OPALINE MICROFOSSILS IN SOME MICHIGAN SOILS[1]

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Identification of the type and amount of microfossils in soils provides a unique manner in which information can be gained concerning the history of soil development and type of parent material. Besides graminous opal phytoliths, we have discovered a rather rich aquatic flora and fauna in surface horizons of several Michigan soils. Interpretation of these findings gives better insight into the nature of parent materials in this region.

SOILS STUDIED

Samples of the surface and parent material horizons of seven soil types were selected for study from ten widely distributed locations in both the Podzol and Gray Brown Podzolic regions of Michigan. The soils vary in drainage, texture, vegetative type, and physiography. Site numbers and locations are shown on the map in figure 1. Chemical, physical and mineralogical data on the soils are presented elsewhere in the literature (Bailey et al., 1957). Some properties of these soils pertinent to the study reported here are summarized in table 1.

TABLE 1
Some characteristics of soils studied

Soil type	Sampling site no.	Natural surface drainage	Natural vegetation	Physiography
Miami loam	17	good	northern deciduous forest	till plain
Kalamazoo loam	15	good	northern deciduous forest	outwash plain
Kalamazoo sandy loam	10	good	northern deciduous forest	outwash plain
Volinia silt loam	11	good	grassland	outwash plain
Volinia loam	14	good	grassland	outwash plain
Granby loamy sand	2	poor	deciduous forest, wetland species	glacio-fluvial drainageway
Granby loamy sand	18	poor	deciduous forest, wetland species	sandy glacial lake bed
Ontonagon silty clay	37	good	northern deciduous forest	clayey glacial lake bed
Pickford silty clay loam	36	poor	evergreen and deciduous forest, wetland species	clayey glacial lake bed
Sims loam	6	poor	deciduous forest, wetland species	glacial lake plain

Origin of Parent Materials

The Volinia and Kalamazoo soils in this study have formed in stratified outwash materials in well-drained positions on the outwash plains drained by the St. Joseph and the Kalamazoo rivers. The Kalamazoo loam (site 10) and Volinia silt loam (site 11) are in the Kalamazoo River drainage basin adjacent to the part of the valley ponded while the Michigan ice lobe was building the Valparaiso moraine

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during Pleistocene time. Granby (site 2) is in a sandy glacio-fluvial deposit in a ponded area behind the Lansing moraine not more than 10 ft above the Red Cedar River and is poorly drained. Granby (site 18) in Ottawa County is in a sandy lacustrine deposit on the Glenwood lake plain midway between the Glen-

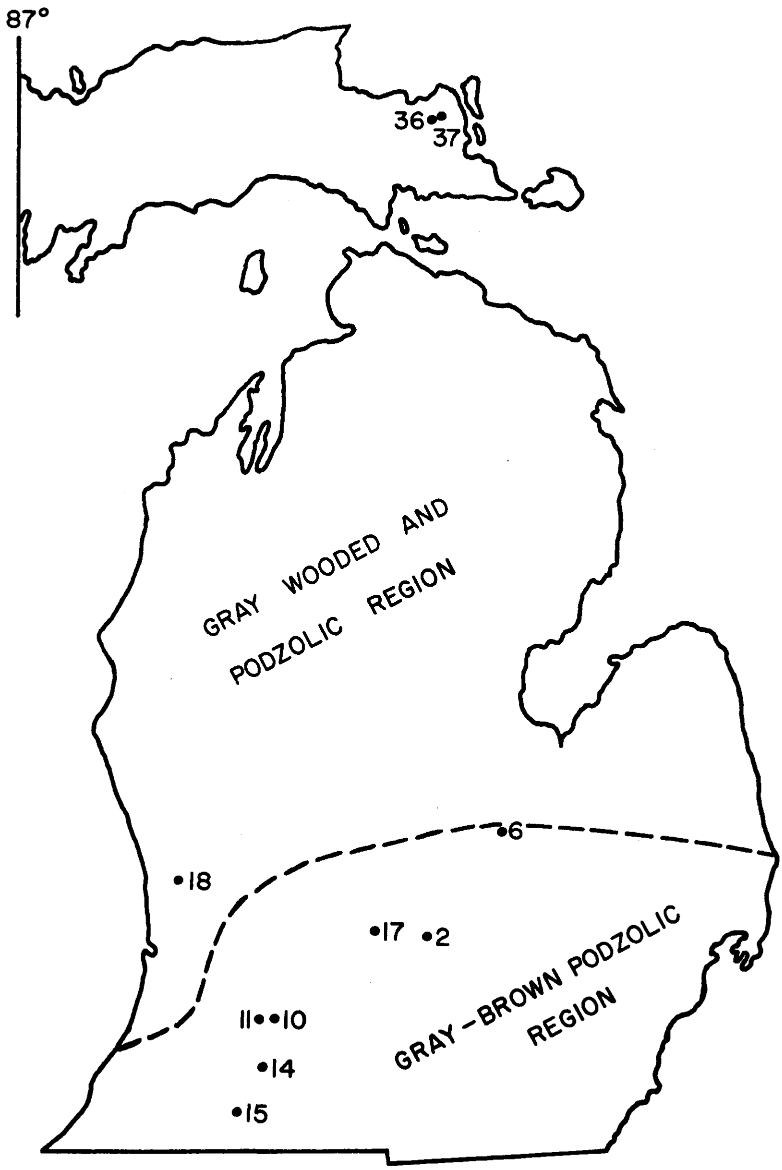

FIGURE 1. Location of sampling sites.

wood and Calumet beach lines in a large area indicated as Newton loamy fine sand (Veatch, 1926). It is at the head of the Pigeon River drainage way. Miami (site 17) is located on the medium textured till plain in front of the Grand Ledge

Moraine in a well drained position west of Grand Ledge in Eaton County. Sims clay loam (site 6) is on the Arkona lake plain in moderately fine textured glacial till about 1.5 miles south of the Arkona II beach line in a level, poorly drained area in Shiawassee County. The area is drained by the Shiawassee River. The Ontonagon and Pickford (sites 36, 37) soils are formed in a fine textured lacustrine deposit on the Algonquin lake plain about 9 miles south of Sault Ste. Marie and 2 miles east of Dafter in Chippewa County. The present elevations of the Chippewa County sites are between 645 and 650 ft. A.T.

Age of Parent Materials

According to Hough (1958), post-Pleistocene uplift of Lake Algonquin beaches amounts to 410 ft at a point 6 miles north of Sault Ste. Marie in Ontario and about 200 ft at Mackinac Island. Thus, in 56 miles, there has been a differential in the rate of uplift of about 4 ft per mile since the Algonquin beaches were formed. Therefore, at Dafter, the land surface must now be some 350 ft higher than it was during Algonquin time and with glacial lake Algonquin at 605 ft A.T., the Ontonagon and Pickford sites must have been under about 300 ft of water. As uplift progressed through the various lake stages the water depth probably decreased gradually until Lake Nipissing time. Sometime before Nipissing time the sites finally emerged above water permanently. The Ontonagon site is close beside a modern drainage way and is more sloping than the Pickford site. Therefore it has probably been better drained than the Pickford site since before Lake Nipissing time. By the radiocarbon method emergence of these sites occurred some 3500 years ago (Hough, 1958).

The parent materials of the Granby soil (site 18) in Ottawa County were probably deposited during Lake Glenwood time from sandy material deposited in the lake by the Grand River, with some wind deposition after the water receded to the Lake Calumet stage. The site finally emerged permanently above water at the close of the Glenwood Stage which occurred between 10,000 and 11,000 years ago (Hough, 1958). Since there is about 20 ft difference in elevation between Lake Glenwood beaches and beaches of the following Calumet Stage, the Granby site was probably never under more than 20 ft of water. The area is nearly level, and the water table is high; the site is now poorly drained. Granby (site 2) and Miami (site 17) parent materials were deposited during middle Cary time when the Grand Ledge moraine was being formed. The Sims (site 6) location was under water less than 15 ft deep during early Arkona time and emerged at the end of Arkona I but before Arkona II in late Cary time. According to Hough (1958) this occurred about 14,000 years ago.

The Kalamazoo and Volinia sites (10, 11, 14, 15) are the oldest of the sites studied and are of early Cary age. They were not inundated by waters of the recent Great Lakes.

ANALYTICAL TECHNIQUE

The microfossils were identified microscopically in permanent slide preparations made from less than 2.30 sp gr separates of 2 to 20 μ and 20 to 50 μ size fractions, which were obtained in the usual manner by repeated decantation from oxidized and dispersed total soil samples. A quantitative estimate (table 2) of the amount of less than 2.30 sp gr material in the 20 to 50 μ fraction was obtained by weighing this and the greater than 2.30 sp gr fraction. An indication of the total amount of opal in the soil was obtained by multiplying the percent of opal in the 20 to 50 μ fraction by the amount of 20 to 50 μ material in the soil. As pointed out by Jones and Beavers (1964) this figure represents about one-third of the total opal present in the soil. A detailed discussion of the specific gravity separation used is given by Jones and Beavers (1963).

RESULTS AND DISCUSSION

Gramineae

Opal phytoliths in the coarse-silt fraction are represented principally by opal infillings of graminous bulliform, fundamental, and trichome cells. Fundamental, trichome, and nodulated cells from the costal area of the leaf are found in the fine-silt fraction. Color ranges from flesh color to black (opaque) by transmitted light and hyaline to porcelain (opaque opal bodies) by reflected light. Surfaces of the particles are pitted and etched.

The data for opal (table 2) in the soils studied clearly reflect the influence of vegetation. Opal content of the Brunizem, Volinia, is from 3 to 10 times that of the other soils. With the exception of the Pickford, opal content of the Humic-Gley soils is very low—much lower than the values reported by Jones and Beavers (1964) for Humic-Gley soils in Illinois. This dearth of opal probably reflects

TABLE 2

Opal content of the coarse-silt fraction of surface horizons

Soil series	Site no.	Horizon	Depth in.	20 to 50 μ fraction Mechanical analysis[1] %	20 to 50 μ fraction Opal %	Total soil opal %
Granby	2	A_p	0–9	2.8	1.68	0.05
Granby	18	A_p	0–8	4.2	1.21	0.05
Kalamazoo	10	A_p	0–8	14.0	1.13	0.16
Kalamazoo	15	A_p	0–11	13.4	1.44	0.19
Miami	17	A_p	0–8	15.7	0.26	0.04
Ontonagon	37	A_p	0–5	14.2	0.58	0.08
Pickford	36	A_p	0–8	26.8	0.60	0.16
Sims	6	A_p	0–7	13.5	0.50	0.06
Volinia	11	A_p	0–8	19.2	2.43	0.47
Volinia	14	A_1	0–11	15.0	3.60	0.54

[1]By pipettte analysis by Dr. A. E. Erickson et al., Soil Science Dept., Mich. State University.

persistent low grass productivity associated with frequent ponding and also the dominance of water-tolerant forest plants found at these sites. Among the other soils, the two Kalamazoo samples, which were sampled within 25 miles of each other, have essentially the same amount of opal which indicates a similar vegetative history. The amount of opal in these Gray-Brown Podzolic soils is about half that reported by Jones (1962) for Gray-Brown Podzolic soils in northeastern Illinois. The Gray-Brown Podzolic soil Miami and the Gray Wooded soil Ontonagon have similar amounts of opal and much less opal than the Kalamazoo soils; in fact, concentration of opal in these soils approaches that in the Humic-Gley soils.

Absolute age of the landscape has a direct influence on amount of opal in the soil. Jones and Beavers (1964) considered about 5,000 years of grass growth was necessary to account for opal concentrations found in Illinois soils. Among the Michigan soils studied, age would be a factor in rationalizing opal contents of the Sims, Pickford, Ontonagon, and Granby (site 18) soils because of the relationships of these soils to areas inundated by recent stages of the Great Lakes. This problem is not solved here, but the study of both amount and type of opaline fossils in soils developed in sediments of these lakes might prove to be a valuable geologic correlation tool.

Data from the Michigan soils do indicate the usefulness of opaline phytoliths as an indicator of the prominence of grass or grass production in the ecosystem.

Spongillidae

The occurrence and relative abundance of sponge spicules in these soils is given in table 3. Spicules occur mostly as fragmented oxeas in the coarse-silt fraction. In the fine-silt fraction oxeas, amphidiscs, and rare sphaerasters occur. Rare minute, smooth-textured spheres attributed to the Spongillidae are also present in the less than 20 μ fractions. Certainly in the soils where they are found in abundance, the spicules are indicative of an aquatic habitat favorable for sponge growth, a habitat probably not greatly different from that which currently supports a rich sponge fauna in Michigan waters (Old, 1932). In their dispersed

TABLE 3

Opaline microfossils, other than phytoliths, of the 2 to 20 μ fraction

	Sampling Site Numbers									
	2	18	10	15	17	36	37	6	11	14
Spongillidae	a	a	d	d	d	c	a	—	d	d
Chrysostomataceae	b	a	—	—	e	b	d	e	e	d
Carnegia	1	1	—	—	1	1	1	1	—	—
Chrysostomum	1	1	—	—	1	1	1	1	1	—
Clericia	2	2	—	—	—	1	1	—	1	1
Outesia	3	3	—	—	—	3	3	—	—	—
Bacilliarophyceae	d	c	—	—	e	a	d	—	—	e

Key: a, very abundant, 20 to 30 pph[1]; b, abundant, 10 to 20 pph; c, rare, 5 to 10 pph; d, very rare, 1 to 5 pph; e, trace, 1 pp 500. 1, 2, and 3 order of decreasing abundance. *Carengia* includes *Lithensphaerella*.

[1]Particles per hundred opal particles.

form spicules have little taxonomic value and therefore unequivocal identification of the fauna represented in these samples is not possible although the types of amphidiscs and sphaerasters suggest that *Spongilla fragilis* was important. This is a common species now found in Michigan. The C horizons of these soils do not contain spicules which suggests a favorable change in habitat, possibly in the waning stages of the Great Lakes, with respect to sponge growth.

We favor an aeolian origin to explain their presence in surface soils where spicules are rare (table 3). That is, the spicules were blown from spicule-bearing deposits or sediments. This interpretation was invoked by Jones and Beavers (1963) to explain similar spicule occurrences in Illinois.

Chrysostomataceae

Opaline shells of Chrysostomataceae occur in different amounts (table 3). Representatives of the genera *Carnegia*, *Chrysostomum*, *Clericia*, *Lithensphaerella* and *Outesia* were identified (fig. 2). In the Pickford, Ontonagon, and Granby (site 18) soils the occurrence of Chrysostomataceae is either associated with waters of the late stages of the Great Lakes or with very recent ponded water. At Granby site 2, Chrysostomataceae are associated with recent ponded waters. In the Volinia, Sims, and Miami soils these tests were probably derived in the same manner as the sponge spicules—that is, blown from fresh-water sediments. Firtion (1944) reports a similar occurrence of fresh-water sponges and Chrysostomataceae in a lignite in the region of Lac Chambon, France.

Bacilliarophyceae

Broken and whole valves of diatoms occur in some of the soils. They are particularly abundant in the Granby (site 18) and Pickford soils where they are associated with abundant Chrysostomataceae. These forms suggest a rich planktonic fauna and flora in these waters. Occurrences in the Volinia and Miami profiles are explained by aeolian transport.

Opal Content of Parent Materials (C horizon)

To assess the distribution of microfossils in deep horizons, the total sample (not size fractionated or oxidized) was separated on 2.30 sp gr liquid for all soils except Ontonagon. Except for rare phytoliths and organic blebs which were probably derived from roots, opaline microfossils do not occur in the parent materials of these soils. In the instances of soils developed in stratified deposits,

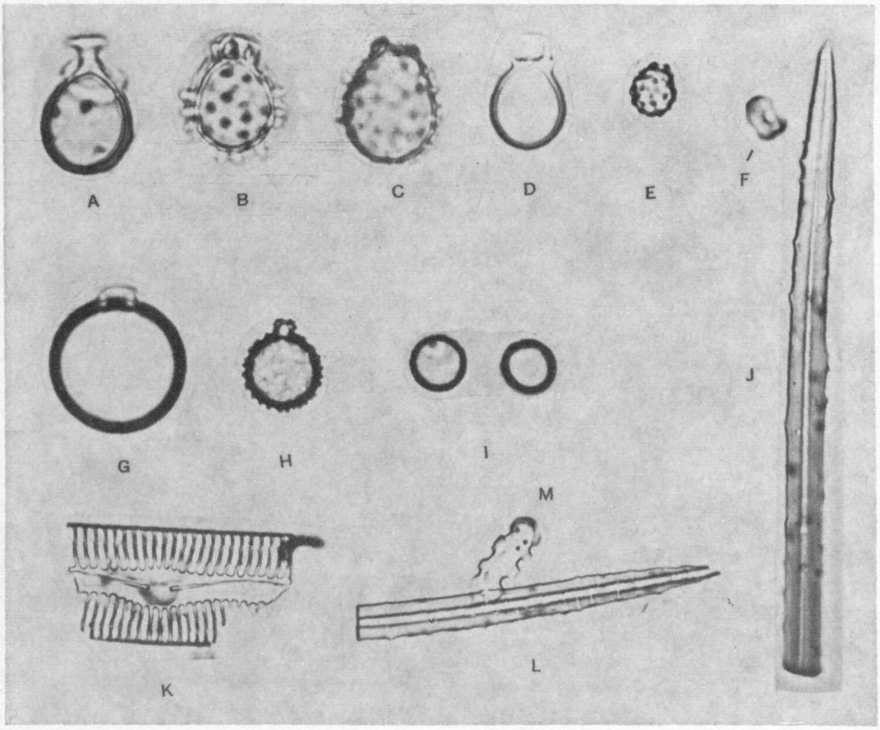

FIGURE 2. Microfossils separated from Granby site 18. A, C, D—*Carnegia* sp.; *Lithensphaerella* sp.; E—*Outesia* sp.; F—phytolith (silica cell); G, H—*Clericia* sp., I—*Chrysostomum* sp.; J—sponge spicule (megasclere); K—diatom; L—sponge spicule (megasclere); M—phytolith (short cell). Chrysostomataceae ×1100, Other ×600.

particularly Ontonagon, Pickford, and Granby (18), this implies marked changes in conditions for growth of phyto- and zooplankton and sponges. The rare occurrence of spicules in surface horizons of certain soils is an indication of recent aeolian contribution to most, if not all, of the soils.

SUMMARY

A survey of organogenic opal in seven Michigan soils revealed the presence of shells of Chrysostomataceae, valves of diatoms, and sponge spicules in addition to phytoliths. The phytoliths prove useful as indicators of the extent of grass occupation of the site. Sponge spicules, diatoms, and Chrysostomataceae are

useful in interpreting changes in ecology and establishment of a rich plankton association in standing water at the site. In some cases opaline microfossils in soils are best accounted for by invoking aeolian transport.

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