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A RADIOCARBON DATED POLLEN SEQUENCE FROM THE WELLS MASTODON SITE NEAR ROCHESTER, INDIANA[1]

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ABSTRACT

A radiocarbon date (I–586, 12,000±450) has been obtained from wood beneath a mastodon (*Mastodon americanus*) in north-central Indiana. The sediment sequence includes 72 inches of marl at the base, overlain by 12 inches of sand, capped by 34 inches of peat. The peat is truncated at the top by fire and cultivation. Pollen spectra from the marl associated with the mastodon burial indicate a predominantly coniferous forest consisting of spruce (*Picea*), fir (*Abies*), birch (*Betula*), and ash (*Fraxinus*) with small amounts of oak (*Quercus*), Hickory (*Carya*), and elm (*Ulmus*) pollen. Field evidence and pollen data indicate that the animal died prior to the formation of the peat. Correlation of this sequence with other radiocarbon-dated pollen sequences indicates that the mastodon died prior to the replacement of spruce pollen by oak pollen approximately 10,500 years ago. Molluscan data support the inferences derived from the pollen analysis.

A vertebra and the right lower jaw of a *Mastodon americanus* were uncovered in 1959 in the excavation of a drainage ditch on a farm five miles west of Rochester, Indiana (fig. 1). Cursory probing by Mr. James Wells, owner of the farm, and James Cope and James Thorp of Earlham College revealed more bones a few feet below the bottom of the ditch. About 25 persons, under the direction of James Cope and Gertrude Ward of Earlham's Joseph Moore Museum, assisted during the summer of 1960 in the recovery of most of the mastodon skeleton. A. M. Gooding assisted with the dig, studied the geological setting and stratigraphy, and collected samples for pollen, molluscan, and radiocarbon analysis. John O'Brien, an Earlham senior geology major, studied and prepared the molluscan data, and J. Gordon Ogden, III, with technical assistance by Barbara Spross, prepared and analyzed the pollen samples. A pollen diagram and discussion of the conditions of burial are included in this report.

GEOLOGICAL SETTING

The Wells Mastodon Site is located in a broad area of valley train and outwash deposits between the Maxinkuckee and Packerton Moraines of Cary age (fig. 2). Outwash sands around the mastodon site have been worked by the wind in places, and groups of low dune hills interrupt the otherwise flat topography of the area. The water table is high, natural drainage poor, and extensive areas are covered with peat (Carlisle muck soil; Rogers, 1956) which lap onto the dune hills. The peat is commonly underlain with marl of variable thickness. The sluggish Mud Creek drainage system (fig. 1), along one tributary of which the Wells mastodon site is located, probably originally connected a series of small lakes and ponds in the area.

STRATIGRAPHY OF MASTODON SITE

The drainage ditch in which the mastodon was exposed was cut initially to a

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depth of about 5 ft to improve the Carlisle muck soil for agricultural use. Excavation for the skeleton extended across the drainage ditch, and a pit was opened which measured about 30 ft across and 8 ft deep (fig. 3).

The following stratigraphic section on the south side of the pit was measured, described, and sampled for pollen and radiocarbon analysis:

Unit	Thickness	Description
3	34 in.	Peat—dense, black to brown. Upper few inches showed effects of burning of surface vegetation.
2	12 in.	Sand—well-sorted quartz sand, probably largely wind-blown, containing numerous fine streaks of finely divided organic matter.
1	72 in.	Marl—gray, consisting almost entirely of fragments of gastropod and pelecypod shells. An occasional piece of wood was encountered in this unit, but no concentration of plant remains. Radiocarbon-dated wood sample collected at 90 in. from surface (I-586,12,000 ±450). Bottom 28 in. determined by auger. Bottom of marl probably on till.

Later extension of the pit to the north showed the same stratigraphy, although units varied slightly in thickness.

INTERPRETATION OF FIELD DATA

The Wells mastodon is exceptionally well preserved and few of the bones are broken or fragmented. Except for the left legs and the pelvis, which probably

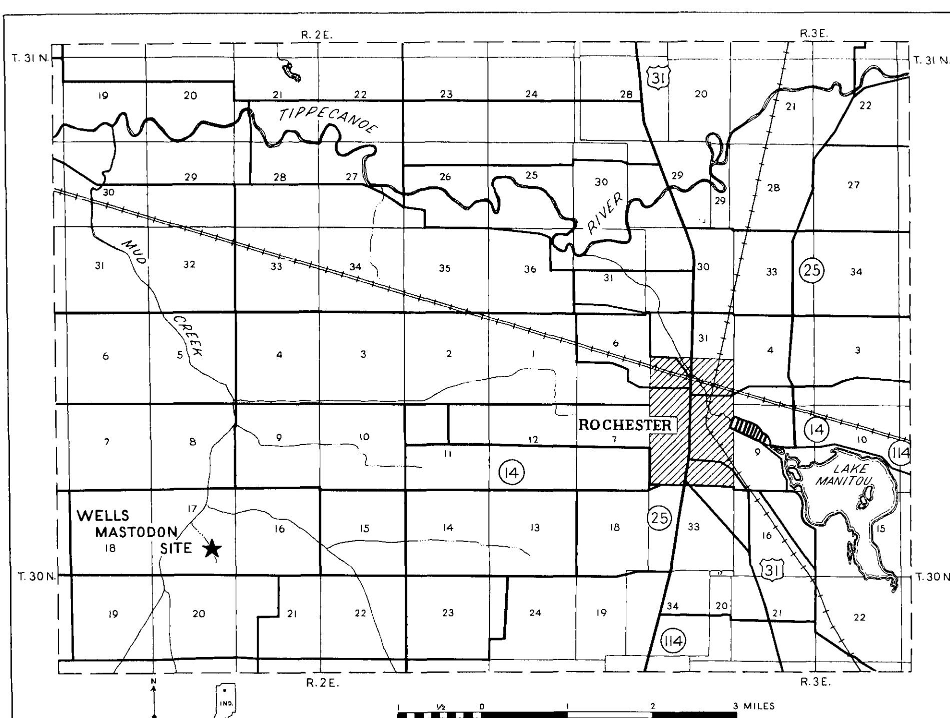

FIGURE 1. Location of the Wells Mastodon Site, near the center of the SE ¼, Sec. 17, T.30N., R.2E., in Fulton County, Indiana.

lie deeper in the marl, most of the skeleton was recovered. None of the bones show rodent teeth marks or other evidence of surface exposure after death.

All of the skeletal remains were found in marl (unit 1), mostly in a zone between 5 and 7 ft below the surface, although some bones extended vertically downward to greater depths. The skull, with the lower jaws and the right tusk in place, was overturned to the left about 130 degrees. Most of the rest of the bones were found approximately in their proper positions with respect to this orientation of the skull.

Although, obviously, the marl sediment around the skeleton must have been disturbed by the animal in his death struggles, and by later oozing into skeletal cavities, the field evidence suggests that burial occurred before the completion of

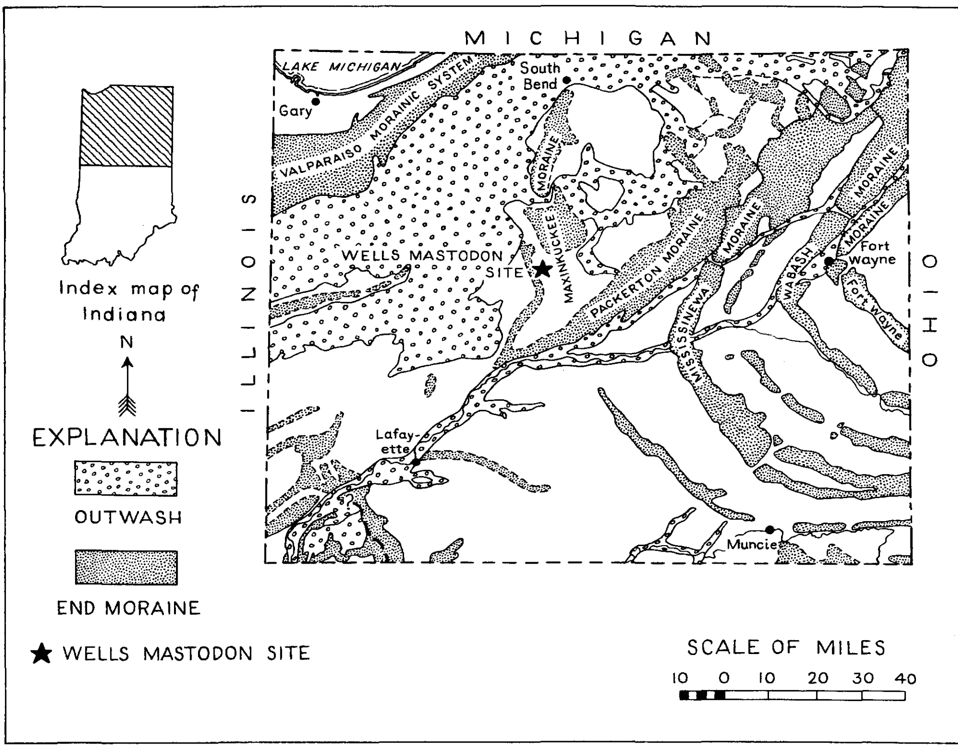

FIGURE 2. Glacial map of northern Indiana showing location of Wells Mastodon Site in relation to the Maxinkuckee moraine. (Map modified from glacial map of Indiana in Indiana Geological Survey Report of Progress 7).

marl deposition. The contacts between the overlying marl, sand, and peat appeared undisturbed, and no peat or sand from the upper units was found included in the marl around the skeleton, as would be expected if the animal had broken through the upper layers of sand and peat.

These field observations indicate the following history: the animal became mired in the marl sediment of an open small lake or pond, possibly by breaking through ice. After death, probably by drowning, the carcass came to rest on its left side in shallow water. Further marl deposition completely buried the remains, and the shallow pond or lake basin became filled. In the early stages of the bog phase, conditions developed in the area which favored activity of wind and the aeolian sand (unit 2) was deposited over the mastodon site. The absence of intermixed aeolian sand in the marl (unit 1) and peat (unit 3) suggests that the work of the wind, and presumably the formation of the dunes of the area, occurred mainly during the time of deposition of the aeolian sand (unit 2). With a decrease in aeolian activity in the area, bog vegetation flourished and accumulated to form the peat (unit 3) over the mastodon site.

POLLEN ANALYSIS

Methods

Pollen samples were collected at two-inch intervals immediately adjacent to the mastodon skeleton section by A. M. Gooding. The samples were placed in stoppered vials and kept under refrigeration until preparation and analysis in the laboratory.

Preparation of the sediments for pollen analysis included the following treatments: deflocculation in hot 10 per cent KOH; removal of carbonates with hot

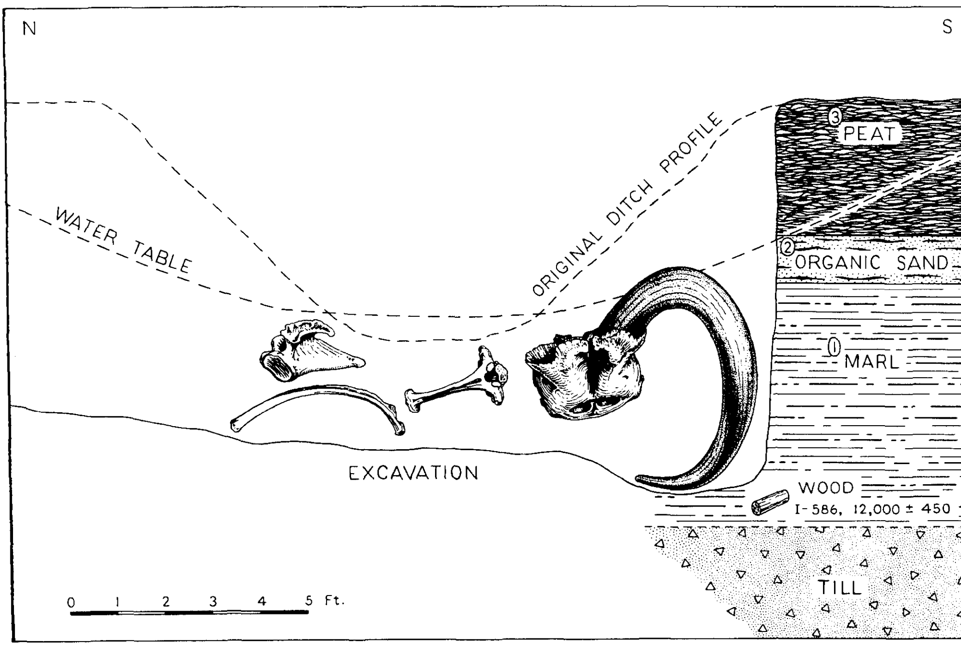

FIGURE 3. Diagram showing the stratigraphy, occurrence of the mastodon skeleton, and nature of the excavation at the Wells Mastodon Site.

10 per cent HCl; flotation in bromoform (sp gr 2.4, after Frey, 1958); acetolysis (modified from Faegri and Iversen, 1950); a final wash in hot 10 per cent KOH; and mounting in basic fuchsin-glycerine jelly.

Pollen identification and counting was done at 320 × using a Leitz Ortholux microscope equipped with planapochromatic objectives. Critical identifications were made at 500 × and 1250 × (oil immersion). Coordinates of unknown specimens were recorded for later relocation and study, or photographing.

The pollen spectra at each stratigraphic level were calculated as percentages of total pollen, exclusive of the pollen of aquatic plants and spores.

Results

Figure 4 summarizes the pollen data in the form of a pollen diagram. Minor non-arboreal pollen, aquatic plant pollen, spores and algal types encountered in the analysis are listed in Table I.

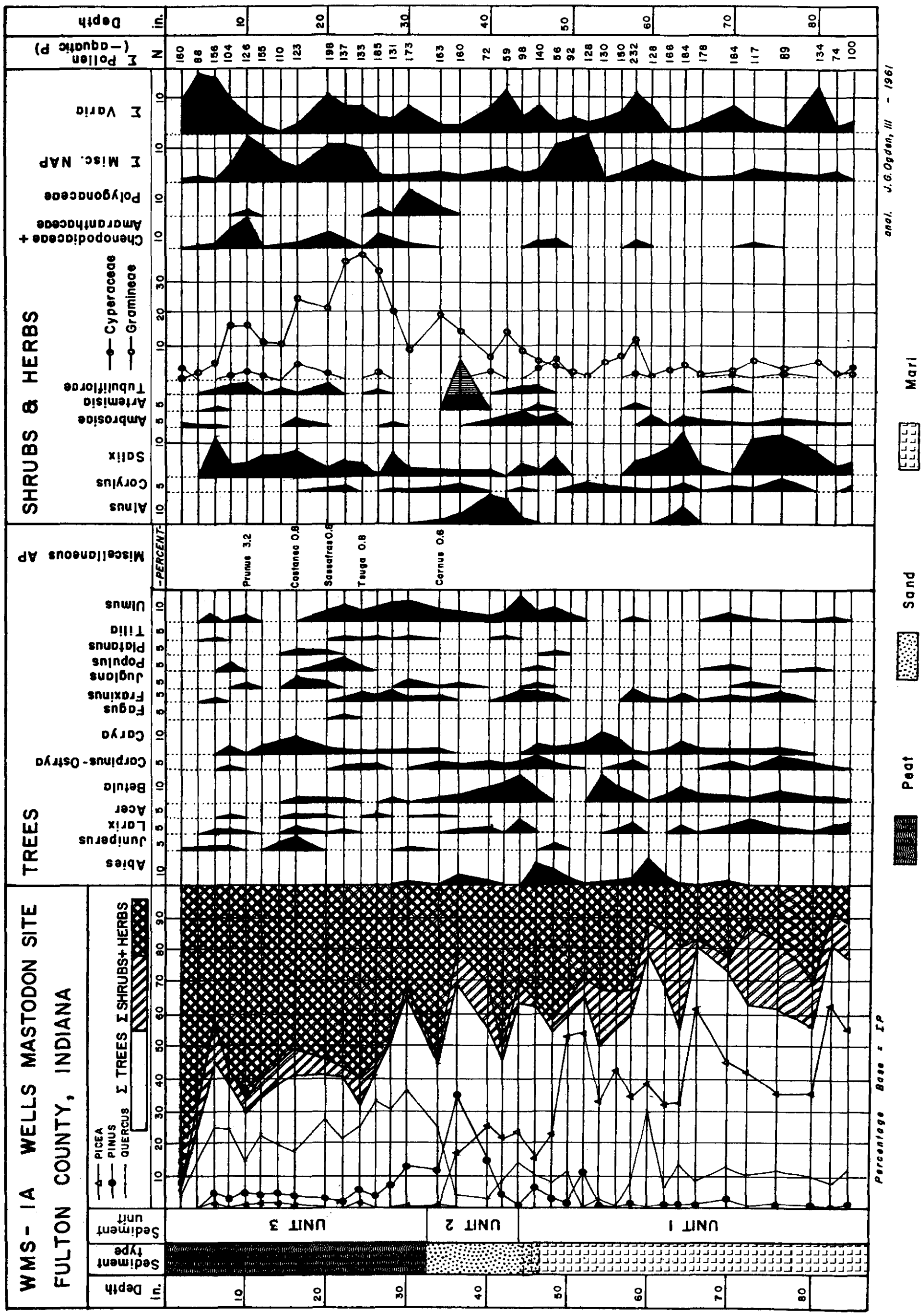

FIGURE 4. Pollen diagram for the Wells Mastodon Site.

The main block diagram at the left of figure 4 shows the percentage values of the major arboreal pollen types: spruce (*Picea*), pine (*Pinus*), and oak (*Quercus*). Also shown is the percentage of tree pollen (ΣAP), represented by the clear area; the percentage of shrub, or sub-arboreal pollen (ΣSAP) is shown as single hatching, and the percentage of herbaceous pollen types (ΣNAP) is shown as double hatching.

Pollen spectra from sediments associated with mastodon and mammoth in central Michigan have been dated at 10,700 ±400 (M–1254) (Oltz and Kapp, 1963). The pollen spectra of the Smith mastodon as well as pollen profiles from near the mastodon site show close similarities to the pollen spectra from sediment unit 1 (marl) of the Wells Mastodon Site. As in the case of the Wells site, however, the possibility of considerable sediment disturbance by the mastodon makes close correlation uncertain. The two profiles presented by Oltz and Kapp (1963) are incomplete (approximately 50 cm) and provided only 10 pollen spectra, which further discourages attempts to relate the two sites. High frequencies of spruce pollen (to 49 per cent) from the Smith site resemble the pollen record of the Wells site. Although the Michigan sequences show higher percentages of pine than does the Wells Mastodon Site, the low frequency of deciduous tree pollen is similar in both diagrams.

A late-glacial pollen spectrum of spruce, fir, sedge, and grass pollen associated with a woodland musk ox find in Michigan (Benninghoff and Hibbard, 1961) apparently dates from the same period as the mastodons.

Spruce, fir, and pine pollen types dominate the pollen spectra associated with the Orleton Farms mastodon (Sears and Clisby, 1952). A log recovered from beneath the animal and thought to have been punched into the marl by the mastodon (Thomas, 1952) has been radiocarbon-dated at 8240 ±400 yr (M–66).

Comparison of the Wells Mastodon Site pollen diagram with that from Sunbeam Prairie Bog, located in southwestern Ohio (Kapp and Gooding, 1964), reveals several points of similarity. The basal portion of the diagram is dominated by spruce (*Picea*), with oak (*Quercus*) pollen showing greater abundance in the Wells Mastodon Site than at Sunbeam Prairie. Just as in the Sunbeam diagram, pine (*Pinus*) shows a maximum at the transition to hardwood pollen dominance. Unlike the Sunbeam sequence, however, there is no maximum of pine pollen at the base of the diagram.

Since the transition from predominantly spruce pollen to predominantly oak pollen coincides with the change from marl sedimentation to peat formation in both the Wells site and the Sunbeam Prairie sites, it is quite likely that this represents an event of considerable climatic significance. It is apparent from the Sunbeam Prairie profile (Kapp and Gooding, 1964) that the change in sediment type culminated in the cessation of sediment accumulation in this deposit. At the Wells Mastodon Site, however, peat continued to accumulate for some time after the transition in sediment type occurred.

From the description of the site given earlier in this report, it is believed that the mastodon became mired near the margin of the lake in which marl was being deposited. Because of the probability of considerable sediment dislocation during his death struggles and oozing of the marl into the body cavities as the flesh disintegrated, it is unlikely that the pollen record from the marl records any significant climatic history.

The sand layer (unit 2) undoubtedly indicates a period of exposure and perhaps erosion of the marl. Pollen was extremely scarce in this zone, and many of the grains were fragmented. The maximum of pine pollen may be a lag concentrate as a result of partial or total destruction of other pollen types by mechanical abrasion as the sand was being deposited. The presence of the sand layer indicates an hiatus in bog deposition of unknown duration. It is quite possible that, as in the Sunbeam Prairie pollen sequence, where the radiocarbon age of the peat (L–550B, 10,600 ±200 B.P.) is little younger than wood recovered from the marl

(L550C, 11,700 ±250 B.P.), there is no significant time lapse between the cessation of marl deposition and the onset of peat formation at the Wells Mastodon Site. The low-lying, relatively level, poorly drained region around this deposit probably supported a vegetation similar to the modern black spruce tracts of the former glacial lake Barlow-Ojibway basin in central and northern Ontario.

The environmental conditions which caused the formation of the peat (unit 3) may have caused oak pollen to replace spruce as a dominant in the pollen record. This transition is marked by an increase in the pollen of grasses and the presence of maple (*Acer*), walnut (*Juglans*), and basswood (*Tilia*) in the pollen record. The decrease in arboreal pollen types and the maximum of grass pollen may reflect increasing aridity. The maximum in Chenopod-Amaranth pollen above the grass pollen maximum also indicates progressively drier conditions. The decline in grass pollen above the 22-in. level may indicate drying out of the basin, as the sediments become more oxidized above this level. The curve for unknown pollen types (Varia) at the extreme right of the diagram includes strongly oxidized and fragmented grains, many of which appear to be Compositae.

The apparent increase in spruce pollen shown in the analyses from 6 to 16 in. (figure 4) may be due to a decrease in pollen productivity at the site, with a consequent increase in the contribution from long-distance transport. Alternatively, if spruce survived in the vicinity of the site, a decrease in upland pollen types would have the same effect. Taken altogether, these pieces of evidence indicate a vegetation developing into a progressively more open parkland, similar to the "oak openings" familiar to midwestern plant ecologists.

Degradation of the peat is taking place at present. Cultivation and fire have oxidized and burned the surface materials extensively. There is little to indicate the time at which peat accumulation may have ceased, but on the evidence of increasing aridity cited above, it is not unreasonable to infer that the pollen spectra shown above 26 in. may indicate the Xerothermic Interval described by Sears (1942) and observed as extensions of the Prairie Peninsula by Transeau (1935). If this were the case, the surface materials at the Wells Mastodon Site may be 3000 to 5000 years old. The lack of European weeds at the surface, together with charcoal and strongly oxidized peat and pollen grains supports this inference. There is little doubt that the section is truncated at the top, certainly by human activity, and possibly as a result of climatic change in late postglacial time.

RELATION OF THE MASTODON BURIAL TO THE POLLEN SEQUENCE

The pollen recovered from sediment units 1 and 3 are sufficiently distinct to preclude the possibility that the mastodon punched through the peat and into the marl. The restriction of ***Juniperus*** (Cedar), ***Juglans*** (Walnut), ***Tilia*** (Basswood, ***Ulmus*** (Elm), and especially Chenopod-Amaranth pollen to the peat (unit 3) supports this conclusion. Virtually none of the non-arboreal pollen types shown in Table I as belonging to unit 3 were found in unit 1. The high values of oak pollen in the marl (unit 1), which could be due to mixing if the animal punched some of the peat into the marl, may be more simply explained by long-distance transport. Similar values of oak may be found in the Sunbeam-Prairie profile (Kapp and Gooding, 1964), and in unpublished pollen data from central Ohio by Ogden.

There is nothing in the pollen data to contradict the conclusion that the animal became mired in the marl, which he undoubtedly stirred to some extent in his death struggles, before deposition of peat.

AGE OF WELLS MASTODON

Although the pollen data indicate possible disturbance of the marl by the mastodon in his death struggle, the radiocarbon-dated wood sample (I–586, 12,000 ±450), found below the skeleton was probably deposited before the animal

TABLE 1 *Non-arboreal pollen, aquatic plant pollen, spores and algal remains identified from Wells Mastodon Site. Percentages shown are based on total pollen exclusive of aquatic plant pollen, spores, and algae*

Depth inches	Sediment unit	Caryophyllaceae	Cruciferae	Dryas-type	Impatiens sp.	Labiatae	Liliaceae	Linnaea cfr. borealis	Potentilla cfr. palustris	Ranunculaceae	Rhus spp.	Rosaceae	Sambucus spp.	Saxifragaceae	Thalictrum spp.	Viburnum spp.	Vitis spp.	Potamogeton spp.	Nuphar spp.	Nymphaea spp.	Typha spp.	Dryopteris spp.	Osmunda spp.	Misc. Ferns	Isoetes spp.	Lycopodium	Bryophyta	Botryococcus	Pediastrum	Dinoflagellates
2			.5																											
6															1.3									1.9						
8												5.8							2.9					1.9						
10		.8				1.6	2.4			.8		6.5	.8								.8			.8						
12																								2.0		3.3				
14	UNIT 3—PEAT																													
16							1.6				.8	1.6						.8	.8		.8		1.6				11.1			
18																														
20			1.5			.5	.5				1.0	3.0		.5	.5		1.0		1.0		.5									1.0
22		.7																	2.2						5.1	1.5				
24															1.5				.8	2.3										
26										.5		1.1							.5		.5			.5				.5		
28															.8					.8						1.5				
30										.9		1.8							.9		.9	1.8						1.8		
34											.6	1.8							.6		.6							.6		
36																								2		2				
40										1.4														1.4	1.4					
42	UNIT 2—SAND														1.7					1.7				1.7						
44																								4						
46									.7						1.4													2.1	1.4	
48					1.8					1.8		1.8												3.6				3.6		
50																				1.1				3.3						
52																														
54																												4		
58			.4								.4				.9						1.3			.9						
60																		2.1										4		
62																					1.5			1.5						
64																								2.4						
66																			.6		.6			1.7	.6					
70										.5		1.5									2.2	.5				.5		.5	.5	
72	UNIT 1—MARL																							1.7	1.7					
76																					2.3			1.1						
80																					4.4			1.1		1.1		.7	.7	
82																								1.3						
84																							3	3						

SPECIES / LEVEL	Acella haldemani	Amnicola gelida	Amnicola leightoni	Ferrissia sp.	Fossaria obrussa decampi	Goniobasis livescens	Gyraulus altissimus	Helisoma anceps striatum	Pleurocera sp.	Promenetus exacuous	Pyrgulopsis letsoni	Valvata lewisi helicoidea	Valvata sincera	Valvata tricarinata	TOTAL	REMARKS
48-52"	1	--	--	2	2	--	81	1	5	--	--	--	14	179	285	Sphaeriidae are common, as are ostracodes, also abundant seeds, general dearth of fossils
52-56"	1	95	6	11	14	--	216	6	12	1	12	--	67	310	744	Sphaeriids common, seeds and ostracodes also fairly common, fossils abound
56-60"	7	273	18	2	11	--	241	11	5	--	3	--	48	383	1002	Sphaeriid mussels common, ostracodes and seeds, probably of water plants
60-64"	2	374	15	--	6	2	112	20	10	1	7	1	27	173	850	Sphaeriids less common than above, seeds and ostracodes are quite common

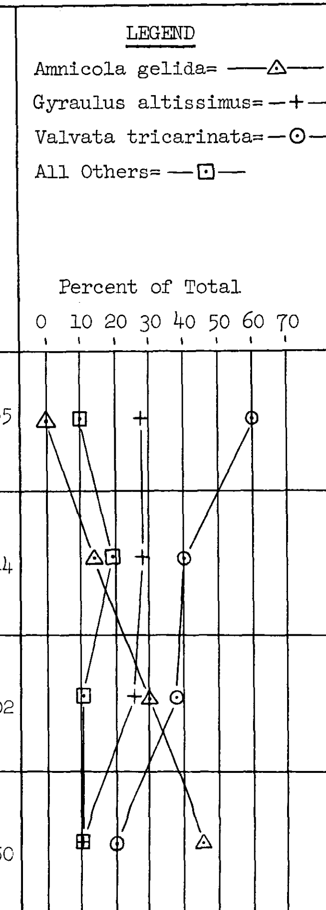

FIGURE 5. Stratigraphic distribution of mollusks in marl unit 1 at the Wells Mastodon Site.

met death. As has been discussed, the stratigraphic and pollen data indicate also that the animal met death before completion of marl deposition. It has been suggested also that the rapid climatic change recorded by the quick transition upward from coniferous to deciduous pollen in the top of the sand unit 2 and the bottom of the peat unit 3 is the same climatic change recorded in numerous other mid-western postglacial pollen profiles. Several radiocarbon dates across this pollen profile horizon place the time of the climatic change at about 11,000 radiocarbon years B.P. (Kapp and Gooding, 1964; Ogden, in press). Thus, it is concluded that the Wells Mastodon met death after 12,000 and before 11,000 radiocarbon years B.P., probably nearer the latter date.

MOLLUSCAN DATA

Unfortunately, the marl (unit 1) was not sampled completely for mollusks. Approximately ½- to ¾-quart grab samples were taken in 4-in. zones in only the top 16 in. of the marl deposit. The faunal assemblages in these samples were found to add interesting information to the stratigraphic and pollen data, however, and are presented here briefly to show the value of complementary pollen and molluscan studies in marl deposits.

The upper sixteen inches of the marl (unit 1) yielded fourteen species of gastropods (figure 5), all of which occur in aquatic habitats. Three species (*Amnicola gelida*, *Gyraulus altissimus*, and *Valvata tricarinata*) comprise nearly ninety per cent of the total gastropod fauna. Little information is available concerning the ecological implications of *A. gelida*, but it occurs in late glacial lacustrine marl deposits in Ohio (Baker, 1920: 440), and is believed to be closely related to *A. oneida*, which is abundant today in quiet waters of the upper Great Lakes region at depths between 5 and 10 ft (Baker, 1928: 112). *G. altissimus*, an extinct Pleistocene form (Baker, 1928: 383), inhabited the shallower portions of small quiet lakes and ponds, while *V. tricarinata* is found on all varieties of bottoms and at all depths down to 18 ft (Reynolds, 1959: 160). It may be inferred, therefore, that the upper sixteen inches of the marl (unit 1) were deposited in quiet, cool to cold, waters of a small lake or pond. This general climatic interpretation agrees well with that indicated by the pollen data for this portion of the marl (unit 1) (figure 4).

There is, in addition, a significant change in the relative abundance of *A. gelida* and *V. tricarinata* upward through the sampled zones (figure 5). In the lowest sampled zone (60 to 64 in.), *A. gelida* comprises 44 per cent of the gastropod fauna, while not a single specimen was identified in the upper-most zone (48 to 52 in.). An increase in the relative abundance of *V. tricarinata*, from 20 per cent in the lower zone to 63 per cent in the top zone, apparently coincides with the decrease upward in the population of *A. gelida*. A change in the environment must account for these changes in populations. The cessation of marl deposition at 46 in., and the abrupt decrease of spruce (*Picea*) in the pollen record at 50 in. (figure 4), indicate that the environmental change was of considerable magnitude. Perhaps a shoaling of the water, prior to the filling of the lake by the overlying sand (unit 2), accounts for the disappearance of *A. gelida* from the record. Such a decrease in water depth would not have had a great affect on the populations of *G. altissimus* and *V. tricarinata*. As *A. gelida* is common only in Pleistocene deposits, while *V. tricarinata* abounds today in temperate climatic zones (Baker, 1928: 14), it is possible that the population change is related also to the warming trend in the area as recorded by the abrupt decrease in spruce (*Picea*) in the upper part of the marl (figure 4).

TIME OF DUNE FORMATION

It has been noted that the stratigraphic evidence at the Wells Mastodon Site suggests that aeolian activity in the area was mainly restricted to the time of deposition of the sand (unit 2). The pollen data in unit 2 (figure 4) record a rapid climatic change which is judged to be the same as that dated elsewhere in Indiana and Ohio at about 11,000 radiocarbon years B.P. It would appear from these data that the sand dunes in the vicinity of the site have been dormant since that time.

ACKNOWLEDGMENT

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