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THE ORLETON FARMS MASTODON

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In November, 1949, some workmen at Orleton Farms, Madison County, Ohio, were probing with an iron rod to locate a plugged drain tile. Striking a hard object, they made an excavation, finding instead of a tile a large mammal bone. The manager of the farms, Mr. W. G. Putnam, notified members of the staff of The Ohio State Museum, who identified the specimen as that of the mastodon, *Mammut americanum*. Arrangements were made to excavate the site.

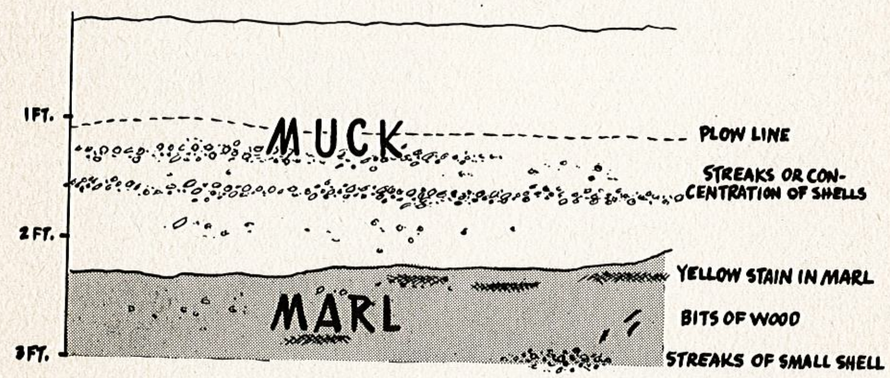

FIGURE 1. Diagrammatic section of excavation. The skeleton of the mastodon was imbedded in the marl layer, extending up into the muck layer above.

The work was done under the supervision of Mr. Raymond S. Baby, Curator of Archaeology, and the writer. Mr. Robert M. Goslin, assistant in Natural History at the Museum, who has had much experience in archaeological excavation, was actively in charge. Mr. Putnam and Miss Mary Johnstone, owner of Orleton Farms provided all possible assistance to the project.

The site of the find is in Somerford Township, Madison County, about 11½ miles northwest of West Jefferson. It is located a few hundred feet northeast of State Route 29 and about 2 miles west of the village of Plumwood. The bones were found in a low place in gently rolling ground moraine, which Dr. Richard P. Goldthwait, glacial geologist, Ohio State University, considers probably material of the Cary stage of the Wisconsin Age.

Excavation showed that the bones were lying on and in a layer of limy clay or marl about 1 foot in thickness which extended to a depth of about 3 feet. The marl lies upon the glacial till. Above the marl layer is a layer of black muck or peaty material about 2 feet in depth. Shells of Mollusca and Ostracoda were plentiful in both the muck and the marl, forming conspicuous windrows or horizontal streaks in places.

The uppermost portions of the skeleton averaged about 1 foot 8 inches below the surface, with a range between 1 foot 4 inches and 2 feet 2 inches. It was so close to the surface, in fact, that the ditching machine which cut the trench for the original tile line removed a portion of the top of the skull.

In order to secure as complete a picture of the conditions under which the animal lived, a number of specialists were called into consultation. Dr. Goldthwait

FIGURE 2. View of excavation. The skull is beneath the drain tile at the back of the pit. Photo by courtesy of Columbus Dispatch

visited the site on a number of occasions and made a study of the glacial geology. Dr. E. N. Transeau, plant ecologist, Ohio State University, Dr. Paul B. Sears, specialist in fossil pollens, Yale University and Mr. William H. Sassaman, comparative anatomist, Western Reserve University also paid visits to the site. Specimens of Mollusca from the excavation were submitted to Dr. Aurèle La Rocque, paleontologist, Ohio State University. A number of bones which had been gnawed by rodents were examined by Dr. Albert E. Wood, Amherst College.[1]

[1]Reports of Drs. Goldthwait, La Rocque, Sears, and Wood appear in this number of The Journal.

Dr. George Gaylord Simpson, American Museum of Natural History, and Dr. Robert W. Wilson, Museum of Natural History, University of Kansas, also provided valuable information and comments.

The skeleton proved to be badly disturbed and the bones crushed and broken. As an example of the amount of disturbance, one of the ribs lay beneath one of

FIGURE 3. Some of the large bones in situ. The femur in foreground has been broken square across. Photo by courtesy of Columbus Dispatch.

the tusks, while another was thrust through an aperature in the pelvis; a shoulder blade rested to the right of the skull and one of the large neck vertebrae was found about ten feet from the skull, near a portion of the pelvis. In spite of the wide dislocation of the parts, the bones of one of the feet remained intact and in place, very possibly in the spot where the animal last stepped.

Even the largest of the bones, such as the thigh bones, were broken squarely across in places, indicating that some considerable force had been exerted upon them. While any conclusion as to an agency powerful enough to cause such destruction must be highly speculative, trampling by other mastodons seems to me to be a reasonable explanation.

A number of the bones had been gnawed by rodents, the tooth-marks varying considerably in size. Dr. Wood is of the opinion that the marks were caused by a number of different species of rodents. The tooth-marks are taken as an indication that the skeleton was exposed above the surface of the ancient marsh, at least periodically, since it is believed that rodents, with the exception of beaver or muskrat, would not be likely to gnaw bones beneath the surface of the water.

Dr. La Rocque reports that the populations of mollusca are very different in the upper black layer from those in the lower gray marl layer, indicating that very different ecological conditions existed at the times when the two types of material were being deposited.

It appears altogether likely that the site was originally covered by a shallow pond, with scanty vegetation, fed by surface water and springy seepages from the surrounding moraines. The water which fed the pond must have carried good quantities of lime in solution and this, along with suspended silt, was precipitated eventually to form the marly deposits in the bottom of the depression. As the depression became partly filled with sediments, swamp vegetation was able to invade, the decomposition of which resulted in the upper layers of black, fibrous, peaty material. The pond probably was not so deep that portions of the mastodon skeleton were not exposed during occasional droughts over considerable periods of time.

Dr. Sears reports pollen of fir, spruce, and pine in the lower deposits, indicating a coniferous forest surrounding the pond at the time at which the animal was alive, much the same as now obtains in the northernmost portions of the United States and parts of Canada.

The epiphyses of the bones had not yet united. Mr. Sassaman and Mr. Baby estimated that the condition of the epipyhses corresponds with that of a 14-year old human being. This, of course, is not to be interpreted as indicating the age of the animal, since the age at which the epiphyses unite in mastodons is not known. That the specimen was sub-adult is also borne out by the small size of the tusks and by the teeth.

Each jaw had the following tooth arrangement from front to rear: (1) a small, badly worn molar, 3 inches long, with 3 crests or cusps and apparently about ready to be shed, (2) a molar 3½ inches long, with three cusps, which was performing most of the work, (3) a molar 4¼ inches long, with 3 crests, with only the foremost crest showing any wear, and (4) a large molar 6½ inches long, with 4 crests plus a small additional one, embedded in the jaw and as yet without roots. The first tooth is interpreted as the last deciduous tooth, the remaining three being the true molars.

In spite of the fact that the animal was sub-adult, it was a large individual. One thigh-bone measures 42 inches and is comparable in size to those of the well-known Warren Mastodon in the American Museum of Natural History, which is a large animal.

Samples of muck, marl, and bones were sent to the Institute for Nuclear Studies, University of Chicago, in order to secure a dating by the radioactive carbon 14 technique, but no report has as yet been received.

A number of pieces of wood were found in the marl immediately beneath the skeleton and in the lower strata surrounding it. These were submitted to Dr. Richard A. Popham, Ohio State University, for identification, but the cellular structure had been destroyed beyond recognition. The wood was then sent to The Harrison M. Randall Laboratory of Physics, University of Michigan, for analysis by the carbon 14 method. Dr. H. R. Crane, of the Laboratory, reports that the radiocarbon age determination of the samples gives 8420±400 years ago. The work at the Laboratory is supported by the Michigan Memorial-Phoenix Project.

Found among the mastodon bones were two fragments of the tibia and a talus of a deer and the claw of a large bird of prey. Another interesting find was a spear-point of chert 3½ inches in length. It was located about 5 inches above the lower end of one of the mastodon femurs and 14 inches from the surface. Mr. Baby and Mr. Goslin have pronounced it to be an early type of point. It unquestionably is not contemporaneous with the mastodon bones, but it is undoubtedly of considerable antiquity, probably dating prior to 500 B. C.

The presence of the bones of the various animals and the spearpoint in this site indicates that it may have been a favorite water-hole for animals, to which early men came in search of game.

GEOLOGICAL SITUATION OF THE ORLETON FARMS MASTODON

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The finding of a rather complete skeleton of a mastodon, *Mammut americanum*, on the Orleton Farms in Madison County, Ohio, in November 1949 aroused great public interest and led to extensive investigations of the nature of the late- and post-glacial deposits which enclosed the bones. A general account of the find by Dr. Edward S. Thomas appears in this number of The Journal. A careful study of the mollusks and one of the pollen in the same beds follow this account. This is an account of the glacial deposits and the layers representing post-glacial time. Most of the field study was made in 1949, prior to the discovery of the mastodon, as part of a continuing surficial survey by the Water Division of the Ohio Department of Natural Resources and the Groundwater Division of the U. S. Geological Survey.

The bones were found in a depression on Orleton Farms in the northeast part of Sommerford Township, Madison County. The pit lies about 500 feet north of State Highway 29 two thirds of the way from West Jefferson to Mechanicsburg. All of the bones lay from 16 to 26 inches below the surface. Most of them lay in the upper part of a 22-inch thick gray clay layer. Upper parts of large bones projected well up into a black muck layer 13 inches thick and just under the plow-turned surface. These two layers, black muck above and gray marl below, rest directly upon glacial till.

THE UNDERLYING GLACIAL DEPOSITS

The glacial till beneath the mastodon excavation is Cary (?) drift of the Wisconsin glacial stage. It is a sticky clay till oxidized light brown and containing rock fragments of all sizes. That the till is of "Wisconsin" age is agreed by all who have studied the region (Leverett, 1902). The topography is constructional with less than ten percent of area in dissected valleys; soils are of the young Miami catena with less than three feet depth of leaching of carbonates and no thoroughly rotted gumbo- or meso-till. Whether this surface dates from the Cary ice advance or the older Tazewell substage is debatable. It is proposed here that it is probably of Cary age because:

(1) The undisputed Miami soils (B horizon to 30 inches depth) are typical of some areas of Cary drift further north in Ohio and Indiana.

(2) Analyses of the Carbon-14 ratio in logs buried in related drift south of Dayton, Ohio, and in Oxford, Ohio, indicate antiquity of "more than 17000 years" and "at least 15000 years" (Arnold and Libby, 1950). These imply a time lapse

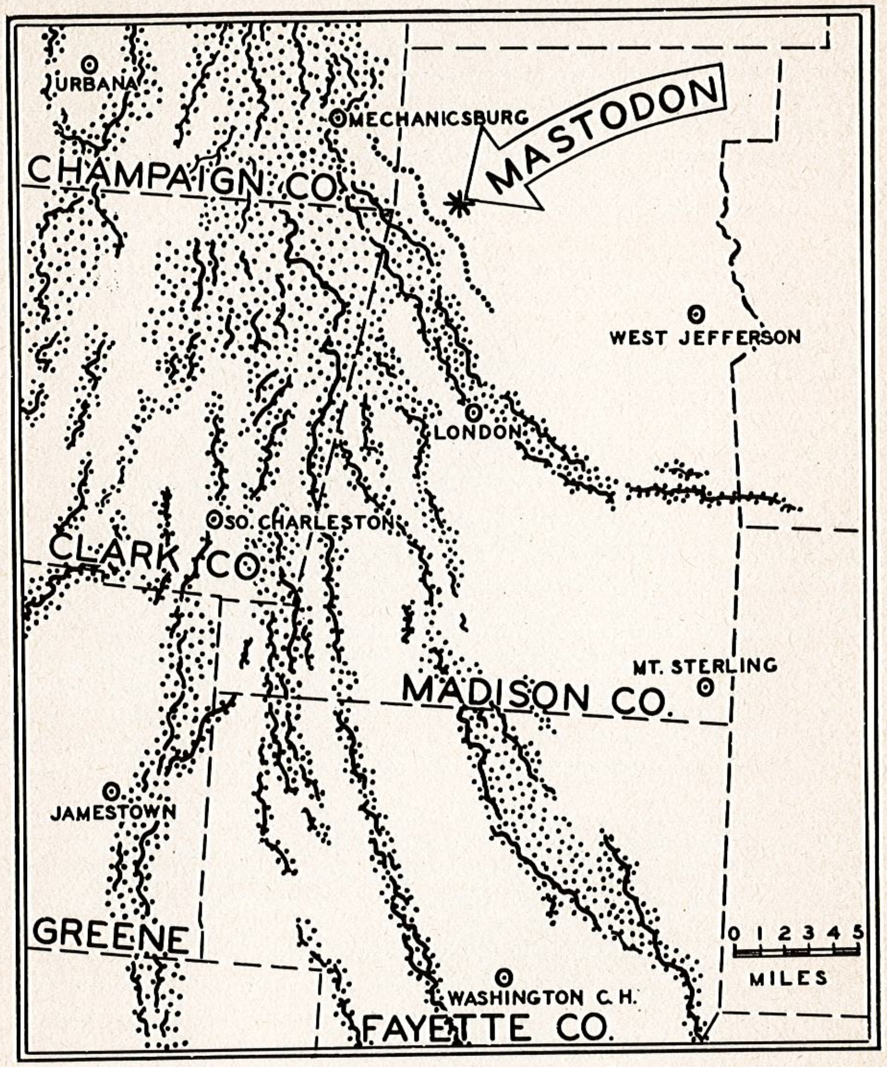

FIGURE 1. Map of the end moraines of central Ohio. Solid lines are crests of moraines; stippled areas have hummocky moraine topography; dotted line shows crest of poor moraine near mastodon site.

far short of acceptable Tazewell substage but older than similar dating for the Mankato substage (Flint and Deevey, 1951).

(3) The dimpled till plain topography with distinct hilly belts of end moraine and a scattering of fresh crystalline boulders simulates typical Cary drift in Illinois and Wisconsin.

Thus the proposal is that this area was uncovered as Cary ice withdrew less than 17,000 years ago.

The uncovering by the ice sheet came at the conclusion of a long period of repeated halts in the recession of the ice edge because the mastodon site lies on the northeast "inside" edge of a nested series of end moraines (fig. 1). Less than 2½ miles west of this site is the edge of the 8-mile wide belt of Cable Moraine. It comprises coalesced chains of rugged hills rising 200 feet above the till plain, and it is composed of unconsolidated drift about 300 feet deep.[1] This was deposited along the west edge of the ice lobe which spread southwestward out of the Scioto Valley. Counts of pebble lithologies in the moraine demonstrate that it is the same sort of drift found in the deposits throughout Madison County, as shown in table 1. Furthermore the chains of hills in the Cable Moraine fray out southward

TABLE 1
Counts of pebble lithologies.

Area	Number of counts	Limestone	Dolomite	Chert	Shale	Crystalline erratics
Cable Moraine............... (Champaign Co.)	12	8.5%	84.6%	0.5%	1.0%	5.5%
Till Plains.................... (Madison Co.)	7	10.8%	82.7%	0.6%	1.0%	5.2%

into several lower separate belts of end moraine. Since these curve to the east they mark the nose of the retreating ice lobe in the Scioto Valley.

Most northeasterly and youngest of these distinct hummocky moraine belts is the London Moraine. Parallel with London Moraine, but one mile northeast of it where it joins the Cable Moraine, is a belt of less distinctly rolling topography between Lafayette and Mechanicsburg (line of dots, fig. 1). Undoubtedly this

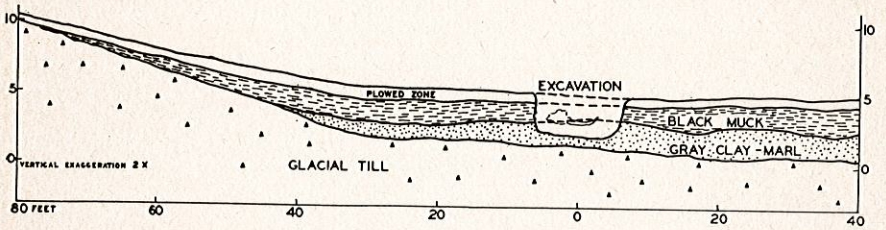

FIGURE 2. Cross section of west edge of kettle hole in which excavation for mastodon was made. Based upon soil auger test holes.

poorer moraine topography marks a short final halt of the curved ice edge as the ice sheet began to disappear rapidly up the Scioto Valley. The mastodon was found on the gentle northerly slope of this last halting belt.

The hollow in which the bones were found appears to be a glacial kettle hole. The bottom four (or 7 before filling) feet of the depression was completely undrained, and rolling uplands of till still rise 15 to 30 feet higher on three sides. Dozens of similar depressions may be found nearby. The dissolving away of carbonates did not produce these hollows because the bedrock is buried 80 feet down and is not sufficiently soluble to produce good sink holes.[2] Nor has sufficient time elapsed

[1]Two wells in lower hills near Mechanicsburg penetrated 230 and 385 feet to reach bedrock. Some 56 water wells in the moraine in Champaign County south of Cable (where bedrock is shallow) never reach bedrock and average 117 feet depth.

[2]Fourteen water wells within a 2-mile radius reach bedrock at an average depth of 86 feet; the well at farm buildings not 500 feet away reaches bedrock 83 feet down. The rock is Monroe dolomite.

to permit differential settling from solution within the till. Since dozens of similar hollows are found in a zone all along the east edge of the indistinct northeasterly end moraine they must be the products of glacial deposition. We know that the ice margin oscillated extensively for there are wide areas near London of ice-laid till over sands previously deposited by meltwater. It is easy to suppose that when the broad fringes of the ice sheet melted thin the last scraps in one marginal zone were dirt-littered lenses of dead ice. A minor advancing pulse of the active ice lobe may have deposited more till over these buried masses. Long after the edge of the moving ice lobe retreated to the north the buried ice melted out leaving kettle holes. Under periglacial conditions these dirt-protected ice masses may have lasted for centuries.

LAYERED DEPOSITS AFTER THE ICE

As buried ice melted and depressions developed, water collected in the hollows. In these poorly drained pools clay and marl lie directly on top of slightly oxidized brownish till (fig. 2). The water oozing in from surrounding slopes was charged with carbonates leached out of the upper 30 inches of soil on adjacent uplands. The waters were too saturated with carbonates to dissolve carbonates out of the till at the bottom of the pond for this till is calcareous to the top. Instead, marl was precipitated through evaporation, temperature change, or bacterial action, together with clay "impurities" washed from the adjacent till slopes. The dearth of organic matter expressed by the whiteness and the scarcity of pollen grains suggest that vegetation was sparse. Since the gray clay is only 22 inches thick at the deepest points and does not lap up onto adjacent slopes more than two feet above, the lowest known point (fig. 2) the pool may have been only a few feet deep.

Into this pond the mastodon wandered, for the bones are imbedded in the upper part of the clay. Since all of the bones are 13 or more inches above the underlying till, the clay and marl had begun to collect long before the animal came. Did he fall through the ice in winter? Did he bog down in sticky clay? There is no sign of any animal large enough to drag the carcass here.

The upper layer of black calcareous muck on top of the clay denotes a marked change in environment.[3] The muck is made up of organic matter suggesting luxurious swamp vegetation. Leaves and bits of wood demonstrate a shallow alkaline swamp surrounded by woodland. Unlike the clay this muck layer laps as much as six feet up onto adjacent slopes showing that surrounding ground was soggy but well bound by roots. Contributing to the change from open pond to swamp was the 22-inch layer of clay already filling the pool, and possible slight lowering of a surface outlet through a low saddle to the north. Flow was insufficient to produce any visible or lasting cut in this threshold which is four feet above the bottom of the hollow today.

How recent are these layers in which the bones are imbedded? Certainly it took several centuries to develop the swamp muck on top. Dr. P. B. Sears and Kathryn Clisby (1951) find pine and spruce to be the most abundant pollen in the lower clay. The maximum abundance of such pollen clearly predates the first mixed deciduous forest of warmer postglacial time (6000 years ago) and probably before "pine time" 6000 to 9000 years ago. It is usually associated with the last ice retreat, namely the Mankato. (Sears, 1941; Flint and Deevey, 1951.) The radiocarbon dating, reported in the preceding article by Dr. Thomas, suggests that wood in the lower part of this muck layer is 8420+400 years old, thus we may conclude that the open pool condition resulting in the gray clay lasted from about 15,000 to about 9,000 years ago.

[3]This is fully corroborated by the nature of the mollusk assemblages in the two layers described by Dr. A. LaRocque in an article following this one.

SUMMARY

Thus the geological nature and date of the layers may be summarized as follows:

1. Underlying the whole area is some 80 feet of glacial till deposited by the Wisconsin ice sheet, probably during its Cary advance about 17,000 years ago.
2. Mastodon bones were imbedded in the upper part of a 0 to 22-inch thick layer of gray marl and clay directly on top of the till. At this time, there was a small poorly-drained pool a few feet deep.
3. Overlying most of the bones is 0 to 15 inches of black calcareous muck indicating heavy forest vegetation around an alkaline swamp.
4. Plowing has disturbed the upper 8 to 12 inches of surface soil within the last century.

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POLLEN SPECTRA ASSOCIATED WITH THE ORLETON FARMS MASTODON SITE

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Because the pollen from adjacent vegetation is embalmed in lake and swamp sediments, pollen analysis is a valuable aid to Pleistocene and recent paleontology. Through this technique we may obtain, not only a notion of the environment of the living animal, but a good approximation of its place in the climatic sequence.

The Madison County site was visited twice in order to collect material for pollen analysis—unfortunately not until after the remains had been lifted. The first visit was by John Hopkins, Graduate Assistant at Oberlin College, the second by the senior author of this paper. Table 1 is based upon Mr. Hopkin's notes.

TABLE 1
Profile at Mastodon site.

Depth in centimeters	Material
0	present surface
25	lower limit of plowed soil
55	lower limit of soil—pollen scanty, ill-preserved
65	mollusc shells and pollen—upper limit of bones
75	yellow clay, molluscs and pollen—bones present
85	yellow to blue clay, pollen, below bones.

In all, seven samples have been studied. As indicated in table 1, the upper three had been so affected by soil-forming processes as to yield little or no fossil pollen. Of the remaining four, three are from known depths, while the fourth consists of material obtained from the jaw-bone after it had been removed to the

Museum. The position of this last specimen in the sequence is quite clear, however, as table 2 reveals.

The sequence in table 2 represents a shift from fir-spruce forest with some pine to a forest predominantly pine, with no fir, some spruce and some deciduous trees—principally oak and hickory. The climate, while remaining cool, was becoming warmer and dryer—an assumption supported by the appearance of considerable amaranth and composite pollen at the 75 cm level.

This shift is well-known and was general throughout the North-Central States (Sears, 1948). It was certainly subsequent to the Cary stage of Wisconsin glaciation, probably subsequent to a later readvance of the ice, since the warming-drying conditions indicate a time of glacial retreat.

TABLE 2

Pollen analysis of sediments

Depth	Forest Pollen %							Non-forest per 100 F. P.						
cms.	F	Sp	Pn	B	Al	O	H	Sx	Gr	Sg	Wl	Cp	Am	?
65	00	27	62	01	01	02	09	01	02	01	10	00	02	07
75	03	39	45	00	00	10	02	01	04	00	00	16	03	12
*	04	48	42	01	01	04	00	01	07	00	00	01	00	05
85	07	52	41	00	00	00	00	01	00	00	00	01	00	00

*Sediment scraped from jaw-bone.

KEY TO ABBREVIATIONS

F—fir	O—Oak	Wl—water lily
Sp—spruce	H—hickory	Cp—composite
Pn—pine	Sx—willow	Am—amaranth
B—beech	Gr—grass	?—unknown
Al—alder	Sg—sedge	

With the aid of Carbon 14 analysis and the ultimate untangling of the minor glacial episodes following the Cary, it should be possible to date the fossil, both geologically and chronologically, with considerable precision.

Acknowledgment is due THE GEOLOGICAL SOCIETY OF AMERICA for financial assistance incident to the above report.

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MOLLUSCAN FAUNAS OF THE ORLETON MASTODON SITE, MADISON COUNTY, OHIO

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THE SITE AND COLLECTION OF MATERIAL

Occurrence. The two molluscan faunas studied in this paper are from the Orleton farm, Somerford Township, Madison County, 2 miles west of Plumwood and about 23 miles from Columbus, Ohio. They were uncovered in excavations for a mastodon skeleton by members of the staff of the Ohio State Museum of Archeology. In order to ascertain the age of the mastodon remains as exactly as possible, all available evidence was used. Pollen analyses were made, the geological situation carefully examined, and specimens of wood, bone, and mollusk

shells submitted to the Institute of Nuclear Studies, Chicago, for carbon 14 determinations. The geological situation of the site has been studied by Dr. Richard P. Goldthwait and forms the object of a separate paper. Geological data in this paper will therefore be confined to those necessary for the understanding of the occurrence of the two faunas.

The exposure produced by the excavations consists of two lithologically distinct fossiliferous layers. They are underlain by till and overlain by 8 inches of disturbed soil. The lower layer, 22 inches thick, consists of gray, impure, clayey marl, with a plentiful molluscan fauna, together with ostracodes, vertebrate bones, and a few plant remains. The mastodon remains were found in this layer. The upper layer, 13 inches thick, consists of black, peat-like muck in which are found numerous shells of mollusks, ostracodes, plant remains, and dissociated and broken bones of small vertebrates. Henceforth, the upper and lower strata will be referred to as the "black layer" and the "gray layer" respectively.

Sampling. The material for this study was collected by Drs. R. P. Goldthwait and C. H. Summerson in December, 1949, while the excavations for the mastodon skeleton were progressing. Two large samples, one from each of the layers represented, were collected and turned over to the writer. Special care was taken to avoid mixing of material from each layer with the other while securing representative quantities from each of them, so that the material studied might reflect as exactly as possible the fauna of each sample.

Methods of study. Each sample was carefully weighed after drying for a few weeks in air. No attempt was made to remove all moisture from the samples since an air-dry weight was thought to be sufficiently representative. A measured quantity of each sample was then soaked in water, passed through sieves to remove the finer particles of silt without losing the mollusca. Sieves of sufficiently small mesh were used to retain all but the very smallest of fragments. This process yielded a large quantity of shells which was divided into fractions, separated unselectively so that a fair representation of the fauna would be found in each one. One of these fractions was then separated into species and the number of shells of each species counted. Next the proportion of each species found in the sample from each of the layers was reduced to a percentage of the total number of shells (table 1, columns 1 and 2) in order to compare the occurrence of each species in the two samples and other molluscan assemblages studied quantitatively. In order to arrive at a more correct estimate of each species from the ecologic standpoint, the comparative volume of individuals of each species was computed (table 1, columns 3 and 4). This was felt to be necessary since the abundance of a given species in a particular environment depends largely on the amount of food available for the individuals of this species. Even if it is assumed that the potential supply of individuals of a given species is unlimited, or at least limited only by the reproductive capacity of the species, it is obvious that the limited food supply will soon eliminate a large proportion of the potential population. Hence, the volume of the individual must be taken into account in estimating the favorable nature of an environment; percentage of individuals regardless of their size will be insufficient. Both the volume figures and the percentage counts are given here since published data on molluscan faunas usually include only the latter, less significant in the writer's opinion than figures taking volume into account.

Acknowledgments. The writer is grateful to Dr. Richard P. Goldthwait who suggested the study, to Dr. C. H. Summerson who assisted Dr. Goldthwait in the collection of the samples, and to Philip Katich who helped in the tedious work of separating and counting the species in both samples.

COMPOSITION OF FAUNAS

Before discussing this subject it may be well to emphasize the relative value of the data on which the study is based. No limnologist would confine his study of the fauna of a present day lake to a single sample from one station, however large that sample may be. He would feel obliged to collect at many different stations to make sure that his sampling covers variations from place to place in the lake. Such a procedure is usually easy enough since most stations are accessible. In studying an extinct lake it would likewise be desirable to examine samples from more than one station but circumstances often make this impossible. Studies based on a single sample will reflect conditions obtaining in only a small portion of the habitat studied and the conclusions based on them are necessarily limited. On the other hand, they have some value and lack of exhaustive information should not prevent an attempt at their interpretation, providing their limitations are kept in mind. It is with these reservations that the following data are presented.

TABLE 1

Composition of Faunas

SPECIES	PERCENT OF TOTAL INDIVIDUALS		PERCENT OF TOTAL VOLUME	
	Gray	*Black*	*Gray*	*Black*
PELECYPODA:				
Musculium sp	0.11	1.02	5.73	2.58
Pisidium sp	73.40	2.63	51.23	2.58
Sphaerium sp	.....	1.51	.....	2.58
Naiades (fragments)	traces	traces	traces	traces
GASTROPODA (freshwater):				
Stagnicola palustris elodes (Say)	.....	0.41	.....	23.34
Stagnicola lanceata (Gould)	0.02	0.22	11.72	4.77
Fossaria galbana (Say)	13.05	6.90	12.05	7.74
Helisoma trivolvis (Say)	0.01	0.45	2.31	35.02
Planorbula armigera (Say)	.....	trace	.....	trace
Gyraulus altissimus (F. C. Baker)	9.93	81.81	12.41	12.88
Gyraulus crista (Linn.)	0.09	.....	trace	.....
Menetus exacuous (Say)	0.14	3.10	1.52	1.29
Physa gyrina Say	1.02	0.97	2.15	1.41
Ferrissia parallela (Haldeman)	.....	0.63	.....	0.73
Valvata lewisi Currier	2.23	0.20	0.87	2.94
GASTROPODA (land):				
Oxyloma retusa (Lea)	.....	0.05	.....	1.38
Succinea ovalis Say	.....	0.02	.....	0.76
Stenotrema monodon (Rackett)	.....	0.02	.....	trace
Mesodon clausus (Say)	.....	0.02	.....	trace
Hawaiia minuscula (Binney)	.....	trace	.....	trace
Vertigo ovata (Say)	trace	.....	trace	.....

The species represented in each of the two layers are shown in table 1, together with their abundance, expressed as a percentage of the total number of individuals and their relative volume. The figures are based on separation of 12,254 specimens from the gray layer and 5,755 specimens from the black layer. It will be noted that all the species found in the gray layer are also present in the black, but in different proportions and with the addition of several species not found in the gray layer. No illustration could be more convincing of the fallacy of comparing two faunas on the sole basis of the species represented, without regard to quantitative changes. Mollusca are able to exist under a variety of conditions (see below, Ecology and distribution of the species) but their abundance is an index of the suitability of an environment to their particular requirements. The gray layer could be termed one in which optimum conditions obtained for ***Pisidium*** spp. (73.4 percent of total individuals and 51.23 percent of total volume) and the

black layer one favorable especially for *Gyraulus altissimus* (81.8 percent of total individuals and 12.88 percent of total volume) although the two mollusks are found in both layers.

The ecologic significance of each fauna will be discussed in detail later. For the present it should be pointed out that the two faunas are remarkable for the absence of forms usually associated with those recorded, notably species of the genus *Amnicola*. Both may be interpreted as undeveloped faunas, *i.e.*, faunas not established for a sufficiently long time to permit the arrival into the environment of all species capable of thriving in it.

It will be seen that the importance of the species listed for the two faunas varies considerably. The writer assumes that the most significant species are those which form the largest proportions of the faunas, both in numbers of individuals and actual volume. For the two layers, the significant species are listed in table 2.

TABLE 2

Significant Species

Gray layer	*Black layer*
Pisidium spp.	*Gyraulus altissimus*
Fossaria galbana	*Fossaria galbana*
Gyraulus altissimus	*Helisoma trivolvis*
Stagnicola lanceata	*Stagnicola palustris elodes*

ECOLOGY AND DISTRIBUTION OF THE SPECIES

A cursory examination of the list of species in table 1 shows that the molluscan assemblage of both layers is a freshwater one. This is confirmed by the quantitative data, for in each assemblage the most abundant species are freshwater. In reconstructing the environment in which these mollusca lived and in estimating the age of the deposit in which they are preserved, a proper evaluation of the fauna must be made. The species on which most reliance will be placed are the ones listed in table 2 but this estimate must not neglect the lesser elements of the fauna for they too have something to contribute to the discussion.

The land snails of both lists (*Oxyloma retusa*, *Succinea ovalis*, *Stenotrema monodon*, *Mesodon clausus*, *Hawaiia minuscula*, and *Vertigo ovata*) may be considered as intruders but in different degrees. For instance, *Oxyloma retusa* may be expected in freshwater assemblages for it lives in moist situations near the margins of streams, ponds, and lakes and sometimes ventures far out from shore, going from one stalk or leaf to another until it is far from dry land. Its presence in the black layer should therefore not occasion any surprise. *Succinea ovalis* is less amphibious in its habits and its presence in the black layer is best explained as a stray shell which rolled into the water from a drier habitat. The same remarks apply to the other land snails and their presence indicates nearness of a good forest cover not far from the lake or pond in which the freshwater mollusca lived at the time of the accumulation of the black layer.

It is from the strictly freshwater species and their comparative abundance that we derive the most telling information as to the environment in which the two deposits were formed. In order to make the basis of the conclusions clearer, data on the ecology and distribution, where available, are given for each species. This information is derived from many sources, not all readily accessible, and it is felt that its repetition here is preferable to mere references to the literature. Source of the data is given in each case except for pH and fixed carbon dioxide figures which are all quoted from Morrison (1932).

Musculium, Pisidium, and Sphaerium

The ecology of the species of these genera cannot be discussed here as it has been impossible for the writer to identify the several species to which they belong. The taxonomy of this difficult group is being revised at present by the Rev. Mr. H. B. Herrington but his studies have not progressed to the point where non-specialists can identify the species with certainty. In the absence of specific determinations, the mere mention of generic name is devoid of ecologic significance. Sphaeriidae may be found in all kinds of freshwater habitats although certain species appear to be partial to particular stations. Sufficient information may be gleaned from the gastropods, however, to identify the habitats represented by the two faunas.

Naiades

The Naiades, or freshwater mussels, are represented in the two collections by fragments which are almost unidentifiable. It may be surmised from the thinness of the fragments that they belong to a species of the genus *Anodonta* but there are other genera in which they might also be placed, *e.g.*, *Strophitus* and *Alasmidonta*. Naiades, especially of the genus *Anodonta*, are frequently found in small lakes, as will be seen by the examination of the lists given (see "Comparison with other faunas").

Stagnicola palustris elodes (Say)

Baker (1932) has made a special study of the ecology of this subspecies. His findings may be summarized as follows: It inhabits both clear and stagnant water, but prefers a habitat in which the water is not in motion. Typical *elodes* is not usually found in swales but in lakes and rivers where the water is quiet and where vegetation is more or less abundant. The margins of rivers and protected bays of lakes and ponds appear to be its natural habitat. Baker (1928, p. 215) describes a typical habitat as follows: "Vegetation mostly *Typha*, with *Pontederia* and *Sagittaria;* animals in water from 0.3 to 1 meter deep, but most abundant in 0.3 m. at the edge of a pool, on mud bottom." Morrison found it in water with pH 7.4, fixed carbon dioxide 21.0 p.p.m.

The subspecies has a very wide distribution from New England west to the Rocky Mountains, and from Canada south to New Mexico.

Stagnicola lanceata (Gould)

There seems to be no significant difference between the habitat preferences of this species and those of *S. palustris elodes*. The wider range in pH (6.95 to 7.7) and fixed carbon dioxide (7.5 to 22.56 p.p.m.) may be due to more abundant data for *S. lanceata* than for *S. palustris elodes*.

The species has a very wide distribution at present, from northern Ohio west to Wisconsin, northward to the north shore of Lake Superior and eastern Ontario.

Fossaria galbana (Say)

Since this is an extinct species, its ecology may be inferred from that of *F. obrussa decampi* (Streng), a form of small, shallow lakes, whose pH range is 7.42 to 7.7 and fixed carbon dioxide range 10.65 to 18.87 p.p.m. and with that of *F. obrussa obrussa* (Say) found in both small and medium sized lakes with a somewhat greater range in pH (5.86 to 8.37) and fixed carbon dioxide (1.26 to 25.75 p.p.m.). Both species are closely related to *F. galbana* and both are widely distributed in the northern tier of states and Canada. The majority of the species of the genus *Fossaria* are semi-amphibious snails living in shallow water or on moist mud flats frequently out of water for considerable periods of time. Baker's (1928) notes on the ecology of these two forms is given for comparison: *F. obrussa obrussa* (p. 296): "The normal habitat of this species is in small bodies of water, as creeks, ponds, sloughs, bays, and marshy spots along river banks. It is at home on sticks, stones, and any other debris that may be in the water or along its edge." *F. obrussa decampi* (Streng), (p. 300): "The habitat of *decampi* is probably the same as that of *obrussa*." Both forms are widely distributed in North America, especially in the northern tier of states and Canada, although *F. obrussa obrussa* is found as far south as Arizona and northern Mexico.

Distribution. *Fossaria galbana* is found in marl and other deposits from New Jersey west to Wisconsin and northward into Canada.

Helisoma trivolvis (Say)

Ecology. Baker (1928, pp. 332–33) describes the ecology of this species as follows: "Typical *trivolvis* is always an inhabitant of quiet, more or less stagnant water. Many of the Wisconsin habitats have been formed behind beach barriers, and the *trivolvis* in such places is usually very large and fine. Specific habitats are as follows: Asylum Bay, Lake Winnebago, in marsh behind barrier beach, mud bottom, water .9 m. deep, vegetation thick and consisting of *Myriophyllum*, *Ceratophyllum*, *Elodea*, *Potamogeton*, *Typha*, and some *Scirpus;* algae very abundant and of the blanket form; Fox River at Omro, swampy shore fine sand bottom, water .5 m. deep; Green Lake, West Creek, 2 m. deep, mud bottom, shells on floating debris or on vegetation along shore; Lake Chetek, swamp behind beach, .8 m. deep, mud bottom, on logs and debris; Tomahawk Lake, in creek and swampy overflow protected from rough water of lake, mud bottom, water few cm. to 1 m. deep, on logs and shore. . . ."

pH 6.6 to 8.37; fixed carbon dioxide 7.5 to 30.56 p.p.m.

Distribution. (Baker, 1928) "Atlantic coast and Mississippi River drainages, northward to Arctic British America and Alaska and southward to Tennessee and Missouri. The southern distribution is not clear owing to mixing with related species."

Planorbula armigera (Say)

Ecology. (Baker, 1928, pp. 358–359) "*Planorbula armigera* is largely a species of swales or of small and stagnant bodies of water. Some of the specific habitats in Wisconsin are noted below; North of Oshkosh, in small pool beneath railroad track, mud bottom, water .3–.5 m. deep; Plummers Point, Lake Butte des Morts, woodland swale, water shallow, bottom meadow grass or mud; Devils Lake, marsh at southwest end, mud bottom, water .3–1 m. deep; small pool behind beach, Lake Chetek, shallow, with mud bottom; slough, west end Lake Chetek, soft mud bottom, water .3–1 m. deep, snails on deciduous logs, not on coniferous logs; pond behind beach, Wisconsin River, Oneida Co."

pH 6.6 to 7.6; fixed carbon dioxide 7.5 to 16.7 p.p.m.

Distribution. New England west to Nebraska, south to Georgia and Louisiana, north to Great Slave Lake.

Gyraulus altissimus (F. C. Baker)

Ecology. Since the species is extinct no precise ecologic data can be given except by inference from its close relative *G. arcticus* ("Beck" Möller) which also lives in small lakes with quiet water and abundant vegetation. Morrison (1932) has given figures (pH 8.37, fixed carbon dioxide 25.75 p.p.m.) for Mann Lake, Wisconsin, in which *G. arcticus* was collected. From its association with other species found both in Pleistocene and living faunas, it may be inferred that *G. altissimus* was a species of small lakes with a wide pH and fixed carbon dioxide range.

Distribution. Pleistocene deposits in Ohio, Indiana, Illinois, Michigan, Wisconsin, Ontario, and Quebec. Baker thinks it will also be found in other states.

Gyraulus crista (Linn.)

Ecology. The only ecological notes for this species in North America are those of Nylander (Nautilus, vol. X, p. 117) who, according to Baker (1928, p. 386) found it "in Barren Brook, Maine, in three or four inches of water under logs and bark. The writer has found it sparingly on dead leaves in stagnant water in small lakes in the company of *G. deflectus obliquus* but in much smaller numbers than that species." No pH or fixed carbon dioxide figures are available.

Distribution. Maine west to Alberta, Wisconsin, and Illinois. Living and fossil. Baker (1928, p. 386) states that "it was at one time believed to have been introduced from Europe, as it is widely distributed on the eastern continent, but its present widespread range in America indicates it to be indigenous or at least of very remote migration from Europe, if that be its center of dispersal. Its presence in Pleistocene deposits also indicates some degree of antiquity in America."

Menetus exacuous (Say)

Ecology. Baker (1928, pp. 362–63) found it "generally in quiet places, more or less marshy. Specific habitats: slough near west end of Lake Chetek, water .6 m. deep, bottom soft, sticky mud, from few cm. to .3 m. deep, snails on logs (not on coniferous logs). Chicago Creek, half mile above Lake Superior, on mud flat on edge of small mountain stream of clear, cold water. The *exacuous* were always found on the mud flats in quiet water while *Physa* and *Galba* were observed in the more rapid part of the stream, especially in the little falls and rapids."

pH 7.0 to 7.6; fixed carbon dioxide 9.3 to 22.5 p.p.m.

Distribution. Baker (1928, p. 363) records it for "United States east of Rocky Mountains, north to Alaska and the Mackenzie River, south to New Mexico."

Physa gyrina Say

Ecology. The species appears to be characteristic of slow-moving and stagnant bodies of shallow water, usually on a mud bottom. It has been found in overflows from large rivers, in small ponds behind river and lake beaches. (Condensed from Baker, 1928, pp. 451–52.)

pH 7.1 to 8.37; fixed carbon dioxide 9.5 to 25.75 p.p.m.

Distribution. (Baker, 1928, pp. 451–52) "From the Arctic regions south to Alabama and Texas. The typical form is characteristic of the Mississippi Valley where it reaches its greatest perfection."

Ferrissia parallela (Haldeman)

Ecology. This species is also an inhabitant of quiet water, on plants and the shells of Naiades, in shallow water from 0.3 to 2 m. in depth. The animal is usually found near the surface but may occur on the lower part of such plants as *Scirpus*, near the bottom. *Parallela* appears to be a pond or lake species, at least in Wisconsin. It is found on *Potamogeton*, *Nymphaea*, *Scirpus*, and *Castalia* leaves or on any smooth surface which is suitable for protection. (Condensed from Baker, 1928, p. 397.)

pH 6.05 to 8.37; fixed carbon dioxide 2.75 to 25.75 p.p.m.

Distribution. (Baker, 1928, p. 397) "Nova Scotia and New England west to Minnesota, Manitoba, south to Rhode Island, Central New York, Northern Ohio, and Indiana (Walker). A species of northern distribution. In Illinois it is recorded authentically from the northeastern part, in Lake and McHenry counties."

Valvata lewisi Currier

Ecology. (Baker, 1928, p. 28) "Prairie Lake, shallow water, sand bottom, in vegetation; Lake Butte des Morts, 1 m., mud bottom, on plants. Apparently not found in as deep water as *sincera*. Also a lake species largely."

pH 7.6; fixed carbon dioxide 22.5 p.p.m.

Distribution. (Baker, 1928, p. 28) "Northern part of the United States from the Atlantic to the Pacific Oceans, northward, in British America, to the upper Mackenzie River. Its southward range is not fully known. It is recorded from La Salle Co., Ill."

Oxyloma retusa (Lea)

Ecology. (Goodrich, 1932, p. 38) "A species of the marshes and other wet places. It can be found upon partly submerged sticks, on rotting water weeds, and often high on the stems of cat-tails. Frequently, it is in the company of the nearly amphibious species of *Lymnaea*.

Distribution. Northern and Middle United States north into Ontario and Quebec to Yukon and British Columbia and east to Labrador and Maine.

Succinea ovalis Say

Ecology. (Goodrich, 1932, p. 39) "The snail prefers drier localities than those frequented by *retusa* and often is to be found among the weeds of the edges of upland pools. In wet seasons it has been seen ten or twelve feet above the ground upon the trunks of smooth-barked trees."

Distribution. Arkansas to Georgia and northward into Canada from Saskatchewan east to Newfoundland, Prince Edward Island, and Nova Scotia.

Stenotrema monodon (Rackett)

Ecology. (Goodrich, 1932, p. 18) "When found in the southeastern part of the state (Michigan), it is usually in quite damp places and occasionally in very large colonies . . . A subspecies, *fraterna* (Say) . . . is an upland form rather than a habitant of the margins of swamps and marshes."

Distribution. New York, Ontario, and Quebec, Michigan, Wisconsin, Minnesota, and South Dakota south to Maryland, Illinois, Indiana, Ohio, Missouri, and Kansas.

Mesodon clausus (Say)

Ecology. (Goodrich, 1932, p. 18) ". . . found on railroad embankments and among roadside weeds. Judging from the numbers of individuals occurring in such situations, *clausa* flourishes better in sunlit, and sometimes baking hot, places than in the densely shaded woods."

Distribution. Minnesota, Michigan, Illinois, Indiana, Ohio, and New York south to Alabama.

Hawaiia minuscula (Binney)

Ecology. (Goodrich, 1932, p. 33) "Alive, it is to be found rarely in greater numbers than four or five individuals, usually by the borders of streams and lakes, but it is one of the commonest shells of the stream drift."

Distribution. Alaska and Northwest Territories of Canada south to British Columbia, east to Quebec and Maine, south to Florida and Texas.

Vertigo ovata Say

Ecology. (Franzen and Leonard, 1947, p. 355) "*Vertigo ovata*, although found in various parts of the state, lives only in moist environs afforded by shaded slopes near streams and shores of ponds. Its range in Kansas extends westward into the generally dry regions of the High Plains. In these regions are local ponds and streams, many of which are fed by artesian springs, along whose shaded slopes *V. ovata* is found, though not in great numbers."

Distribution. Labrador west to British Columbia, north to Alaska, south to Mexico, Florida, and the West Indies.

NATURE OF THE ENVIRONMENTS

General. With the reservations stated previously (see Composition of faunas) the following conclusions concerning the nature of the two environments may be stated. Both environments are similar to those found at present in small lakes and ponds. None of the species of exposed shores in large lakes occurs in either assemblage. Still less may these assemblages be interpreted as river assemblages unless it be in sheltered bays in sluggish streams with weed-choked, muddy bottoms. In addition to these characteristics which they share, the two faunas show marked differences which can also be interpreted in terms of changing environment.

Gray Layer. The molluscan fauna of this layer is remarkable for the paucity of species represented (see table 1). It consists of an overwhelming abundance of the shells of the small bivalve *Pisidium*, a mere sprinkling of the shells of its relative, *Musculium*, and a negligible proportion of Naiad fragments. Among the gastropods, the lymnaeid *Fossaria galbana* is the most abundant (13.08 percent), followed closely by the planorbid *Gyraulus altissimus* (9.93 percent). The other gastropods are much scarcer.

All the species found in this assemblage are represented in the black layer, but in different proportions. Their changing relative abundance from one layer to the other indicates a change in environmental conditions, natural in a small lake, which will be discussed later.

The assemblage is remarkable also for the absence of amnicolids. The environment of the gray layer was not unfavorable for operculates since one of them, *Valvata lewisi*, is represented. Amnicolids are found in most collections from marl in small or large lakes, from subarctic Canada to Wisconsin, Michigan, Indiana, and Illinois. In only a few marl collections are the amnicolids absent, notably the New Milford, Connecticut, deposit studied by Cooper (1930) which is questionably of post-Wisconsin age, and the Urbana, Illinois, deposit (Baker, 1918, pp. 660–65) of early Wisconsin age. The latter deposit shares with the Orleton gray layer the absence of *Helisoma* other than *H. trivolvis* but not too much importance is attached to this fact for *Amnicola* and *H. anceps striatum* have been recorded from at least one other early Wisconsin deposit in Illinois (Baker, 1930, p. 389).

Compared with its immediate successor, the Orleton gray layer is remarkable for the absence of land species, even in small numbers. Only two specimens of *Vertigo ovata*, listed as "trace" in the table, were found in the gray layer. This may be interpreted as an indication either of larger size of the lake during the formation of the gray layer or the lack of forest cover in the immediate vicinity of the lake while the gray layer was being formed. With the limited data available at present, it is not possible to adopt one of these theories in preference to the other. The problem could be solved by the collection of samples of the molluscan fauna in other parts of the deposit and comparison of the species represented with those in the sample of the gray layer now available.

The molluscan assemblage of the gray layer suggests a small lake with comparatively deep water, 3 to 10 feet, perhaps deeper in its central portion, without any great abundance of vegetation but with a sufficient amount to provide cover and food for the species present in it. It was such an environment as one can imagine for a lake in its early history, when the water is clear and free of vegetation, when the outlet is just beginning to cut its bed downward and before the bed of the lake has been choked up with accumulated debris and its water level has been lowered by cutting down of the outlet. A modern parallel may be found in Chilcott Lake, Quebec (La Rocque, 1932) although Chilcott Lake is in a later stage of development, with a more abundant fauna. Such an environment is radically different from that in which the black layer was formed.

The absence of the species which should be present in the gray layer cannot readily be accounted for. Other similar faunas (see Comparison with other faunas) contain many genera not found in the gray layer. These were probably prevented from establishing themselves here because of barriers whose nature will not be known until more data are available on the Pleistocene mollusca of Ohio.

Black Layer. The sediments of the black layer by themselves indicate radically different conditions from those obtaining when the gray layer was formed. They suggest a muddy, spongy bottom, such as is found in the shallow bays of modern lakes or the weed-choked remnants of glacial lakes in the last stage of their existence when most of the lake is covered with shallow water from a few inches to three feet deep. The molluscan fauna, and especially the proportions in which the species are represented, confirm this hypothesis.

The molluscan fauna of the black layer consists of the same species which are found in the gray layer with the addition of several others and a marked change in the proportions of each species. The dominant forms here are no longer pelecypods but gastropods. Most numerous from the standpoint of numbers is the small planorbid *Gyraulus altissimus* (81.8 percent) and next in order of abundance is the small lymnaeid *Fossaria galbana* (6.90 percent). Another small planorbid, much less abundant than *G. altissimus*, but still an important element of the fauna, is *Menetus exacuous*. Less conspicuous in the percentage tables, but nevertheless important because of their large size, are the lymnaeids *Stagnicola palustris elodes* (23.34 percent by volume) and *S. lanceata* (4.77 percent by volume).

Amnicolids are absent here, as in the gray layer, but their absence appears to be perfectly natural in an environment which suggests shallow water, a deep, soft mud bottom, and more pond-like conditions than those of the gray layer.

The presence in the black layer of land snails, absent in the gray layer, indicates nearness of shore and the presence, in the immediate vicinity of the lake, of a plentiful forest cover.

The absence of other species, especially *Aplexa hypnorum* (Linn.) typical of temporary ponds, indicates that the lake had not yet reached the last stages of its existence where it would have become a mere temporary pond, surrounded by forest and dry in summer. That sort of environment is suitable only for a small number of species of various families which have been noted and studied by a number of investigators but notably by Mozley (1938). If such a stage in the life of the lake had been reached, one would expect to find *Aplexa hypnorum* to be an important element of the fauna. The molluscan assemblage suggests, therefore, a small lake but a permanent one, whose bed had become choked with mud and vegetable debris and in which the water was mostly shallow but still present the year round. It is such an environment which can be found in many Ohio lakes in the late stage of development today.

COMPARISON WITH OTHER FAUNAS

The resemblances and differences between the fauna studied and others, both Pleistocene and living, are worthy of detailed treatment. The comparisons are made both from the standpoint of the nature of the environments of the two layers, already stated, and as a preliminary to the discussion of the age of the two faunas. The faunas compared have been selected so that comparisons might be made from three different aspects: geologic, geographic, and ecologic. These three factors must be considered in estimating the age of a Pleistocene molluscan assemblage, but they add considerably to the difficulty of arriving at definite conclusions. The faunas are arranged in two main groups (Living and Pleistocene) and under each of these the examples are given in order from south to north. In each list, the nomenclature has been brought up to date.

Living Faunas

Fisher's Pond, Middle Bass Island, Ohio. In his study of the molluscan fauna of Middle Bass Island, Dennis (1928) includes records of an assemblage similar to the Orleton faunas, especially the black layer, from Fisher's Pond. The pH was 7.4 and the species found in two of four zones are as follows:

Zone 1, at water line, water 2 inches deep, dense growth of water lilies. The substratum was muck. The snails found were in most cases clinging to the stem or the lower surface of the water lilies: *Helisoma trivolvis, Physa ancillaria, Fossaria humilis, Gyraulus parvus, Menetus exacuous.*

Zone 2, water 4 inches deep, dense growth of emergent vegetation (*Scirpus*); no snails.

Zone 3, water 5 inches deep, in another belt of water lilies like that in zone 1. The conditions were the same except that the water was 3 inches deeper in zone 3 than in zone 1: *Helisoma trivolvis, Physa ancillaria, Fossaria humilis, Gyraulus parvus.*

Zone 4, middle of pond, muck a foot deep, water 6 inches deep, dense growth of submerged vegetation; no snails.

The population of Fisher's Pond is poorer in number of species than that of even the gray layer, although the environment is almost the same in both cases. This one example from Ohio is given to show the variation which may exist between similar habitats geographically close together.

Pond near Canandaigua Lake, New York. The closest approach to the Orleton black layer is that of the type locality of *Stagnicola palustris elodes*, studied by Baker (1932). The pond was formed by the cutting off of a bay of the lake at a point 3 miles south of the city of Canandaigua; the area of the pool is given by Baker as about 3 acres. He describes the vegetation as follows: "There are three characteristic zones of vegetation, (1) an outer belt of large forest trees; (2) a zone of bushes bordering the shore; and (3) a border of small water plants on the inner edge of the bushes." Baker found 14 species "living on the muddy bottom which was filled with plant debris serving as food, or on the vegetation that lined the shore and filled the deeper water." The molluscan fauna consists of the following species: *Stagnicola palustris elodes* (Say), *Sphaerium occidentale* Prime, *Musculium securis* (Prime), *Pisidium roperi* Sterki, *Valvata lewisi* Currier, *Helisoma pseudotrivolvis* (F. C. Baker), *Menetus exacuous* (Say), *Menetus rubellus* (Sterki), *Gyraulus deflectus obliquus* (DeKay), *Gyraulus arcticus* ("Beck" Möller), *Gyraulus parvus* (Say), *Gyraulus circumstriatus walkeri* (Vanatta), *Physa gyrina elliptica* Lea, *Aplexa hypnorum* (Linn.). Three land snails were also found on the shore and near the shallower parts of the pool: *Oxyloma retusa* (Lea), *Succinea avara* Say, *Zonitoides nitidus* (Müller).

Unfortunately, Baker did not give quantitative data for the several species but the agreement between his list and that of the black layer is striking. With the exception of *Aplexa hypnorum* (Linn.) the genera are the same and his list of land snails around the pool is suggestive of the origin of those found in small numbers in the black layer of the Orleton deposit.

Table 3

Occurrence of molluscan species in three environments of Meach Lake, Quebec

Species	Rock	Sand	Mud
Musculium rosaceum Prime	0*	r	0
Pisidium sp	0	r	0
Anodonta marginata Say	0	0	c
Elliptio complanatus (Dillwyn)	r	r	0
Lymnaea stagnalis lillianae F. C. Baker	c	c	r
Bulimnea megasoma (Say)	r	0	c
Pseudosuccinea columella (Say)	0	0	c
Gyraulus parvus (Say)	0	0	r
Helisoma trivolvis pilsbryi F.C.B	r	0	c
H. campanulatum wisconsinense (Winslow)	c	c	c
H. anceps latchfordi (Pilsbry)	r	c	r
Physa latchfordi F. C. Baker	c	c	0
P. gyrina Say	0	0	r
Ferrissia parallela (Say)	0	0	c
Amnicola limosa porata (Say)	0	0	c
Campeloma cf. *decisum* (Say)	0	c	0
Oxyloma retusa (Lea)	0	0	r

*c—common: r—rare; 0—absent.

Similar assemblages of mollusca are found far to the west of both Ohio and New York, and northward into Canada. A few examples will demonstrate the widespread occurrence of this kind of molluscan population.

Meach Lake, Quebec. The molluscan fauna of this lake was studied by La Rocque (1935). The condensed data in table 3 for the three environments of the lake will serve to show the similarities between the Orleton faunas and the mud habitat of Meach Lake and the different assemblages which are found in the rock and sand habitat of the same body of water.

Chilcott Lake, Quebec. This lake, west of Wakefield, Quebec, about 30 miles north of Ottawa, Ontario, was studied by La Rocque (1932). No quantitative data were obtained during the study but the list of species will show the character of the molluscan fauna which may be expected in a lake in an advanced stage of development and of somewhat larger size than that of the Orleton deposit:

PELECYPODA	GASTROPODA
Elliptio complanatus (Dillwyn)	*Campeloma decisum* (Say)
Anodonta cataracta Say	*Amnicola limosa porata* (Say)
Lasmigona costata (Rafinesque)	*Lymnaea stagnalis jugularis* Say
Alasmidonta undulata (Say)	*Stagnicola emarginata canadensis* (Sowerby)
Musculium sp.	*Pseudosuccinea columella* (Say)
Sphaerium simile (Say)	*Helisoma trivolvis* (Say)
	H. campanulatum (Say)
	H. anceps (Menke)
	Physa cf. *latchfordi* (F. C. Baker)

The disparities between the Chilcott Lake list and the Orleton deposit lists may be interpreted as due to differences in depth of water (deeper in Chilcott Lake), greater time for immigration of molluscan species, and connection of the lake with the Gatineau River, a tributary of the Ottawa, which in turn forms part of the St. Lawrence system.

Manitoba and Saskatchewan. The small lake fauna ranges much farther north and west than the examples so far cited would indicate. To give the full extent of its range, a few examples recorded by Mozley (1938) from Manitoba and Saskatchewan are given.

Small Freshwater Lakes: (1) A pond on Moose Mountain, southern Saskatchewan: *Lymnaea stagnalis jugularis*, *Stagnicola palustris*, *Helisoma trivolvis*, *Menetus exacuous*, *Physa gyrina*. (2) Pelican Lake, Ninette, Manitoba: (i) on *Potamogeton* near the centre of the lake, *Physa gyrina* (abundant), *Stagnicola palustris* (less common); (ii) in *Typha* and *Scirpus* marsh around the shore of the lake, *Lymnaea stagnalis jugularis*, *Stagnicola palustris*, *Menetus exacuous*, *Gyraulus arcticus*, *Planorbula armigera*, *Physa gyrina;* (iii) in a moist meadow on slightly higher ground near the marsh, *Stagnicola caperata*, *Fossaria parva* var., *Aplexa hypnorum.*

In this region, as well as in others, the molluscan fauna of small lakes differs from that of temporary ponds on the one hand and that of large lakes with outlet streams on the other. Two examples from Mozley's (1938) work will suffice to show the contrast:

Temporary pond near St. Vital, Manitoba: *Stagnicola palustris*, *S. caperata*, *Menetus exacuous*, *Gyraulus umbilicatellus*, *Planorbula campestris*, *P. crassilabris*, *Aplexa hypnorum.*

Large lake with outlet stream, Shoal Lake, eastern Manitoba: (i) Exposed rocky shores of Indian Bay, *Physa ancillaria;* (ii) sandy shore of Indian Bay somewhat exposed to wave action, *Lymnaea stagnalis lillianae;* (iii) protected shore of Indian Bay, *Fossaria obrussa exigua;* (iv) Falcon Bay in quiet water, on sand bottom and in small marshes, *Lymnaea stagnalis jugularis*, *Helisoma campanulatum wisconsinense*, *H. trivolvis pilsbryi*, *H. anceps sayi*, *Menetus exacuous*, *Gyraulus hirsutus*, *G. arcticus*, *Planorbula crassilabris*, *Sphaerium crassum*, *Anodonta kennicotti.*

In addition, the lists given by Russell (1934) cited later in this paper, should also be examined. They are not repeated here since they are quoted specially to show the relationships between interglacial, post-glacial, and living faunas in one region.

Pleistocene Faunas

Rush Lake, Ohio. Baker (1920) has studied the mollusca from a marl bed at the south end of Rush Lake, Logan County, Ohio. The bed is dated as post-Wisconsin in age and after examination of the list of species, Baker concludes that "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 list of species is of interest for comparison with the Orleton faunas:

Anodonta species—fragments
Sphaerium sulcatum (Lamarck)—abundant
Musculium rosaceum (Prime)—a dozen odd valves
Pisidium compressum Prime—common, almost abundant
P. variabile Prime—about as common as *P. compressum*
P. tenuissimum Sterki—the most abundant species of Sphaeriidae
P. medianum Sterki—a score
P. noveboracense Prime—2 valves
P. pauperculum Sterki—2 valves
Valvata tricarinata (Say)—one of the most abundant species; several hundred
V. tricarinata perconfusa Walker—about 10 percent of the carinate *Valvatas*
V. tricarinata unicarinata—a single specimen
V. sincera Say—3 specimens out of about 20,000
Amnicola walkeri Pilsbry—not common, about 50 in a quart of specimens
A. lustrica Pilsbry, var.—nearly 40 percent of total
A. winkleyi leightoni Baker—"Together with *Amnicola lustrica* variety, it is the most abundant species in this deposit."
Helisoma campanulatum (Say)—a dozen specimens
H. anceps (Menke)—"A fairly abundant species"
H. anceps striatum (Baker)—"about 10 percent of the *antrosus* (*anceps*) may be referred to this variety"
Gyraulus altissimus (F. C. Baker) "The common *Planorbis* of the marl deposits . . . after *Amnicola lustrica* and *A. winkleyi leightoni* is the most abundant shell in this deposit"
G. hirsutus Gould—a single specimen
Menetus exacuous (Say)—fairly common
Stagnicola palustris (Müller)—a single broken specimen
Fossaria obrussa decampi (Streng)—quite common
Physa anatina Lea—adults not common, immature shells are almost abundant
Ferrissia parallela (Haldeman)—a single specimen.

New Milford, Connecticut. The fauna of the New Milford deposit, studied by Cooper (1930), is thought to be post-Wisconsin, Wabash interval. The species are as follows:

Sphaerium rhomboideum	common
Musculium partumeium	rare
Pisidium abditum	very common
P. contortum	rare
P. ferrugineum	rarely common
P. rotundatum	rare
P. ventricosum	rarely common
Valvata tricarinata	rare
Physa cf. *heterostropha*	very rare
P. cf. *ancillaria*	very rare
Ferrissia rivularis	very rare
Helisoma anceps striatum	very rare
H. campanulatum	very common
Gyraulus altissimus	abundant
G. deflectus	rare
Lymnaea stagnalis jugularis	common
Fossaria galbana	very common
F. obrussa decampi	rare
Vertigo ovata	very rare

From the ecologic standpoint, this assemblage suggests slightly different conditions from those obtaining at the Orleton site. Comparison of the two

lists shows more similarity between the gray layer and the New Milford deposit than between the latter and the black layer. On the other hand, the species of *Helisoma*, *Ferrissia*, and *Valvata* are different and the New Milford deposit contains no *Stagnicolae*.

Toronto Interglacial Fauna. This fauna has been the object of a careful study by Baker, because of the concern of geologists regarding its age. No definite conclusions have been reached according to Baker (1931) who considers it either Yarmouth or Sangamon in age but who points out also that A. P. Coleman at various times considered it as of Sangamon, Aftonian, or Yarmouth age. The list of species of this fauna is given here to show the contrast between a Great Lakes fauna and that of a small lake or pond. The contrast is especially apparent in the abundance of Naiades, preponderantly thick-shelled, listed by Baker. No data on abundance are available.

Amblema rariplicata (Lamarck)
Ligumia recta (Lamarck)
Lampsilis siliquoidea rosacea (DeKay)
Elliptio dilatatus (Rafinesque) variety
Pleurobema coccineum solidum (Lea)
Lampsilis ventricosa (Barnes) variety
Obovaria olivaria (Rafinesque)
Anodonta grandis Say
Quadrula pustulosa (Lea)
Sphaerium n. sp.
S. emarginatum (Prime)
S. sulcatum (Lamarck)
S. solidulum (Prime)?
Pisidium compressum Prime
Pleurocera acutum Rafinesque, variety
Goniobasis haldemani Tryon
Stagnicola palustris elodes (Say)?
Gyraulus altissimus (F. C. Baker)
Helisoma anceps striatum (F. C. Baker)
Vancleaveia emarginata canadensis (F. C. Baker)
Cincinnatia cincinnatiensis (Anthony)
Physa niagarensis Lea
P. sayii Tappan
Birgella subglobosa (Say)
Valvata tricarinata (Say)
Campeloma rufum (Haldeman)

McKay Lake, Ottawa, Ontario. The list of species for this deposit is given here to indicate the northward range of the small-lake assemblage. Its fauna was studied by Whittaker (1921) who states that it is Recent and was deposited "just after the retreat of the last marine invasion." The list of species is similar to that of the Orleton deposit with a few important differences. For example, *Stagnicola palustris elodes* is not found in the McKay Lake deposits and they contain two species, *Helisoma anceps* (Menke) and *H. campanulatum* (Say) besides abundant specimens of *Amnicola limosa porata* Say which are not found in the Orleton faunas. Whittaker gives no quantitative information but the writer, from examination of material from McKay Lake, can vouch for the abundance of *Amnicola limosa porata*, *Valvata tricarinata*, and *Gyraulus altissimus* in the deposit. Whittaker's list follows:

Pisidium abditum Haldeman
Triodopsis albolabris Say
Stenotrema monodon (Rackett)
Anguispira alternata (Say)
Helicodiscus parallelus (Say)
Succinea ovalis Say
Fossaria obrussa (Say)
F. galbana (Say)
Helisoma anceps (Menke)
H. campanulatum (Say)
Gyraulus altissimus (F. C. Baker)
Physa gyrina Say
Amnicola limosa porata (Say)
Valvata tricarinata (Say)

North Mud Lake, Indiana. Blatchley and Ashley (1901, p. 226) have given a list from a marl deposit at North Mud Lake, Fulton County, Indiana. The list (table 4) is remarkable in that it is one of the few which includes quantitative data.

A comparison of table 4 with table 1 will show that there are important differences between the North Mud Lake fauna and the two Orleton faunas. Some of the differences may be more apparent than real, for example, in the genus *Gyraulus*, for it is quite possible that the species recorded as *G. parvus* is really *G. altissimus*. There still remains, however, the fact that 50 percent of the North Mud Lake fauna consists of 3 species of *Amnicola* which indicates a habitat much richer in water vegetation than the Orleton gray layer and with deeper water than the Orleton black layer.

TABLE 4

Relative frequency of fauna from a marl deposit at North Mud Lake, Indiana

Species	Percent of total
Stagnicola desidiosa (Say)	4
Fossaria humilis (Say)	2
Physa heterostropha Say	12
Helisoma trivolvis (Say)	5
H. anceps (Menke)	3
Menetus exacuous (Say)	1
Gyraulus parvus (Say)	12
Amnicola limosa (Say)	20
A. cincinnatiensis Anthony	20
A. lustrica (Say)	10
Sphaerium sp. and other broken shells	11

TABLE 5

Occurrence of molluscan species in three kinds of assemblages

Species	1	2	3
	(*Number*	*of*	*localities*)
Pisidium cf. *superius*	1	...	...
P. cf. *rotundatum*	2	...	...
P. compressum	...	1	...
P. sp.	2	0	1
Sphaerium simile	0	1	0
Lymnaea stagnalis jugularis	0	0	4
L. stagnalis subsp. indet.	0	1	0
Stagnicola palustris elodes	1	1	2
S. palustris nuttalliana	2	1	3
S. saskatchewanensis	1	0	0
S. emarginata canadensis	2	0	0
Stagnicola n. sp.	1	0	0
Gyraulus altissimus	2	2	1
G. cyclostomus	3	0	1
Helisoma subcrenatum	0	1	5
H. anceps striatum	0	1	0
Physa gyrina	1	0	1
Physa heterostropha	0	1	0
Aplexa hypnorum	0	0	1
Euconulus fulvus	0	0	1
Succinea chrysis	0	1	1
Succinea grosvenori	0	0	1

Explanation of symbols:
Column 1: Interglacial (probably Peorian), 5 localities.
Column 2: Post-glacial, 2 localities.
Column 3: Living, 6 localities.

Bellflower, Illinois. Baker (1930, p. 389) has given a list of species from a deposit near Bellflower, McLean County, Illinois, which he estimates to be "Early Wisconsin, substage 1 of Leverett." It is of special interest because it yielded a

new record of *Castoroides ohioensis* for Illinois. There is no record of the relative abundance of the species and the list is reproduced here merely to show the variety of molluscan species represented.

Sphaerium sulcatum
Pisidium sp.
Valvata tricarinata
Amnicola leightoni var.
Cincinnatia cincinnatiensis
Pyrgulopsis sp.
Pomatiopsis scalaris
Helisoma anceps striatum
Gyraulus altissimus
G. urbanensis
Ferrissia parallela

Urbana, Illinois. The Urbana deposit, studied by Baker (1918, p. 661), is also Early Wisconsin in age. The deposit is in the Champaign till sheet in a kettle hole on the north side of the Champaign moraine. The fauna shows some affinities with that of the Orleton black layer. The list, together with Baker's indications of abundance, follows:

Sphaerium rhomboideum—1 right valve
S. occidentale—1 valve
Musculium cf. *rosaceum*—1 valve
M. truncatum—rather plentiful
Pisidium adamsi affine—1 valve
P. contortum—?
P. costatum—most abundant next to *P. tenuissimum calcareum*
P. tenuissimum calcareum—most abundant mollusk
P. variabile—1 valve
P. vesiculare—a few
Valvata sincera—quite common
V. tricarinata—not common
Physa gyrina—in abundance; only 3 percent mature
P. sayii—1 specimen
Helisoma trivolvis—not common
Gyraulus urbanensis—"sparingly"
G. altissimus—"a few adult individuals and a number young and immature specimens
Stagnicola caperata—numerous
S. reflexa—occurs plentifully
Fossaria obrussa decampi—common

Winnipeg, Manitoba. A deposit from near Winnipeg, Manitoba, Canada, studied by Mozley (1928) is post-glacial in age. It is given here mainly because of its resemblance to the Orleton fauna in spite of the distance which separates the two deposits and the indications of comparative abundance given by Mozley.

Vallonia costata (Müller)—not common
V. parvula Sterki—rare
Retinella hammonis (Ström)—no data
Discus cronkhitei anthonyi Pilsbry—no data
Succinea ovalis Say—no data
Succinea sp.—no data
Fossaria obrussa exigua (Lea)—rare
Stagnicola vahlii arctica (Lea)—rare
S. caperata (Say)?—no data
Gyraulus parvus (Say)—not common
Helisoma trivolvis ? (Say)
Planorbula crassilabris Walker—no data
Aplexa hypnorum Say—no data
Physa integra Haldeman—no data

Amnicola limosa Say—no data
A. emarginata Küster—the most abundant species, very common
Amnicola winkleyi mozleyi Walker—common
Valvata tricarinata Say—no data
Ferrissia rivularis (Say)—no data
Sphaerium striatinum (Lamarck)—no data
S. solidulum Prime—no data
S. stamineum Conrad—no data
S. notatum Sterki—no data
S. emarginatum Prime—no data
S. torsum Sterki—no data
Pisidium fallax Sterki—no data
P. compressum Prime—no data
Musculium transversum Prime—no data

Southern Saskatchewan. The lists given by Russell (1934) for several localities in southern Saskatchewan are particularly interesting because they include inter-glacial, post-glacial, and living assemblages. The data comparing the three kinds of assemblages are condensed in table 5.

AGE OF THE FAUNA

The age of the Orleton faunas can definitely be stated as Wisconsin because of the presence in them of extinct species such as *Fossaria galbana* and *Gyraulus altissimus* although this statement must be qualified by noting that *G. altissimus*, although extinct in Ohio and the neighboring regions, may still be living (Russell, 1934) in southern Saskatchewan and perhaps northward. The presence in both lists of species still living in Ohio or in the same latitude in other states would indicate a late Wisconsin age. However, it must be admitted that the age determination based on the mollusca alone is far from certain because of the close similarity between Pleistocene and living faunas. In fact, the molluscan assemblage yields more information as to the environment under which the two layers were accumulated than concerning their relative age. This is due in part at least to our lack of knowledge of Pleistocene faunas, especially from a quantitative and stratigraphic standpoint.

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TOOTH-MARKS ON BONES OF THE ORLETON FARMS MASTODON

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A number of bones of a mastodon from Orleton Farms, Madison County, Ohio, exhibiting some tooth-marks have been submitted to me by Dr. Edward S. Thomas of the Ohio State Museum.

Included among the material are seven specimens that show grooves cut in them, clearly the result of gnawing by rodents. These tooth marks are of three or perhaps four sizes.

The largest size, represented by one specimen ("A") is about two centimeters in diameter. Because of its size, this is quite clearly the tooth mark of a beaver (*Castor* sp.). It is much too small for the giant beaver (*Castoroides*), and seems to have been the work of one animal over a very short period of time. Little or no trace of separate cuts can be seen.

The next largest size is represented by three specimens ("B," "C" and "D"). These cuts are approximately a centimeter in width. "B" is a smooth cut, extending into the cancellous bone, "C" is similar, but slightly narrower. There is another, smaller, cut on this specimen. "D" is an irregular cut that seems to have been worked on in a number of separate attempts. These cuts were made by a rodent with much smaller incisors than was that of specimen "A." From their size, they could easily have been made either by a porcupine (*Erethizon*) or a woodchuck (*Marmota*).

Two specimens show the smallest size cuts, about one or two millimeters in diameter ("E" and "F"). In both of these specimens, there are two parallel cuts, spaced about 2 mm apart. These could be cuts made simultaneously by both front teeth of a medium-sized rodent (such as the muskrat, *Ondatra*), but more probably represent separate cuts of a smaller form, of the size of the deer mouse (*Peromyscus*), or a small squirrel (*Sciurus*), or of a vole (*Microtus*, etc.).

Finally, one specimen ("G") shows clear evidence of a series of cuts along the edge of the bone for a distance of about 3 cm. Although the edges of these tooth marks have cut each other, so that they are somewhat indistinct, they seem to have been made by a rodent of about the size of *Ondatra* or *Sciurus*.

This group of bones, then, indicates rather clearly that a considerable variety of rodents had access to the mastodon bones as they lay around on the ground surface. With the exception of the beaver and possible muskrat cuttings, all of these seem to have been made on land and not under water, and all of them could have been made on land.

Rodent gnawings of this sort always cause surprise to the layman. The basic reason for them is the necessity for rodents to wear off their incisor teeth. These teeth grow from persistent pulps, never developing roots. The enamel is limited to the anterior face of the tooth, the rest being formed of softer dentine. Thus, wear gives a sharp chisel-edge of enamel, supported and kept from breaking by the dentine. Due to the continual growth of the incisors, they must be used with great regularity to wear them down. The rate of their growth (and resultant wear) is much greater than is generally realized. For example, in the rat, the upper incisors grow at a rate of slightly over 2 mm per week, and the lower incisors at a rate of about 2.9 mm per week, making a total of about 4.3 and 6.0 inches per year, respectively (Shadle, Wagner, and Jacobs, 1936). In the porcupine, the rate is considerably slower, but still very notable. Here the comparable figures are 1.3 mm per week for the upper incisor and 1,7 mm per week for the lowers, or 2.7 and 3.5 inches per year, respectively (Shadle, Ploss, and Marks, 1944).

Rodents, then, are likely to gnaw any hard objects that are available to them. Where there is some possible nurtitive value, such materials are even more readily gnawed. This seems to be the reason why bones are very often selected by rodents, in view of the mineral matter they contain, which is important to all mammals, but particularly so to ones showing such extremes of tooth growth.

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