Jenyns - the most abundant Sphaeriidae; P. nitidum pauperculum (Sterki) - 2 valves; V. tricarinata (Say) - one of the most abundant species, several hundred; Amnicola leightoni F. C. Baker - "Together with Amnicola lustrica variety, it is the most abundant species in this deposit." A. lustrica Pilsbry - nearly 40 percent of total; Fossaria obrussa decampi (Streng) - quite common; Helisoma anceps striatum (Baker) - "about 10 percent of the antrosus (anceps) may be referred to this variety"; H. campanulatum (Say) - a dozen specimens; Gyraulus altissimus (F. C. Baker) - after Amnicola lustrica and A. leightoni it is the most abundant shell in this deposit; Promenetus exacuous (Say) - fairly common; and Ferrissia parallela (Haldeman) - a single specimen.

ORLETON MASTODON SITE, MADISON COUNTY, OHIO. The molluscan assemblage of this deposit is remarkably similar to that of the Orleton deposit. La Rocque (1952, p. 26) reports that "The age of the Orleton faunas can definitely be stated as Wisconsin" and "both lists of species .... indicate a late Wisconsin age." Both the Jewell Hill and Orleton deposits exhibit more or less parallel development, geologic nature, and environmental conditions.

The significant species in both small lake deposits are comparable in abundance, except for the greater number of Pisidia in the gray layer, and the absence of Amnicola in the Orleton deposit. La Rocque (1952, p. 18) suggests that in the Orleton deposit the establishment of Amnicola and Helisoma, other than H. trivolvis, was prevented due to unknown barriers. The difference between the two assemblages, therefore, becomes minor.

Eleven of the 21 forms present in the Orleton deposit are common to both deposits; they are: Helisoma trivolvis (Say), Planorbula armigera (Say), Gyraulus altissimus (F. C. Baker), Gyraulus crista (Linn.), Promenetus exacuous (Say), Physa gyrina Say, Ferrissia parallela (Haldeman), Succinea ovalis Say, Stenotrema monodon (Rackett), Hawaiia minuscula (Binney), and Vertigo ovata Say.

Six species in the Orleton deposit have ecological requirements similar to those in the Jewell Hill deposit. They are: Pisidium sp., Sphaerium sp., Stagnicola palustris elodes (Say), Stagnicola lanceata (Gould), Fossaria galbana (Say), and Valvata lewisi Currier.

CLEVELAND, OHIO. This loess deposit, studied by Leonard (1953, p. 368), contains two molluscan assemblages, of which the lower faunule is correlated with the Farmdale substage of Wisconsin age and the upper faunule is correlated with the Tazewellian substage. The disparity between the Cleveland loess and Jewell Hill deposits is shown by the number of different species in both faunas. Leonard (1953, p. 370) has listed a number of individuals that "clearly attest" the age of the loess deposit to be early Wisconsin. The list follows: Fossaria dalli grandis Baker, Gyraulus pattersoni Baker, Columella alticola (Ingersoll), Discus mcclintocki Baker, Hendersonia occulta (Say), Succinea avara gelida Baker, S. grosvenori Lea, and Vertigo alpestris oughtoni Pilsbry.

SIDNEY CUT, SHELBY COUNTY, OHIO. The fauna of this deposit consists largely of terrestrial snails that have been washed into puddles or pools of a hollow developed on a ground moraine (La Rocque and Forsyth, 1957, p. 85). The evidence supports a Wisconsin age, and "an 'Early' rather than a 'Late' Wisconsin age" is indicated because of the presence of certain species.

especially Columella alticola and Vertigo alpestris oughtoni. The comparison of land snails in the Sidney Cut deposit with those that have been washed into the deposit under study illustrates a striking disparity of terrestrial snails. Only 3 species and 3 genera out of a total of 15 forms are the same in both deposits. The following list is composed of terrestrial species that occur in the Sidney deposit and not in the Jewell Hill deposit: Carychium exile canadense Clapp; Cionella lubrica (Müller), Columella alticola (Ingersoll), Deroceras? sp., Discus cronkhitei (Newcomb), Helicodiscus sp., Helicoid, undetermined fragments; Succinea grosvenori Lea, and Vertigo alpestris oughtoni Pilsbry. Hawaiia minuscula, Succinea avara, and Vallonia gracilicosta are common to both deposits.

Age of Deposit

The Jewell Hill fauna is Wisconsin in age, as shown by comparison of the fauna with others of known Wisconsin age. That the Jewell Hill deposit is pre-Recent is demonstrated by the presence of 5 species which are no longer a part of the living molluscan fauna of Ohio. These are Amnicola leightoni, Helisoma anceps striatum, Gyraulus altissimus, and Vallonia gracilicosta. All of these forms, except Amnicola leightoni, are still found living at higher latitudes.

A "Late" rather than an "Early" Wisconsin age is preferred because of the character of the fauna and the geologic nature of the deposit. The terms "Late" and "Early" Wisconsin are used here with the meaning assigned by Goldthwait and Forsyth and explained by La Rocque and Forsyth (1957, p. 81, footnote). The absence in the Jewell Hill deposit of species which may be indicative of an "Early" Wisconsin age, further supports the preference stated above. These "Early" Wisconsin species, which are also absent from the living molluscan fauna of Ohio, include Columella alticola, Succinea grosvenori, Discus mcclintocki, Vertigo alpestris oughtoni, Gyraulus pattersoni, and Fossaria dalli grandis. The Jewell Hill deposit lies on a till sheet that covers a kame deposit. This mantle of till has been assigned a "Late" Wisconsin age by Forsyth (1956, p. 183).

The writer concludes, therefore, that the Jewell Hill Lake deposit is "Late"Wisconsin in age because of the evidence presented.

Acknowledgements

Thanks are due to my adviser, Dr. Aurêle La Rocque, who suggested this study, and whose guidance made possible the completion of this paper. The writer is also grateful to Rev. Mr. H. B. Herrington for the identification of the sphaeriids; and to James A. Zimmerman and John Cornejo who helped with the excavation, manual operation of the bayonet auger, and mapping. The illustrations were supplied by the Ohio Division of Geological Survey whose generous support is much appreciated.

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DESCRIPTION OF FIGS. 6 - 11, OPPOSITE PAGE

Fig. 6. Quantitative distribution of *Fossaria obrussa* (Say) in the Jewell Hill Deposit.
Fig. 7. Quantitative distribution of *Physa gyrina* Say in the Jewell Hill Deposit.
Fig. 8. Quantitative distribution of *Fossaria obrussa decampi* (Streng) in the Jewell Hill Deposit.
Fig. 9. Quantitative distribution of *Promenetus exacuous* (Say) in the Jewell Hill Deposit.
Fig. 10. Quantitative distribution of *Stagnicola umbrosa* (Say) in the Jewell Hill Deposit.
Fig. 11. Quantitative distribution of *Helisoma trivolvis* (Say) in the Jewell Hill Deposit.

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	202	20.2	
25	167	16.7	
24	88	17.6	
23	541	54.1	
22	407	40.7	
21	474	47.4	
20	395	39.5	
19	242	24.2	
18	341	34.1	
17	188	18.8	
16	159	15.9	
15	169	16.9	
14	199	19.9	
13	259	25.9	
12	44	4.4	
11	18	1.8	
10	47	4.7	
9	39	3.9	
8	2	4.1	
7	167	16.7	
6	171	17.1	
5	167	16.7	
4	114	11.4	
3	59	5.9	
2	57	5.7	
1	55	5.5	

6

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	3	0.3	
25	7	0.7	
24	8	1.6	
23	44	4.4	
22	53	5.3	
21	96	9.6	
20	56	5.6	
19	67	6.7	
18	53	5.3	
17	72	7.2	
16	30	3.0	
15	20	2.0	
14	15	1.5	
13	34	3.4	
12	16	1.6	
11	18	1.8	
10	18	1.8	
9	21	2.1	
8	0	0.0	
7	18	1.8	
6	45	4.5	
5	133	13.3	
4	151	15.1	
3	137	13.7	
2	194	19.4	
1	195	19.5	

7

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	39	3.9	
25	47	4.7	
24	18	3.6	
23	138	13.8	
22	46	4.6	
21	41	4.1	
20	43	4.3	
19	23	2.3	
18	38	3.8	
17	16	1.6	
16	13	1.3	
15	38	3.8	
14	53	5.3	
13	16	1.6	
12	3	0.3	
11	0	0.0	
10	7	0.7	
9	17	1.7	
8	0	0.0	
7	58	5.8	
6	27	2.7	
5	42	4.2	
4	51	5.1	
3	20	2.0	
2	61	6.1	
1	50	5.0	

8

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 1 2 3 4 5
26	6	0.6	
25	10	1.0	
24	5	1.0	
23	1	0.1	
22	11	1.1	
21	1	0.1	
20	12	1.2	
19	22	2.2	
18	33	3.3	
17	46	4.6	
16	58	5.8	
15	26	2.6	
14	17	1.7	
13	25	2.5	
12	11	1.1	
11	13	1.3	
10	27	2.7	
9	25	2.5	
8	0	0.0	
7	13	1.3	
6	22	2.2	
5	4	0.4	
4	1	0.1	
3	1	0.1	
2	2	0.2	
1	1	0.1	

9

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 1 2 3 4 5
26	9	0.9	
25	5	0.5	
24	2	0.4	
23	0	0.0	
22	8	0.8	
21	5	0.5	
20	4	0.4	
19	6	0.6	
18	6	0.6	
17	2	0.2	
16	3	0.3	
15	3	0.3	
14	4	0.4	
13	6	0.6	
12	8	0.8	
11	1	0.1	
10	0	0.0	
9	0	0.0	
8	0	0.0	
7	0	0.0	
6	0	0.0	
5	0	0.0	
4	0	0.0	
3	0	0.0	
2	0	0.0	
1	0	0.0	

10

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 1 2 3 4 5
26	3	0.3	
25	2	0.2	
24	1	0.2	
23	0	0.0	
22	3	0.3	
21	2	0.2	
20	8	0.8	
19	5	0.5	
18	13	1.3	
17	8	0.8	
16	4	0.4	
15	7	0.7	
14	6	0.6	
13	2	0.2	
12	1	0.1	
11	1	0.1	
10	3	0.3	
9	2	0.2	
8	0	0.0	
7	0	0.0	
6	0	0.0	
5	0	0.0	
4	0	0.0	
3	0	0.0	
2	0	0.0	
1	0	0.0	

11

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	1	0.1	
25	0	0.0	
24	1	0.2	
23	1	0.1	
22	3	0.3	
21	3	0.3	
20	1	0.1	
19	29	2.9	
18	5	0.5	
17	113	11.3	
16	102	10.2	
15	6	0.6	
14	2	0.2	
13	0	0.0	
12	109	10.9	
11	163	16.3	
10	156	15.6	
9	102	10.2	
8	2	4.1	
7	70	7.0	
6	61	6.1	
5	50	5.0	
4	59	5.9	
3	68	6.8	
2	33	3.3	
1	28	2.8	

12

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	1	0.1	
25	0	0.0	
24	6	1.2	
23	0	0.0	
22	1	0.1	
21	0	0.0	
20	0	0.0	
19	6	0.6	
18	1	0.1	
17	2	0.2	
16	1	0.1	
15	6	0.6	
14	94	9.4	
13	3	0.3	
12	209	20.9	
11	369	36.9	
10	91	9.1	
9	52	5.2	
8	3	6.1	
7	11	1.1	
6	35	3.5	
5	71	7.1	
4	67	6.7	
3	101	10.1	
2	45	4.5	
1	51	5.1	

13

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	0	0.0	
25	0	0.0	
24	5	1.0	
23	0	0.0	
22	0	0.0	
21	0	0.0	
20	0	0.0	
19	0	0.0	
18	0	0.0	
17	0	0.0	
16	1	0.1	
15	0	0.0	
14	0	0.0	
13	0	0.0	
12	129	12.9	
11	134	13.4	
10	7	0.7	
9	6	0.6	
8	3	6.1	
7	18	1.8	
6	66	6.6	
5	201	20.1	
4	232	23.2	
3	301	30.1	
2	312	31.2	
1	324	32.4	

14

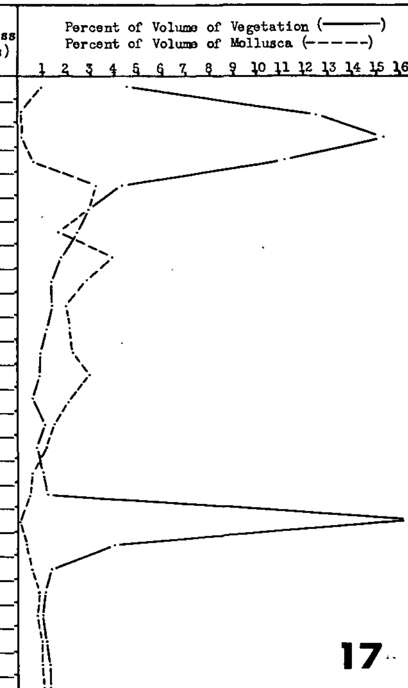
COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 10 20 30 40 50
26	4	0.4	
25	11	1.1	
24	9	1.8	
23	9	0.9	
22	40	4.0	
21	36	3.6	
20	44	4.4	
19	16	1.6	
18	49	4.9	
17	15	1.5	
16	14	1.4	
15	57	5.7	
14	40	4.0	
13	5	0.5	
12	0	0.0	
11	1	0.1	
10	11	1.1	
9	24	2.4	
8	4	7.8	
7	44	4.4	
6	37	3.7	
5	0	0.0	
4	0	0.0	
3	0	0.0	
2	0	0.0	
1	1	0.1	

15

COLLECTION NUMBER	NUMBER OF INDIVIDUALS	PERCENT OF TOTAL INDIVIDUALS	GRAPHIC REPRESENTATION OF PERCENTAGE OF TOTAL INDIVIDUALS 1 2 3 4 5
26	0	0.0	
25	0	0.0	
24	1	0.2	
23	3	0.3	
22	6	0.6	
21	3	0.3	
20	6	0.6	
19	8	0.8	
18	23	2.3	
17	25	2.5	
16	14	1.4	
15	9	0.9	
14	16	1.6	
13	11	1.1	
12	1	0.1	
11	0	0.0	
10	0	0.0	
9	2	0.2	
8	1	2.0	
7	12	1.2	
6	18	1.8	
5	1	0.1	
4	1	0.1	
3	2	0.2	
2	0	0.0	
1	1	0.1	

16

UNIT	Coll. No.	Thickness (inches)
7	26	12
	25	2.5
	24	2.5
	23	2
6	22	2
	21	2
	20	2
	19	2
	18	2
	17	2
	16	2
	15	2
	14	2
	13	2
	12	2
	11	2
	10	2
	9	2.5
5	8	3
	7	2.5
4	6	2
	5	2
	4	2
	3	2
	2	2
	1	2



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DESCRIPTION OF FIGS. 12-17, OPPOSITE PAGE

Fig. 12. Quantitative distribution of *Valvata tricarinata* (Say) in the Jewell Hill Deposit.

Fig. 13. Quantitative distribution of *Amnicola leightoni* F. C. Baker in the Jewell Hill Deposit.

Fig. 14. Quantitative distribution of *Pisidium nitidum* Jenyns in the Jewell Hill Deposit.

Fig. 15. Quantitative distribution of *Pisidium casertanum* (Poli) in the Jewell Hill Deposit.

Fig. 16. Quantitative distribution of *Pisidium obtusale rotundatum* (Prime) in the Jewell Hill Deposit.

Fig. 17. Variation in relative abundance of vegetation and mollusks in the Jewell Hill Deposit.

ECOLOGICAL DATA -- 1. LATCHFORD'S NOTES ON ELLIPTIO COMPLANATUS (DILLWYN).

The following information was published by F. R. Latchford (1882, Trans. Ottawa Field-Nat. Club, I, No. 3: 49) nearly 80 years ago. It is reproduced here with annotations in order to make it more accessible to malacologists. Its value lies in the acute observation displayed, the time at which it was recorded, and the fact that the localities mentioned are in the northern part of the range of the species. The geology of the area is well known (see Wilson, 1946, Geol. Survey of Canada, Mem. 241, especially maps 413A and 414A). The writer revisited some of the localities mentioned 25 or 30 years ago and can vouch for the accuracy of Latchford's data. The annotations (indicated by capital letters in parentheses) will help the reader find the various localities mentioned and supply additional pertinent information. Latchford's notes are reproduced in the following excerpt from the paper mentioned above.

"UNIO COMPLANATUS Sol. Rideau R. (A) everywhere, Ottawa R. above the Chaudière Falls (B). In company with the typical form, I found near Skead's Mills (C), in 1880, a specimen of a small variety. Although presenting every appearance of maturity, it is only an inch in height by two and a half in length. For its size it is very thick and regularly inflated. I am informed that a similar variety occurs in some streams in Western New York. A form almost as small is found in the cold and limpid waters of Meech's Lake (D). But it is a thin and not a thick shell; not inflated but depressed. Its colour is a very light brown. About half a mile from Meech's Lake, on the creek through which it finds an outlet, are a few shallow ponds, with a bottom of coarse sand and gravel washed down from the surrounding hills. In the warmer water of these ponds, where food also must be more abundant, U. complanatus is three times as large as in the neighbouring lake. It differs moreover in being proportionately less depressed, and more equally rounded at both extremities. Its colour is a rich dark brown with a silken lustre, and, not unfrequently, a tinge of bright orange along the umbonal slope.

"Near Kettle Island (E) there occurs a form of much interest on account of its curious angular inflation. How extraordinary this is for a species whose most constant characteristic is its flatness, may be inferred from the fact that a representative specimen whose height is 1.6 in. measures 1.5 in. in diameter. The inflation is greatest near the dorsal margin behind the hinge-ligament, where a section of the shell would be an almost perfectly equilateral triangle with the base and the angles at the base slightly rounded. A specimen found by Mr. Poirier is 3 in. high 4.9 long, and weighs only 3 oz. (F).

"At the same locality is found a still more remarkable variety and one of no little beauty. In some respects it resembles U. Raleighensis Lea from North Carolina and in others U. tortuosus Sowby from Maryland. It is like the former in shape and in the numerous prominent rays which diversify its surface; and like the latter in the strange peculiarity that its valves meet at the ventral margin not in a straight but in a sinuous line. A correspondent writes that under Dr. Lea's treatment it would be entitled to rank as a species. Whether a variety of U. complanatus or a distinct species, it is a most unique and interesting shell."

(A) Rideau River: a north-flowing tributary of the Ottawa, part of which was incorporated into the Rideau Canal in the 1830s. The canal joined the Ottawa with the east end of Lake Ontario at Kingston, Ontario. For an account of the Rideau Canal, see Robert Legget's "Rideau Waterway" (1955, U. of Toronto Press, xiv + 249 pp., illus., incl. maps).

(Continued p. 32)

PRELIMINARY CHECKLIST OF LAKE BONNEVILLE MOLLUSCA

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The existence of an ancient lake in the Bonneville Basin of western Utah was first recognized, on physical evidence alone, by Howard Stansbury in 1849. Some ten years later the first observation on fossil mollusks from deposits of this lake was made by Henry Engelmann although publication of his observations was delayed until 1876. In the meantime, F. V. Hayden made a small collection and prepared an account of it for his report of 1872, thus getting credit for the first published report of Bonneville fossil mollusks.

Intensive investigation of the Bonneville problem began with G. K. Gilbert whose studies culminated in the classic monograph on Lake Bonneville published by the U. S. Geological Survey in 1890. The molluscan material obtained by Gilbert was submitted to R. E. Call for identification. Call's studies on the Bonneville fossils were included in a report on the Pleistocene and Recent mollusks of the entire Great Basin published by the U. S. Geological Survey in 1884. There has been no review of the Bonneville fauna since that date.

I am indebted to Dr. Dwight W. Taylor, U. S. Geological Survey, for critical reading of the manuscript and for information on certain forms not reported in the literature but present in the Survey collection in Washington, D. C. Both Dr. Taylor and I are cognizant of the tentative nature of some of these determinations; responsibility for inclusion in the present list rests solely with the author. Its chief value will probably lie in the consolidation of the widely scattered literature. Criticisms and suggestions are earnestly solicited from all interested persons.

The checklist is arranged in general accordance with the plan outlined by La Rocque in a previous number (Sterkiana, 1: 19-22). References are given only to those papers in which Lake Bonneville mollusks are reported. Synonymy is not given here but can be reconstructed from the references cited.

1. NAIADES

Margaritiferidae

1. MARGARITIFERA MARGARITIFERA (Linné) 1758. Call 1884: 14; Henderson 1924: 88-89; Chamberlin and Jones 1929:29.

Unionidae

?2. ANODONTA CALIFORNIENSIS Lea 1852. Henderson 1931b: 109-113.

3. ANODONTA NUTTALLIANA Lea 1838. Call 1884: 14-15; ?Hannibal 1912: 126, 197, 203; Henderson 1924: 85; Chamberlin and Jones 1929: 19, 23, 26; Henderson 1936: 82; Christensen 1950: 107.

4. ANODONTA OREGONENSIS Lea 1838. ?Hannibal 1912: 126, 197, 203; Chamberlin and Jones 1929: 23-25; Henderson 1936: 82.

5. ANODONTA (SP.). Eardley and Gvosdetsky 1960: 1336-1338.

2. SPHAERIIDAE

6. PISIDIUM COMPRESSUM Prime 1851. Henderson 1931b: 109-113; Herrington and Roscoe 1953: 98.

7. PISIDIUM (SP.). Eardley and Gvosdetsky 1960: 1336-1338.

?8. SPHAERIUM DENTATUM (Haldeman) 1841. Call 1884: 15; Henderson 1924: 91.

9. SPHAERIUM PILSBRYANUM Sterki 1909. Sterki 1909: 141; Sterki 1916: 437; Chamberlin and Jones 1929: 32; Henderson 1931b: 109-113; Berry and Crawford 1932: 53-54; Hunt, Varnes, and Thomas 1953: 25.

10. SPHAERIUM STRIATINUM (Lamarck) 1818. Boutwell 1904: 471-472; Eardley and Gvosdetsky 1960: 1336-1338.

11. SPHAERIUM (SP.). Engelmann, in Simpson 1876: 313; Eardley and Gvosdetsky 1960: 1336-1338.

3. FRESHWATER PULMONATA

Physidae

12. APLEXA HYPNORUM (Linné) 1758. U. S. G. S. collections.

?13. PHYSA AMPULLACEA Gould 1885. Henderson and Daniels 1917: 58; Chamberlin and Jones 1929: 159-162; Henderson 1931b: 109-113; Berry and Crawford 1932: 53-54; Hunt, Varnes, and Thomas 1953: 25.

?14. PHYSA GYRINA Say 1821. Call 1884: 18; Stearns 1901: 293; Henderson 1924: 184.

?15. PHYSA HETEROSTROPHA (Say) 1817. Gilbert 1875: 100; Yarrow 1875: 938; Call 1884: 18; Stearns 1901: 288; Henderson 1924: 185.

?16. PHYSA LORDI Baird 1863. Call 1884: 19; Henderson 1924: 185; Hunt, Varnes, and Thomas 1953: 25.

17. PHYSA (SP.). Eardley and Gvosdetsky 1960: 1336-1338.

Lymnaeidae

?18. LYMNAEA AURICULARIA (Linné) 1758. Hannibal 1912: 140-141; Henderson 1924: 163.

19. LYMNAEA BONNEVILLENSIS (Call) 1884. Call 1884: 24, 28; Call 1886: 6; Gilbert 1890: 219, 298; Stearns 1901: 291; Baker 1911: 105; Henderson 1924: 163; Chamberlin and Jones 1929: 135; Henderson 1936: 117; Hasler and Crawford 1938: 25-26; Ives 1946: 195-199; Ives 1951: 787.

20. LYMNAEA CAPERATA Say 1829. Eardley and Gvosdetsky 1960: 1336-1338.

?21. LYMNAEA CATASCOPIUM Say 1817. Hayden 1872: 170; Henderson 1924: 163.

22. LYMNAEA COCKERELLI (Pilsbry and Ferriss) 1906. Eardley and Gvosdetsky 1960: 1336-1338.

23. LYMNAEA DALLI (Baker) 1906. Eardley and Gvosdetsky 1960: 1336-1338.

?24. LYMNAEA DESIDIOSA Say 1821. Hayden 1872: 170; Gilbert 1875: 99, 100; Yarrow 1875: 994; Henderson 1924: 167.

25. LYMNAEA HUMILIS Say 1822. Stearns 1893: 275; Henderson 1924: 167.

26. LYMNAEA KINGI (Meek) 1876. Chamberlin 1933: 97-100; Henderson 1924: 124; Berry and Crawford 1932: 53-54.

27. LYMNAEA MODICELLA Say 1825. Chamberlin and Jones 1929: 138.

28. LYMNAEA OBRUSSA Say 1825. Chamberlin and Jones 1929: 141-143.

29. LYMNAEA PALUSTRIS (Müller) 1774. Call 1884: 17; Gilbert 1875: 100; Yarrow 1875: 943; Henderson 1924: 168-169; Henderson 1931b: 109-113; Chamberlin and Jones 1929: 128-133; Berry and Crawford 1932: 53-54; Eardley and Gvosdetsky 1960: 1336-1338.

30. LYMNAEA PROXIMA Lea 1856. Henderson and Daniels 1917: 58.

31. LYMNAEA STAGNALIS APPRESSA (Say) 1818. Call 1884: 17; Baker 1911: 146, 147; Hannibal 1912: 140; Henderson 1924: 161; Chamberlin and Jones 1929: 123.

?32. LYMNAEA SUMASSI Baird 1863. Call 1884: 18; Henderson 1924: 169.

33. LYMNAEA UTAHENSIS (Call) 1884. Call 1884: 373, 379, 381; Call 1886: 5; Gilbert 1890: 291; Stearns 1901: 291; Sterki 1909: 142; Baker 1911: 458; Henderson 1924: 173; Chamberlin and Jones 1929: 143-144; Henderson 1931a: 77-79; Henderson 1931b: 109-113; Berry and Crawford 1932: 53-54; Henderson 1936: 124; Hunt, Varnes, and Thomas 1953: 23.

34. LYMNAEA (SP. or SPP.). Engelmann, in Simpson 1876: 313; Berry and Crawford 1932: 53-54; Crawford and Chorney 1944: 135-138; Eardley and Gvosdetsky 1960: 1336-1338.

Planorbidae

35. ARMIGER CRISTATA (Linné) 1758. Eardley and Gvosdetsky 1960: 1336-1338.

?36. CARINIFEX ATOPUS Chamberlin and Jones 1929. Chamberlin and Jones 1929: 156-157; Henderson 1931: 77-79.

37. CARINIFEX NEWBERRYI (Lea) 1858. Gilbert 1875: 100; Yarrow 1875: 946; Ingersoll 1877: 132; Stearns 1883: 277; Sterki 1909: 142; Henderson 1924: 181; Chamberlin and Jones 1929: 155-156; Henderson 1931a: 44-79; Henderson 1931b: 109-113; Hunt, Varnes, and Thomas 1953: 25.

38. CARINIFEX (SP.). Berry and Crawford 1932: 53-54.

39. GYRAULUS CIRCUMSTRIATUS (Tryon) 1866. Eardley and Gvosdetsky 1960: 1336-1338.

40. GYRAULUS PARVUS (Say) 1817. Henderson and Daniels 1917: 50; Eardley and Gvosdetsky 1960: 1336-1338.

41. GYRAULUS VERMICULARIS (Gould) 1847. Henderson 1931b: 109-113; Berry and Crawford 1932: 53-54.

42. GYRAULUS (SP.). Eardley and Gvosdetsky 1960: 1336-1338.

43. HELISOMA SUBCRENATUM (Carpenter) 1856. U. S. G. S. collections.

44. HELISOMA TRIVOLVIS (Say) 1817. Yarrow 1875: 947; Call 1884: 16; Henderson 1924: 174; Chamberlin and Jones 1929: 146-147; Berry and Crawford 1932: 53-54.

45. HELISOMA (SP.). Crawford and Chorney 1944: 135-138; Eardley and Gvosdetsky 1960: 1336-1338.

46. POMPHOLOPSIS WHITEI Call 1888. Hunt, Varnes, and Thomas 1953: 25.

47. PROMENETUS EXACUOUS (Say) 1821. Henderson 1931b: 109-113; Eardley and Gvosdetsky 1960: 1336-1338.

48. PROMENETUS UMBILICATELLUS (Cockerell) 1887. Eardley and Gvosdetsky 1960: 1336-1338.

Ancylidae

49. FERRISSIA (SP.). Eardley and Gvosdetsky 1960: 1336-1338.

4. FRESHWATER OPERCULATES

Hydrobiidae

50. AMNICOLA CINCINNATIENSIS (Anthony) 1840. Hayden 1872: 170; Call 1884: 20-21; Gilbert 1875: 99; Pilsbry 1899: 122; Hannibal 1912: 101; Henderson and Daniels 1917: 77; Henderson 1924: 190; Chamberlin and Jones 1929: 175-176; Berry and Crawford 1932: 53-54; Wimber and Crawford 1931: 61;

Henderson 1936: 138; Hasler and Crawford 1938: 25-26; Jones 1940: 40.

51. AMNICOLA INTEGRA (Say) 1840. Baily and Baily 1951: 47.

52. AMNICOLA LIMOSA (Say) 1817. Hayden 1872: 170; Hannibal 1912: 185; Henderson 1924: 190; Chamberlin and Jones 1929: 173-174; Berry and Crawford 1932: 53-54.

53. AMNICOLA LONGINQUA Gould 1855. Cooper 1888: 288; Cooper 1892: 23; Henderson 1931b: 109-113; Henderson 1936: 137; Ives 1946: 195-196; Ives 1951: 787; Hunt, Varnes, and Thomas 1953: 23.

54. AMNICOLA PORATA (Say) 1821. Call 1884: 21; Stearns 1893: 278; Henderson 1924: 190.

55. AMNICOLA (SP.). Engelmann, in Simpson 1876: 313; Hague, Arnold, and Emmons 1877: 454; Hunt, Varnes, and Thomas 1953: 25; Eardley and Gvosdetsky 1960: 1336-1338.

?56. FLUMINICOLA COLORADOENSIS Morrison 1940. U. S. G. S. collections.

57. FLUMINICOLA FUSCA (Haldeman) 1847. Hayden 1872: 170; Ingersoll 1877: 133; Call 1884: 21; Stearns 1893: 282; Sterki 1909: 142; Hannibal 1912: 187; Henderson 1924: 192; Chamberlin and Jones 1929: 180-181; Henderson 1931b: 109-113; Berry and Crawford 1932: 53-54; Hunt, Varnes, and Thomas 1953: 23, 25.

58. PALUDESTRINA PROTEA (Gould) 1885. Stearns 1901: 277, 279.

59. POMATIOPSIS LUSTRICA Say 1821. Gilbert 1875: 99.

60. TRYONIA EXIGUA Conrad 1855. Yarrow 1875: 948; Henderson 1924: 191.

Valvatidae

?61. VALVATA CALLI Hannibal 1910. Hannibal 1910: 104, 107; Henderson 1924: 193.

?62. VALVATA HUMERALIS (Say) 1829. Eardley and Gvosdetsky 1960: 1336-1338.

63. VALVATA HUMERALIS CALIFORNICA Pilsbry 1908. Henderson 1931b: 109-113; Berry and Crawford 1932: 53-54.

64. VALVATA UTAHENSIS (Call) 1884. Hayden 1872: 170; Call 1884: 22, 24, 25; Boutwell 1904: 471-472; Hannibal 1910: 23, 104, 106; Henderson 1924: 193; Chamberlin and Jones 1929: 183-184; Henderson 1931b: 109-113; Berry and Crawford 1932: 53-54; Hunt, Varnes, and Thomas 1953: 25; Eardley and Gvosdetsky 1960: 1336-1338.

?65. VALVATA UTAHENSIS HORATII Baily and Baily 1951. Baily and Baily 1951: 50.

?66. VALVATA VIRENS Tryon 1863. Call 1884: 21; Henderson 1924: 193.

5. LAND GASTROPODA

Camaenidae

67. OREOHELIX PERIPHERICA (Ancey) 1881. U. S. G. S. collections.

68. OREOHELIX STRIGOSA DEPRESSA (Cockerell) 1890. Roscoe 1951: 135-136; Hunt, Varnes, and Thomas 1953: 24.

?69. (OREOHELIX SP. or SPP.). Engelmann, in Simpson 1876: 313; Hansen and Stokes 1941: 34.

Zonitidae

70. ZONITOIDES ARBOREUS (Say) 1816. U. S. G. S. collections.

71. ZONITOIDES NITIDUS (Müller) 1774. This specimen, which was determined by me from material submitted by J. H. Feth, cannot be located in the U. S. G. S. collections.

Endodontidae

72. DISCUS CRONKHITEI (Newcomb) 1865. U. S. G. S. collections.

?73. DISCUS CRONKHITEI ANTHONYI Pilsbry 1906. Henderson and Daniels 1917: 58; Henderson 1931b: 109-113.

Valloniidae

74. VALLONIA CYCLOPHORELLA (Ancey) 1890. U. S. G. S. collections.

Pupillidae

75. PUPILLA MUSCORUM (Linné) 1758. U. S. G. S. collections.

76. VERTIGO OVATA (Say) 1822. Henderson and Daniels 1917: 58.

Succineidae

Because of the difficulty, if not impossibility, of determining species in this family from shell features alone, all records are suspect.

?77. SUCCINEA AVARA Say 1824. Hunt, Varnes, and Thomas 1953: 24.

?78. SUCCINEA LINEATA W. G. Binney 1857. Cooper 1870: 199-219; Gilbert 1875: 99.

79. SUCCINEA (SP. or SPP.). Henderson 1931b: 109-113; Eardley and Gvosdetsky 1960: 1336-1338.

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MUSSEL SHOALS VS. MUSCLE SHOALS

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Seldom is malacology concerned with problems of toponymy. There has been one question of long standing, however, which in spite of an official ruling has never been completely settled in the minds of some malacologists. While the famous rapids in the Tennessee River, habitat of abundant river mussels but known officially and most commonly as "Muscle Shoals," are no longer in existence, the name is perpetuated by the hydroelectric plant and by a nearby town bearing the same name. It is interesting to trace the historical development of this name and its relationship to the work and publications of malacologists.

In *Alabama: A Guide to the Deep South*, (W. P. A. Writers' Project, 1941), the following account of Muscle Shoals is given: "About 1779 the first white rivermen paddled into the region and established a trading post here. They named the rapids Muscle or Mussel Shoals, suggested either by the abundant shellfish or the strong arm muscles required to paddle a boat through the rapids." Apparently from the beginning there was uncertainty as to the actual origin and spelling of the name. The spelling "Muscle Shoals" appeared early in such sources as the *Map of Tennessee Government* by John Ried in 1795; Winterbothem's *American Atlas* of 1796; Reports of the Chief of Engineers, U. S. Army, and the Twentieth Congress, First Session, in 1828; the *Tennessee Gazetteer* by Eastin Morris in 1834; and charts of the Tennessee River made for the U. S. Navy by the Coast Survey, 1864-65. On April 5, 1892, the U.S. Board on Geographic Names, in view of past usage, rendered a decision in favor of "Muscle Shoals." Apparently the spelling "muscle" in reference to bivalve mollusks was common, at least in the Alabama-Tennessee region, during those years. Also it is understandable why non-malacologists responsible for the above mentioned documents, carefully considered by the Board, would naturally think of "muscle" rather than "mussel." Probably but few of them were familiar with the animals now most commonly known as mussels. Even the malacologists of that period usually employed the terms "naiad" or "bivalve" for these mollusks.

Practically all reference sources — dictionaries, atlases, gazetteers, encyclopedias, almanacs, government reports, maps, etc. — published since the Board's decision have used the official spelling of "Muscle Shoals," but not without some hesitation in certain cases. Some list both spellings, but give preference to the official form. The 1914 edition of Funk and Wagnalls *New Standard Dictionary of the English Language*, for example, listed the rapids under two separate names, "Muscle Shoals" and "Mussel Shoals," but gave preference to the first. Even as as 1949 the *Encyclopedia Britannica* states under the entry "Muscle Shoals" that "the first part of the name is probably the obsolete form of mussel." Early writers were divided as to usage. An article published in *Harper's Weekly* in 1890 was entitled "Mussel Shoals Canal," but was indexed under "Muscle Shoals" as the primary entry and under "Mussel Shoals" as a secondary classification in *Reader's Guide to Periodical Literature*. Beginning with twentieth century literature, indexing of the *Reader's Guide* does not again use the classification "Mussel Shoals" with a single exception in volume 7 (Literature published 1925-28), and then only as a synonym of "Muscle Shoals."

It was the eminent malacologist A. E. Ortmann who pleaded in 1924 (*Science* 60: 565-6) that "the common and now official spelling 'Muscle Shoals' should be discarded for the more correct one 'Mussel Shoals'." Ironically his article, entitled "Mussel Shoals," was catalogued in the *Reader's Guide to Periodical Literature* under "Muscle Shoals." Ortmann used the spelling which he advocated in his own scientific papers, but strangely enough did not capitalize the name of the rapids. His usual reference to them was stated as "at the mussel shoals near Florence" (*Proc. Am. Phil. Soc.* 57: 521-626. 1918). A reply to Ortmann by G. H. Matthes ("Muscle Shoals vs. Mussel Shoals." *Science* 61: 209. 1925.) claimed that the old spelling for bivalves was "muscle shells," so named because of the strong muscles which close the shells. While he calls attention to spellings in old dictionaries and maps as examples, he does not mention any scientific work using such a spelling. Early writers about the region were probably not aware of the difference. Few people in recent times associate bivalve mollusks with the name "muscle." It appears that such a spelling has not been generally applied to bivalves since the 19th century, although certain local exceptions have been reported by Meredith F. Burrill, Executive Secretary of the U. S. Board on Geographic Names. The problem seems to arise from an early spelling on the part of writers not familiar with the existence of the two homonyms or who preferred to use the optional spelling for bivalves. Place names derived from mussels have long been used elsewhere such as Musselburgh, Scotland; Mussel Aa (River), Netherlands; and Musselburg, Canada. In 1924, the U. S. Board on Geographic Names reconsidered the spelling of Muscle Shoals but made no change in the matter.

It is interesting that in several other instances the same confusion has apparently existed. The U. S. Board recognizes the name of a village and a township in Chariton County, Missouri, as Musselfork. In *Lippincott's New Gazetteer* of 1913, however, they were both listed as "Muscle Fork," while the stream was called "Muscle River." They appear likewise in Lippincott's *Pronouncing Gazetteer or Geographical Dictionary of the World* edited by Heilprin and Heilprin of 1922. While a creek in Queensland, Australia, is known as "Musselbrook," a town in New South Wales goes under the name of "Musclebrook," according to the *Library Atlas of the World* (1914). Other confusions have been noted in the following instances. Musselbed Shoal (a light station in Rhode Island), Mussel Point (a point in Texas), and Musselshell River (in Montana) are listed as such in the *Sixth Report of the U. S. Geographic Board* (1933). The Lippincott volume of 1922 mentioned above lists the "Muscleshell River" of Montana as an alternate spelling of "Mussellshell River." The *Encyclopedia Britannica World Atlas* (1947) also lists for Montana the village of Musselshell in Musselshell County, through which the river by that name passes. Only "Muscle Shoals" appears under such a spelling in these later two sources. However, James McCormick, a former secretary of the U. S. Board on Geographic Names, cited in 1924 the personal journals of Lewis and Clark who referred in 1805 to the "Muscle Shell River" in their entries of May 20 and 21 to what is now officially known as the Musselshell River. Also, "Mussel Point," Texas, appeared on a U. S. G. S. source as "Muscle Point" according to the Board's records of 1908. In 1909 the postmaster of Providence, Rhode Island, stated that the light station in Narragansett Bay was known as "Musclebed

Shoal Light" and the shoal was called the "Muscle Bed" without known exceptions. At Cape Ann, Massachusetts, a headland was labelled as "Muscle Point" or "Muscle Rocks" on all of the early maps of that region which have been examined. However, the roadway, to this place, which was listed in the Gloucester Directory for the first time in 1925, has always been given as "Mussel Point Road." The recent Lucas maps (1935) of this region spell both the name of the point and of the road as "Mussel." It is interesting that *A Geographic Dictionary of Massachusetts* by Henry Gannett (1894) used the spelling "Muscle Point" for this headland at Cape Ann, but lists a similar one on Cape Cod as "Mussel Point." There is a similar "Mussel Point" at Pacific Grove, California, but the only reference to this found by the writer is in an article published in THE NAUTILUS (69: 82. 1956). The spelling employed is probably correct according to current usage and the one to be expected in a journal of malacology.

The postmaster at Florence, Alabama, informed the U. S. Board in 1914 that "Muscle Shoals" was the more commonly used spelling in that locality although even at that early date the local press varied in its usage. The War Department engineer at the canal at that time used the spelling "Muscle." About the same time the postmaster at Sheffield, Alabama, reported "Muscle Shoals" as the common form although sometimes the name appeared as "Mussel Shoals." The corporation formed to develop water power used "Muscle Shoals" in its corporate name. An amusing and seemingly incongruous item appears in Henry Gannett's book *American Names* (1947) which reads "Muscle Shoals -- series of rapids in the Tennessee River .... so named because of the great number of mussels found there." In another reference work (*Cram's Modern Reference Atlas of the World*, 1931) is recorded a town in Butler County of Alabama by the name of "Mussel." Nowhere else has this been found listed. In its brief existence it may have been unique in escaping the problem which has existed in all other cases involving that name.

Creation of Wilson Dam, completed in 1925 by the Tennessee Valley Authority, destroyed the greater portion of the rapids near Florence but not the controversy over their name. Calvin Goodrich, in his papers on the mollusks of the Tennessee River published in the 30's and 40's, used the official spelling. On the other hand, as late as 1942, J. P. E. Morrison in his study of the shell mounds of the Pickwick Landing Basin in the Tennessee River Valley (Smiths. Inst. Bur. Am. Ethnol., Bull. 129, pp. 339-392. 1942) repeatedly and consistently used the name "Mussel Shoals."

The official spelling of Muscle Shoals, now so widely used and the only official name using "muscle" in reference to river clams, will very likely never be changed, and there is little argument for doing so. However, it will probably always remain a slight irritation to many malacologists to refer to the famous rapids with their once abundant mussel fauna as "Muscle Shoals."

My thanks go to Dr. Hallock F. Raup, Head, Department of Geography and Geology of Kent State University and Meredith F. Burrill, Executive Secretary of the U. S. Board on Geographic Names, for assistance in tracing the ramifications of this controversy.

ECOLOGICAL DATA -- 1. (Continued from page 22)

(B) Chaudière Falls, within the city of Ottawa, are a major barrier to migration of Mollusca. Naiades may have reached that part of the Ottawa River above the Falls as parasites on fish able to scale the Falls or, during late Pleistocene time, when the Ottawa served as an outlet for the upper Great Lakes. The problem is an interesting one that will bear further investigation.

(C) Skead's Mills was on the Ontario shore of the Ottawa River just above the Chaudière Falls. The mills have long since been razed.

(D) Meach Lake is the presently accepted spelling. The writer studied its molluscan fauna (1935, Can. Jour. Res., 13 (D): 45-59). The lake lies some 20 miles north of Ottawa. It is one of several in a chain drained by a tributary of the Gatineau River, itself a tributary of the Ottawa.

(E) Kettle Island is in the Ottawa River just east of the outlet of the Gatineau River. It is surrounded by shallow sandy areas abundantly populated by Naiades in Latchford's day but later (1935 to 1945, perhaps earlier) polluted by mill waste which destroyed the Naiades. The Naiades, including Elliptio complanatus, were still abundant farther downstream when I collected there some 15 or 20 years ago.

(F) There may be some connection between the disparity in size of the shells of Meach Lake and Kettle Island and the geology of the two areas. The basin of the Meach Lake drainage consists of Precambrian igneous-metamorphic rocks poor in calcium carbonate, partly covered by glacial drift, whereas the Ottawa River flows over both Precambrian rocks of the same nature and Ordovician limestones. For example, the lip of the Chaudière Falls is made up of Ordovician limestones as are the rocky headlands on the south shore of the Ottawa River above Kettle Island (see maps 413A and 414A, in Wilson, 1946, cited above). Caution must nevertheless be exercised in reaching such conclusions because the Kettle Island locality was especially favored in another respect: it was just far enough below the sewage outlet on the Ottawa side of the river to provide abundant microscopic food, yet not near enough to it to cause heavy pollution beyond the tolerance of the Naiades.

A. La Rocque

ADDITIONS TO THE NEW BRUNSWICK CHECKLIST

HERBERT D. ATHEARN

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The following are a few additions to the New Brunswick Checklist of Non-Marine Mollusca (La Rocque, 1961a). The records listed are in my collection and in many instances duplicates are in the Museum of Comparative Zoology, the National Museum of Canada, and in the private collection of Arthur H. Clarke, Jr. Insofar as my collection is concerned, these records and the collection are open to examination of any interested malacologist. Most of these records have never been published.

1. NAIADES

1. ALASMIDONTA HETERODON (Lea) 1830. Simpson 1914: 499. Athearn 1952: 8.

2. ALASMIDONTA MARGINATA VARICOSA (Lamarck) 1819. Simpson 1914: 506. Frierson 1927: 21 (Decurambis). Athearn 1952: 8. Also Renous River, Northumberland County.

3. ANODONTA CATARACTA (Say) 1817. Frierson 1927: 16. La Rocque 1953: 87. Widely distributed in New Brunswick.

4. ANODONTA CATARACTA BROOKSIANA van der Schalie 1938. La Rocque 1961b: 43 (A. brooksiana van der Schalie). Kennebecasis Bay, Kings County; Branch of Denny Stream, Charlotte County.

5. ANODONTA IMPLICATA (Say) 1822. La Rocque 1953: 88. Athearn 1952: 8. Widely distributed in New Brunswick.

6. LAMPSILIS OCHRACEA (Say) 1817. La Rocque 1953: 92. St. John River, Queens County, Pond on branch of Aulac River, Westmoreland County.

7. LAMPSILIS RADIATA (Gmelin) 1792. La Rocque 1953: 93. St. John River, York and Kings Counties; Canaan River, Queens County.

8. STROPHITUS UNDULATUS (Say) 1817. La Rocque 1953: 99 (S. rugosus). Clarke and Berg 1959: 43. Shediac River, Westmoreland County.

2. SPHAERIIDAE

9. SPHAERIUM RHOMBOIDEUM (Say) 1822. Robertson and Blakeslee 1948: 115. La Rocque 1953: 115. St. John River, York County (identified by A. H. Clarke, Jr.).

10. SPHAERIUM SULCATUM (Lamarck) 1818. Robertson and Blakeslee 1948: 113. La Rocque 1953: 116. Tantramar River, Westmoreland County.

3. FRESHWATER PULMONATES

11. GYRAULUS HIRSUTUS (Gould) 1840. Robertson and Blakeslee 1948: 63. La Rocque 1953: 294. Hammond River, Kings County.

12. GYRAULUS PARVUS (Say) 1817. Robertson and Blakeslee 1948: 63. La Rocque 1953: 294. St. John River, Queens County.

13. STAGNICOLA EMARGINATA (Say) 1821. Hubendick 1951: 132 (Lymnaea). La Rocque 1953: 277. St. John River, York County.

14. STAGNICOLA PALUSTRIS (Müller) 1774. Hubendick 1951: 119. La Rocque 1953: 280. St. John River, York County; Little River, St. John County.

4. FRESHWATER OPERCULATES

15. AMNICOLA LIMOSA (Say) 1817. Robertson and Blakeslee 1948: 84. La Rocque 1953: 267. Branch of Denny Stream, Charlotte County; Hammond River, Kings County.

16. CAMPELOMA DECISUM (Say) 1817. Robertson and Blakeslee 1948: 81. La Rocque 1953: 266. St. John River, Queens County.

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----- (1961a) Checklist of New Brunswick Non-Marine Mollusca. --- Sterkiana 3: 40-42.

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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.

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

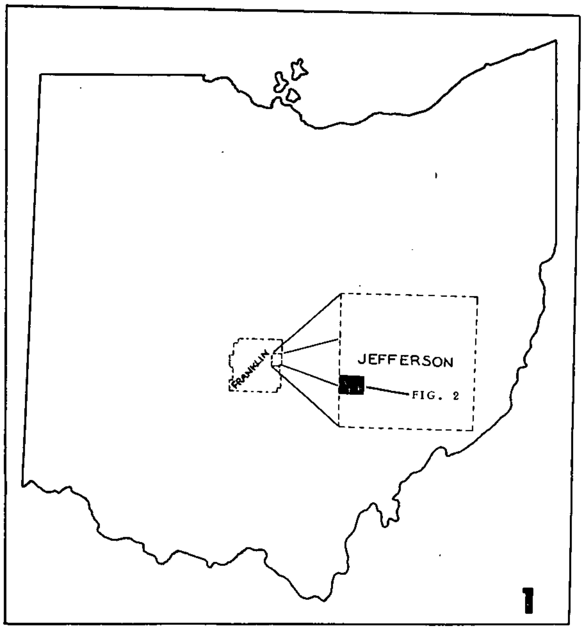
All sections were sampled by means of a bayonet auger with the exception of section 1, the main collecting station (M.S. on fig. 2), where detailed sampling was done at two-inch intervals. Other collections were made at regular intervals on four traverses radiating from section 1; therefore, only section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

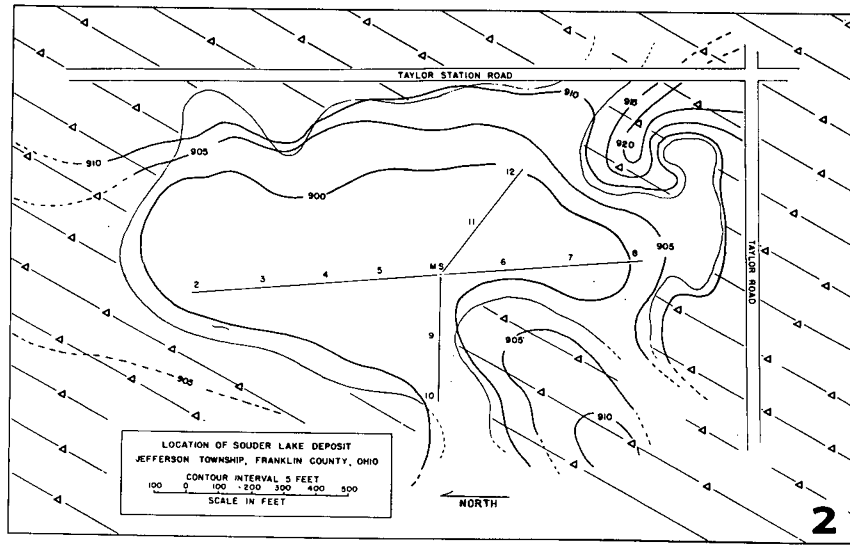
DESCRIPTION OF FIGURES 1-3, OPPOSITE PAGE

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	

3

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.

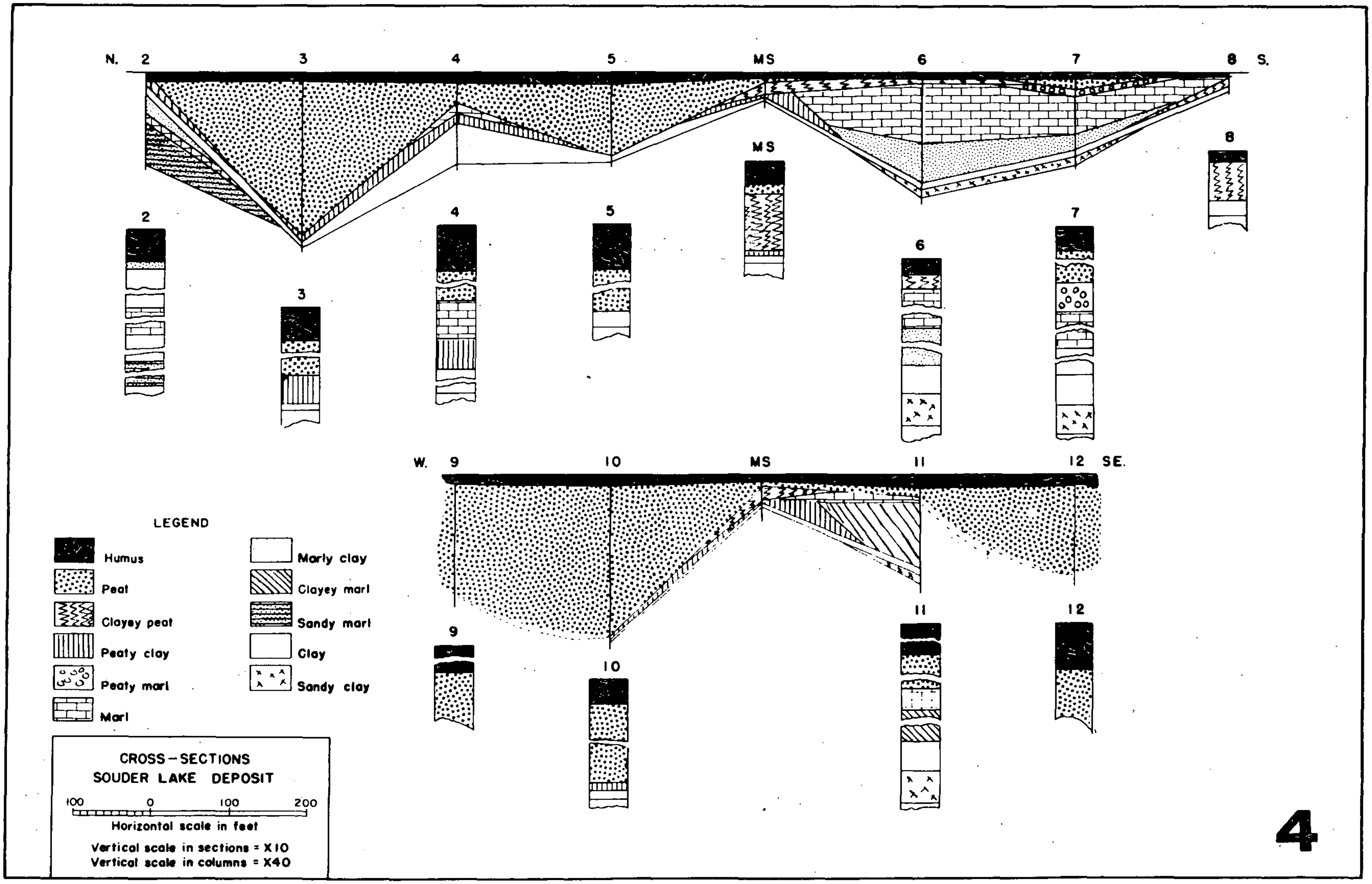
The Sphaeriidae, which include species of *Pisidium* and *Sphaerium*, are present in every collection of the deposit but they are not particularly abundant and only attain a maximum of 14.0 percent in collection 10. The species identified were, in many cases, represented only by separate valves rather 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 (coll ction 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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W.
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10
MS
11
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	

5

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	

7

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	

8

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.

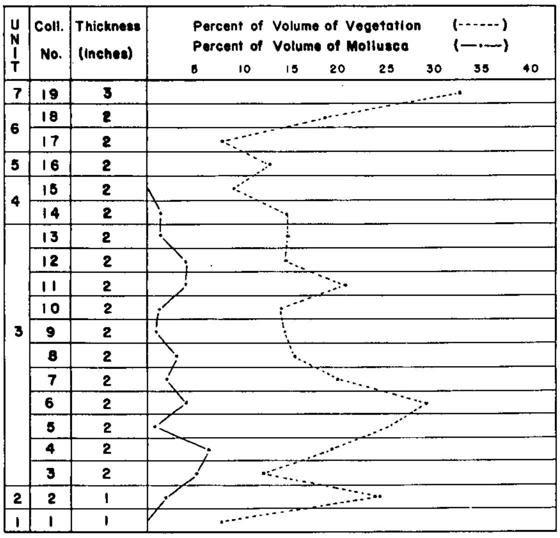
DESCRIPTION OF FIGURES 9-12, OPPOSITE PAGE

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

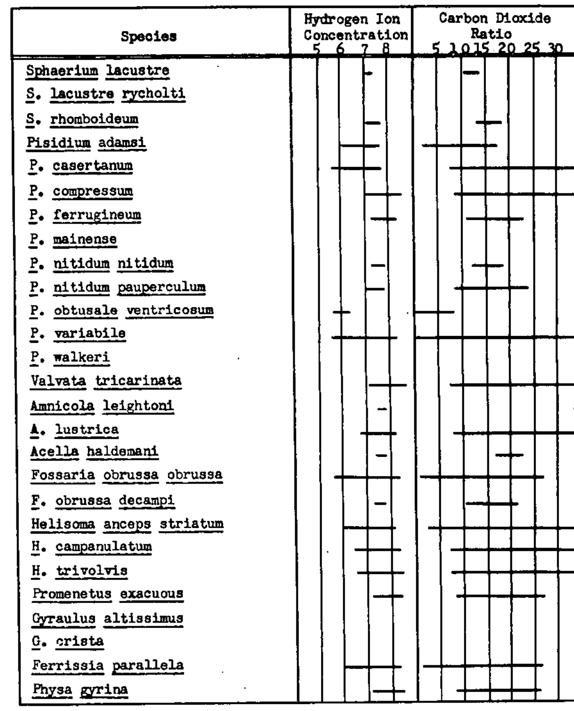
Fig. 10 Relation of Mollusca to water conditions.

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

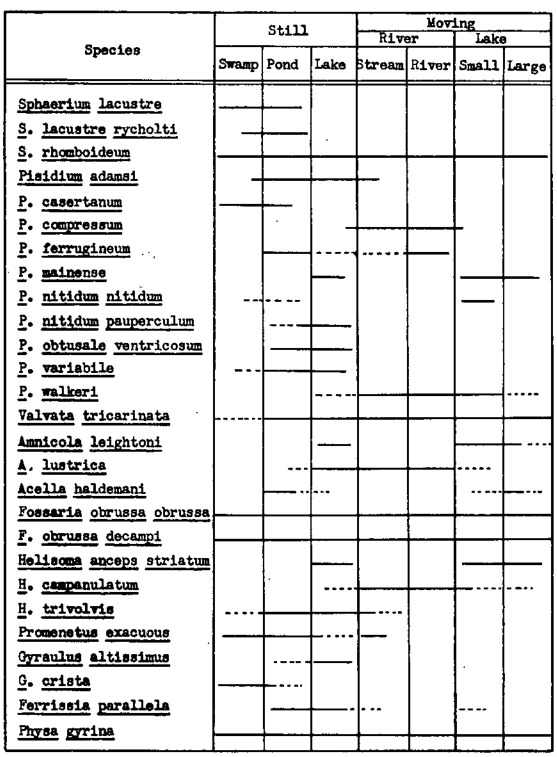
Fig. 12 Relation of Mollusca to character of bottom and depth of water.


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

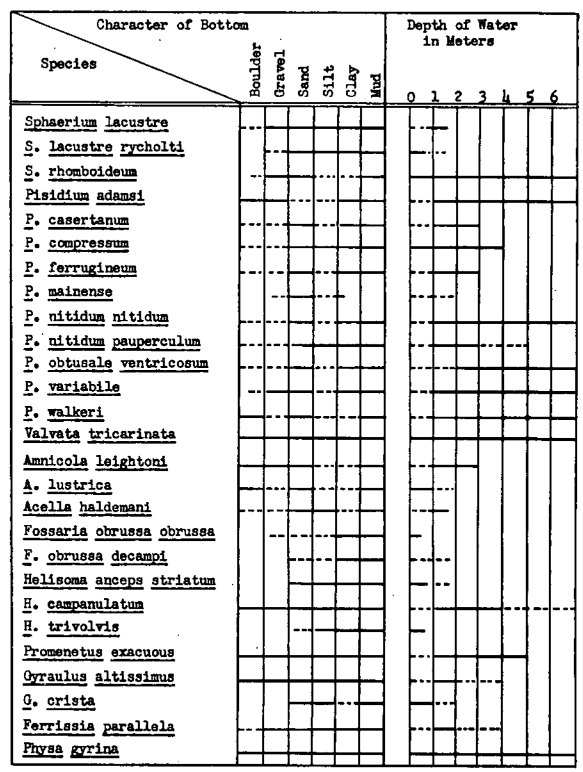
9


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
Moving
River
Lake
Swamp
Pond
Lake
Stream
River
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 nepionic 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.

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ERRATUM

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