MICHIGAN ACADEMY OF SCIENCE, ARTS AND LETTERS

VOLUME XV

CONTAINING PAPERS SUBMITTED AT THE ANNUAL MEETING IN 1931

(*This volume contains papers in Botany, Forestry and Zoölogy only. Volume XVI will contain papers in Anthropology, Geography, Geology and Mineralogy, History and Political Science, Language and Literature, Psychology, and Sanitary and Medical Science.)*

The annual volume of Papers of the Michigan Academy of Science, Arts and Letters is issued under the joint direction of the Council of the Academy and of the Executive Board of the Graduate School of the University of Michigan. The editor for the Academy is Peter Okkelberg; for the University, Eugene S. McCartney.

Previous publications of The Michigan Academy of Science now known as The Michigan Academy of Science, Arts and Letters, were issued under the title, Annual Report of the Michigan Academy of Science. Twenty-two volumes were published, of which those numbered 1, 21 and 22 are out of print. Copies of the other volumes are still available for distribution and will be sent on exchange so long as the editions last. Applications for copies should be addressed to the Librarian of the University of Michigan.

Annual Reports embracing the proceedings of the Academy will however, continue to be published. Applications for copies should be addressed to the Librarian of the University of Michigan.

The prices of previous volumes of the Papers and of other University of Michigan publications are listed at the end of this volume.

Volumes may be ordered by addressing the Librarian of the University of Michigan.

PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS

EUGENE S. McCARTNEY
UNIVERSITY OF MICHIGAN

PETER OKKELBERG
UNIVERSITY OF MICHIGAN

VOLUME XV

"Pusilla res mundus est nisi in illo quod quaerat omnis mundus habeat."
—SENECA, *Naturales Quaestiones*

Ann Arbor

UNIVERSITY OF MICHIGAN PRESS
1932

Set up and printed,
February, 1932
Published, March, 1932

PRINTED IN THE UNITED STATES OF AMERICA
BY THE PLIMPTON PRESS · NORWOOD · MASS.

OFFICERS FOR 1931

CONTENTS

BOTANY

FORESTRY

ILLUSTRATIONS

PLATES

MAPS

MICROFOSSILS FROM GREENLAND COAL*

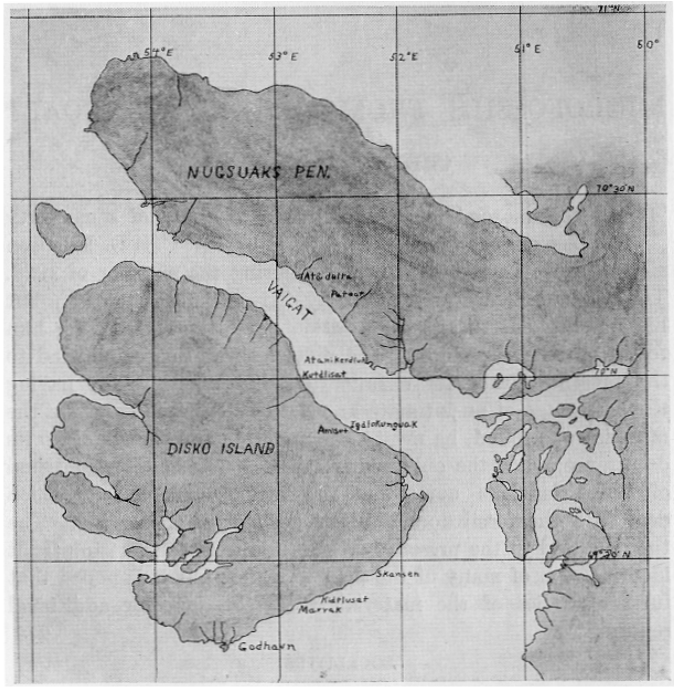
CHESTER A. ARNOLD

THIS account embodies the result of a study of some forty samples of coal which were secured by Mr. Carl O. Erlanson along the west coast of Greenland during the summer of 1928. The investigation was started by Mr. Erlanson himself, but his appointment to another position made it necessary for him to discontinue the study. The material was then submitted to the present author for examination and report. Not having the advantage of an intimate knowledge of the places where the material was found, he must omit many details pertaining to its occurrence, since the only sources of such information consisted of Mr. Erlanson's notes and the various publications which deal with the fossil flora and the geology of the region. The time allotted to the present investigation was too short to permit identification of many of the plant remains, but it is hoped that further studies of the material will yield data for additional reports.

LOCALITIES

The collections were made along the southeast coast of the Nugsuaks Peninsula and along the eastern coast of Disko Island, which is separated from the peninsula by the Vaigat. The localities ranged from the Atâ Delta on the Nugsuaks Peninsula at approximately 70 degrees 15 minutes north to Marrak on the southeast coast of Disko Island, which is approximately at 69 degrees 20 minutes north latitude (Map 1).

Some forty samples were collected at ten different localities. The data for each collection, as taken from Mr. Erlanson's notes, are given below.



MAP 1. Nugsuaks Peninsula and Disko Island, west coast of Greenland, showing localities where coal was collected. Modified from a Danish government map, Copenhagen, 1888. Scale 1:750,000

1. South coast of the Nugsuaks Peninsula

1. *Atâ Delta*. — A, one mile southeast of the delta at altitude of 250 meters, sandstone above and below; B, same as for A, but at 150 meters, sandstone above and below; C, two miles southeast of delta, at 168 meters, sandstone above and below (3 collections); D, northwest side of delta at 70 meters.

2. *Patoot*. —A, at altitude of 85 meters; B, at 165 meters (2 collections); C, between 200 and 300 meters; D, at 255 meters; E, at 350 meters; F, at 380 meters.

3. *Atanikerdluk*. — A, just south of the peninsula near tide level (Steenstrup's station No. 4[1]); B, at outer extremity of peninsula at tide level (Steenstrup's station No. 1[1]).

2. East coast of Disko Island

4. *Kutdlisat*. — At mine, at altitude of 20 meters.

5. *Igdlokunguak*. — One collection between here and Amisut, along stream at altitude of 30 meters.

6. *Amisut*. — A, at sea level (2 collections); B, at altitude of 1 meter; C, at 6 meters; D, north side at 10 meters; E, another collection with no data.

7. *Skansen*. — A, two miles inland at altitude of 140 meters; B, same as for A, but at 385 meters; C, same as for A, but at 420 meters; D, one and one-half miles west and one and one-half miles inland, at 70 meters; E, same as for D, but at 150 meters; F, one mile inland, at 175 meters; G, 400 meters inland, at 8 meters; H, one-half mile east, at 5 meters; I, one-quarter mile west in stream bed; J, another collection at 270 meters, but no additional data.

8. *Kidtlusat*. — One collection at altitude of 90 meters.

9. *Marrak*. — One collection at altitude of 3 meters.

10. *Evinasugsuit*. — One collection; altitude not given. This station is between Skansen and Godhavn, but the exact location is not given.

THE COAL-BEARING FORMATIONS

The geological age of the coal under consideration is upper Cretaceous and Tertiary. Oswald Heer's studies of the fossil plants of Greenland led him to recognize four floras, namely: the Kome, or lower Cretaceous, the Atâne and the Patoot of the upper Cretaceous, and the Tertiary, which he considered to be Miocene.[2] Other geologists have expressed the opinion that the Tertiary flora is Eocene instead of Miocene, and Seward,[3] the most recent paleobotanist to examine the rocks of west Greenland, believes that further subdivisions of the flora should be made. Since Mr. Erlanson made no collections in the Kome series it will not be considered further in this account.

The Atâne flora is the most widespread and it is probable that the majority of the coal collections belong to this. The Patoot flora is higher than the Atâne and is known at the place called Patoot. At this place it commences at about the 500-foot level and goes upward to 2,000 feet. Therefore, all the collections made at Patoot, with the exception of the lowest one at 85 meters, belong to the Patoot series.

In general the Tertiary beds are at a high level.[4] At Atanikerdluk they appear between 1,100 and 1,200 feet above sea level and continue upward for about 2,000 feet more. At Patoot the Cretaceous beds go up to 2,600 feet, where they are overlain by the Tertiary. At Atâ the Tertiary beds extend from 2,180 to 3,180 feet above tide. At no place, then, on the Nugsuaks Peninsula were any of the collections taken from a level high enough to be included in the Tertiary.

At many places on Disko Island the Cretaceous-Tertiary boundary has not been determined. At Skansen Seward examined Cretaceous strata as high up as 1,900 feet. Since the highest collection made at this place was approximately at 1,800 feet, it is altogether improbable that any of the material from Skansen is Tertiary. At the other localities on Disko Island there appears to be no record of the lower limit of the Tertiary, but since all the collections were made at low levels their Cretaceous age is probable.

The greater part of the coal-bearing formation of this part of Greenland consists of loose sand or soft to hard sandstone. Almost anywhere throughout this sand formation where large portions are exposed there are layers of coal varying in thickness from very thin layers to beds three or four feet thick. Above and below the coal there is usually a layer of shale, but occasionally the shale is on one side only, with the sandstone on the other, or, in other places, there may be sandstone on both sides, the shale not being present. Besides the coal carbonized tree trunks are often found lying horizontal and parallel to the sand layers, but sometimes they stand upright, as they grew.[5]

The thickness of the coal formation is difficult to determine, since the entire horizon is rarely exposed. At only one place (Sarkak, which is southeast of Atanikerdluk) can the lower limit be seen lying on the basal gneiss. At other places it dips below the sea or rests upon basalt intrusions. The upper limit varies from sea level to 2,000 feet. Most of the layers lie horizontal, but in some there is a dip of 10 to 15 degrees, and, rarely, as much as 40 degrees. The direction of the dip varies according to local disturbances.

Coal has been known in Greenland as long as Greenland itself has been known. Mention is made of it in an anonymous Norse description. Apparently, it was not used extensively by the early colonies and it was not until 1782, when the first inspector of north Greenland came to the land, that coal was mined in such quantities that none had to be brought from Denmark. It has never been an important product of the country, although at times it has been used by ships within the region. Besides being exceedingly soft and friable, the seams are often situated high up along the steep cliffs, where mining operations are difficult.

DESCRIPTION OF THE COAL

The unmacerated lumps have been kept in the laboratory for about two years, where they have become thoroughly air-dried. Considerable cracking has occurred, which reveals the structure of the coal quite clearly. The different samples vary somewhat in hardness, but most of them, after drying, are quite friable, so that a lump of it may easily be crushed in the hand.

The cracking which results from the drying of the lumps is usually irregular, like that of drying mud (Pl. I, Fig. 1). In some of the harder lumps there is a tendency toward a cubic cleavage such as develops in coals of higher grade (Pl. II, Fig. 1). However, this is not so common as the irregular splitting, and the specimens having a decided pitchy luster often show a crude conchoidal fracture (Pl. I, Fig. 2). Also there is a pronounced tendency for the material to split into plates parallel with the bedding planes (Pl. II, Fig. 2).

Some of the specimens show banding (Pl. III, Fig. 1), but in others the structure is quite homogeneous. In the former the layers can be identified as the “anthraxylon " and the "attritus" constituents, terms which have been coined to designate respectively the bright bands and the dull bands in American coals.[6]

The predominating color of the coal is black; only an occasional specimen shows any brown. One collection, which is highly calcareous and effervesces violently when treated with acid, has a grayish color. Occasional color displays characteristic of the so-called "peacock" coal can be observed on a few small bits.

In view of the black color and the irregular fracture shown by the coal under consideration, it seems that the term "sub-bituminous" is more appropriate than "lignite," which is the descriptive term generally applied to the soft coals from the west coast of Greenland. "Lignite" refers to the material which the Germans designate as *Braunkohle* ("brown coal"). This is a descriptive term based on its brown color, but the term has also been used for any coal which is below bituminous rank, but which is black and has an irregular fracture.[7] With respect to these characters much of the material at hand appears almost identical with a lump of subbituminous coal from the Philippines, which is figured by Campbell.[8] It is believed that this designation, and not "lignite," should be applied to the Greenland coal also.

THE PLANT REMAINS

The coal was macerated by soaking the lumps in dilute nitric acid. Some of it required about three months, but for other specimens more than a year was necessary. After the material had become soft it was treated with a dilute caustic solution until disintegration was complete. The plant fragments were then removed with fine forceps and mounted in glycerin jelly. This method, though slow, was not destructive to even the most delicate plant fragments.

A. Fragments of leaf tissue

Leaf fragments are the most common type of plant remains and were found in all the samples studied except a few which appear to consist entirely of carbonized wood or in which the coalification process had proceeded so far as to obliterate entirely all plant structures. It is probable that in the latter specimens decay was well advanced before coalification took place.

All the fragments were small, rarely being more than two millimeters in diameter. The preservation varies. Some of the more delicate ones show little or none of the original cell detail, but others are preserved with such perfection that they reveal structure as clearly as living material. The greater number of the well-preserved fragments are made up of cells with comparatively thick walls and suggestive of remains of leaves which were somewhat resistant to decay. Some of the more decayed ones were covered with hyphae, thus indicating that decay had gone on for some time before the material was buried to any great depth.

Considerable variety of vegetation is present. Most of the fragments resemble those of woody dicotyledons which grew in or near the original coal-forming swamp. Monocotyledons are indicated by epidermal fragments with cells arranged like those of the lily. Gymnosperms are indicated by fragments on which the stomata are arranged in parallel strips which are separated by spaces free from stomata (Pl. IV, Fig. 10). Besides these, there are numerous fragments with papillate guard cells, such as are observed in several genera of gymnosperms. Stomata very similar in structure and arrangement to those of *Sequoia sempervirens* were observed in one specimen.

Leaf remains of the lower forms of vegetation are not so abundant. In the material from Patoot, however, in the collections made at altitudes of 85 and 165 meters, the plant remains consist largely of light-colored fragments made up of rather rectangular cells, among which there are no stomata. A few remains of moss are recognized, but whether these very abundant fragments are remains of swamp-inhabiting mosses or other aquatic vegetation has not been ascertained. The only remains of moss definitely recognized are a few fragments of Sphagnum (Pl. IV, Fig. 9).

B. Spores and pollen grains

Objects distinguishable as pollen grains are rare in the Greenland coal. Spores, presumably pteridophytic, are more common and show considerable diversity of form. Material taken two miles inland from Skansen, at an altitude of 140 meters, contains several types. The largest are slightly in excess of one millimeter in diameter and are dark brown or black; the exine is deeply folded, so that the spore is covered with a network of irregular diaphanous appendages (Pl. III, Fig. 2). Since these spores are very opaque, it is difficult to identify the triradiate markings. On other smaller spores, which measure approximately 450 X 525 microns, the triradiate markings are visible if the spores are properly oriented. The appendages of these latter spores are slender flimsy structures, which are somewhat shorter, but otherwise resemble those of some species of the Paleozoic Lepidodendra. Both these types are possibly lycopodiaceous spores of some sort.

Figure 8, Plate IV, shows a spore more closely resembling that of a fern. The appendages consist merely of ridges of the exine, which are neither so deep nor so closely set as those described in the two specimens above. Its dimensions, 455 X 525 microns, are rather large for any common species of fern.

Other spores, suggestive of Isoetes, are of frequent occurrence (Pl. IV, Fig. 1). The triradiate markings are quite conspicuous and there appears to be a rim around the equatorial region. Reticulations are visible, but not conspicuous, and the entire spore is translucent.

In two specimens structures were observed which are suggestive of pollen grains rather than cryptogamic spores (Pl. IV, Fig. 3). This assumption is made solely on the basis of their shape and ornamentation. Cryptogamic spores, as a rule, are simpler.

C. Structures simulating bryophytic antheridia

Certain structures which are of uncertain identity, but which closely resemble the antheridia of the Bryophyta, are very common in certain of the collections (Pl. IV, Figs. 3-4). They are most abundant in the collections from the 140-meter level at Skansen, but they are occasionally encountered in material from other localities. When examined under the very low power of the microscope or with a hand lens, they appear as small amber-colored translucent objects, which were first thought to be seeds. A closer examination of these objects shows that they are hollow saclike structures with a wall consisting of a single layer of square or slightly rectangular cells. They are ovoid, pointed at both ends, and slightly broadest above the middle. At the apex there is a small pore which protrudes slightly and which is surrounded by a definite circle of cells. The basal portion consists of cells which appear dark under the microscope, but its exact structure is not clear.

Figure 7, Plate IV, shows a similar object, which differs in details. It is shorter and relatively broader, the pore is flush with the surface, and attachment is by a slender basal stalk. The two types probably represent different species of closely related forms.

D. Remains of fungi

Although fungous mycelium is abundant, the reproductive structures were observed with certainty in only two specimens. Hyphal knots resembling perithecia of the Perisporiales occur sparingly. Septate mycelium is common and occurs on a variety of material. Some of the epidermal fragments, which appear to be badly decayed, are covered with mycelium to such an extent that the cellular structure of the host is obscured. Such fragments probably represent material which partially decayed previous to burial. Other specimens in which there is less decay and in which the hyphae can be observed protruding through the stomata suggest a parasitic relationship.

Another object encountered in the material from the 140-meter level at Skansen is a spherical object having a diameter of about 630 microns and densely covered with short hypha-like protuberances (Pl. IV, Fig. 6). These protuberances cover the object so densely that all structural features are obscured. Among the living fungi the gleba masses of certain of the Sphaerobolaceae germinate in a manner similar to this. All the spores of the mass put out germ tubes which soon cover the structure in a manner similar to that mentioned above.

Other objects always associated with fungous mycelium are numerous small spherical bodies about 70 microns in diameter. They are situated on and slightly sunken in the surface of leaf fragments. Superficially they resemble small fungous fruiting-bodies, but closer observation shows that they consist of dark granular material surrounded by a thin membrane. Of especial interest is one which can be observed in the process of fission (Pl. IV, Fig. 5). The new cell plate extends inward from each side for about one half of the radius of the cell. These objects are suggestive of algae of the Protococcus type.

EVIDENCE PERTAINING TO CLIMATE

Were we to know the Greenland flora in its entirety it is extremely improbable that the proportion of herbs to trees would be greater than is indicated by the previous studies of the leaf impressions. It is a recognized fact that the percentage of herbs and small shrubs in a flora becomes larger as the arctic region is approached, and it is possible that this has a direct bearing on the interpretation of climatic conditions in Greenland during Cretaceous and Tertiary times. Berry[9] has recently questioned the generally accepted idea that the late Mesozoic climate was tropical. He says that the flora thrived there under conditions much more northerly than has hitherto been assumed.

Because of the ability of plants to become adapted to different environmental conditions during the process of their evolution, it follows that a fossil form should not always be relied upon when one is attempting to determine the conditions under which it grew. A striking example of this is the genus Ginkgo, which, during Mesozoic times, was represented by several species and which had spread far beyond its present native limits. Since the fossil species of Ginkgo hardly indicate past climatic conditions over such a wide area which are similar to those of its native habitat in China, it follows that a fossil leaf from Greenland similar to a living leaf from Alabama is not by any means proof that the two leaves grew under similar climatic conditions. Also the sudden appearance of a world-wide angiosperm flora during Cretaceous times, which Darwin referred to as an "abominable mystery," shows that during this time angiosperm evolution was going on rapidly. With the sudden appearance of a multitude of new types came also adaptation to new conditions. It is just as possible that during upper Cretaceous times these plants were adapted to a cooler climate than they are at present, and that, were more of the herbaceous forms known, we would find in the upper Cretaceous of Greenland a considerable admixture of a more northern flora.

UNIVERSITY OF MICHIGAN

---

* Papers from the Department of Botany, University of Michigan, No. 357.

[1] Steenstrup, K. J. V., "Über die Lagerungsverhältnisse der Kohlen und Versteinerungen führenden Bildungen auf der Westktüte von Grønland," *Flora Fossilis Arctica*, 7: 228-250. Zurich, 1883.

[2] Heer, Oswald, "Die fossile Flora Grönlands," *Flora Fossilis Arctica*, 6 (2) and 7. Zurich, 1882-83.

[3] Seward, A. C., "The Cretaceous Plant-bearing Rocks of Western Greenland, *Phil. Trans. Roy. Soc. London. B*, 215: 57-174. 1926.

[4] White, David, and Schuchert, C., "Cretaceous Series of the West Coast of Greenland," *Bull. U. S. Geol. Surv*., 9: 334. 1898.

[5] This and the two following paragraphs are summarized from Steenstrup, K. J. V., "Kulforende Dannelser i nord Grønland," Vedenskabelige Meddelelser fra Dansk naturhistorisch Forening i København, 25 (2-7). 1874.

[6] Thiessen, R., and Francis, W., "Terminology in Coal Research," *U. S. Bur. Mines, Tech. Paper 446*. 1929.

[7] Campbell, M. R., "A Practical Classification for Low Grade Coals," *Econ. Geol*, 3:134-142. 1908.

[8] *Ibid*.

[9] Berry, E. W., "The Past Climate of the North Polar Region," *Smithsonian Misc. Coll*., 82 (6): 29. 1930.

PLATE I

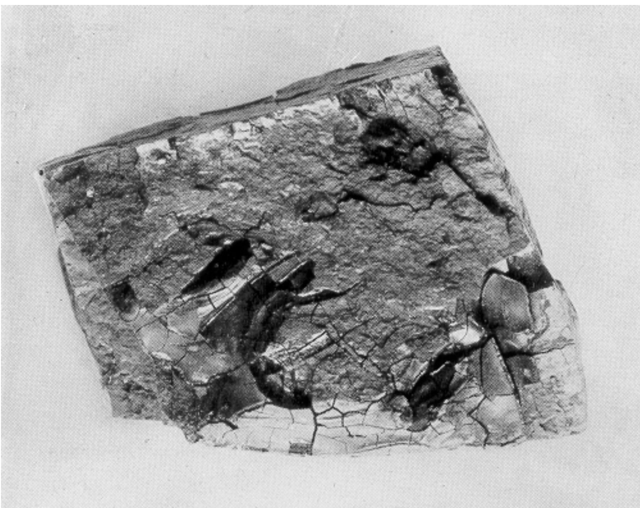


FIG. 1. Subbituminous coal showing pitchy luster and irregular fracture. From Atâ Delta, one mile southeast, at altitude of 250 meters. Slightly reduced

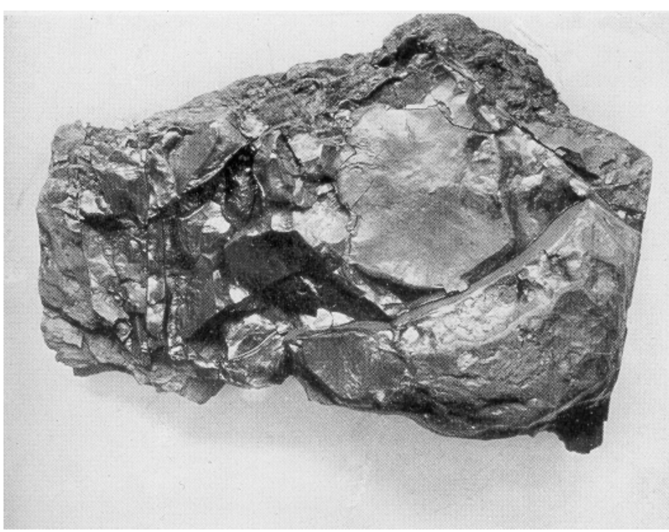


FIG. 2. Data as in Figure 1

PLATE II

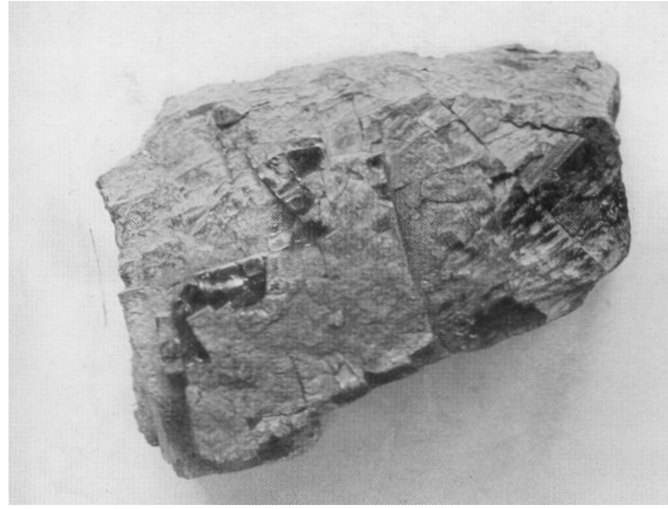


FIG. 1. Subbituminous coal showing tendency to cubic fracture, an approach to the bituminous condition. From Patoot, at altitude of 350 meters. Slightly enlarged

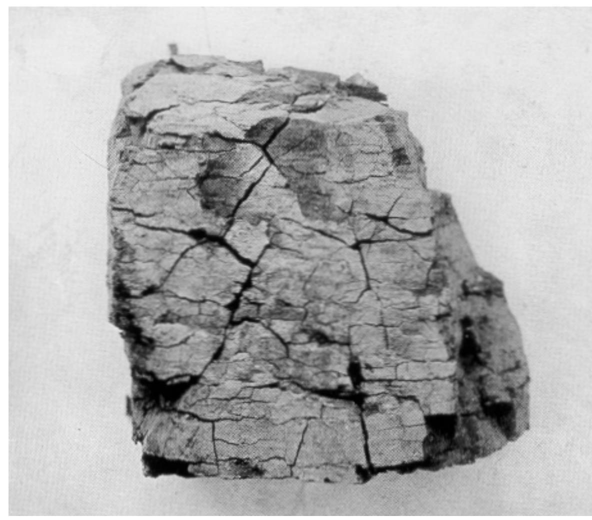


FIG. 2. Subbituminous coal showing tendency to check parallel to the bedding planes. From Amisut, at altitude of 6 meters. Slightly reduced

PLATE III

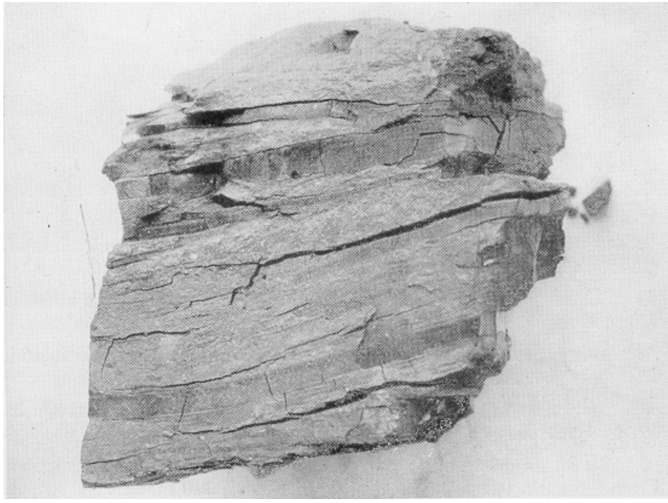


FIG. 1. Subbituminous coal showing banding. The narrow bands of anthraxylon alternate with the thicker attritus layers. From Amisut, at altitude of 1 meter. Enlarged about 2 times

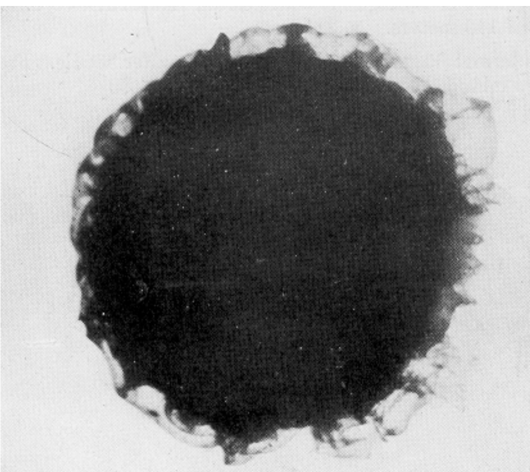


FIG. 2. Large spore showing appendages. From Skansen, two miles inland, at altitude of 140 meters. 1120 microns

EXPLANATION OF PLATE IV

FIG. 1. Spore showing triradiate markings. From Patoot, at altitude of 225 meters. 420 microns

FIG. 2. Antheridium of bryophyte (?). From Skansen, two miles inland, at altitude of 140 meters. 450 X 910 microns

FIG. 3. Pollen grain (?). From Skansen, two miles inland, at altitude of 140 meters. 525 X 540 microns

FIG. 4. Antheridium of bryophyte (?). From Skansen, two miles inland, at altitude of 140 meters. 455 X 805 microns

FIG. 5. Unicellular organism undergoing fission. From Amisut, at sea level. 70 X 90 microns

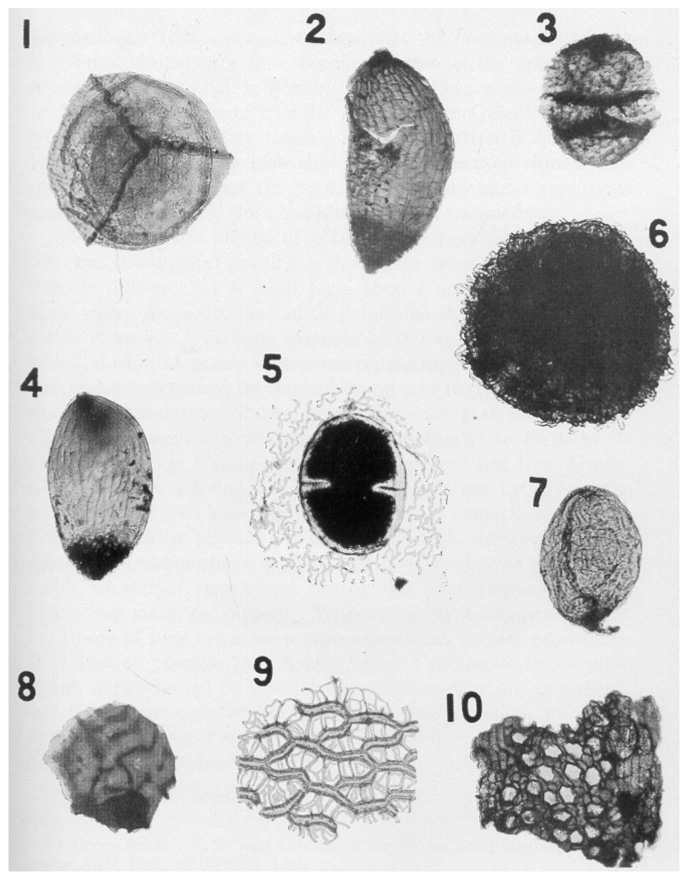
FIG. 6. Structure resembling germinating gleba of the Sphaerobolaceae. From Skansen, two miles inland, at altitude of 140 meters. 630 microns

FIG. 7. Antheridium of bryophyte (?). From Skansen, one mile from coast, in bed of stream at altitude of 175 meters. 470 X 590 microns

FIG. 8. Spore, possibly fern. From Skansen, two miles inland, at altitude of 140 meters. 525 microns

FIG. 9. Fragment of Sphagnum leaf. From Skansen, two miles inland, at altitude of 140 meters. X 225

FIG. 10. Epidermal fragment, possibly from a conifer needle. From Skansen, two miles inland, at altitude of 140 meters. X 80



SOIL MAPS AS A BASIS FOR MAPPING ORIGINAL FOREST COVER

JETHRO OTTO VEATCH

THE statement that vegetation presents different aspects over the face of the earth is accepted as a simple elemental fact. Observation has further revealed that differences exist in composition and form in circumscribed or local areas, as well as in climatic regions. From an abstract point of view there is no limit to which differentiation can be carried. Plants have increased significance to man if these different forms and manner of occurrence which he recognizes can be given geographic interpretation, or, in other words, if they can be mapped in a manner analogous to the mapping of other things or groups of things in nature, as, for example, rocks or soils. Since, obviously, it is impracticable to map each individual species, a grouping for mapping purposes may be made upon a physiological or ecological basis, or may be based upon associations characterized by some particular species or by the dominance of one or more species, and this latter plan appears to be the most logical procedure for the smaller subdivisions, or mappable units. In the United States it is possible to map, with a fair degree of accuracy, the broad plant formations, such as the southeastern mesophytic evergreen forest, or the central deciduous forest, divisions which are regional in extent. Mapping of smaller units of vegetation is also possible where the virgin vegetation remains. There is, however, a large part of the country where the original vegetation cannot be mapped locally and in detail, since it has been obliterated by clearing of land for agriculture, by lumbering and by fire, and therefore no longer exists or exists only as poor remnants widely separated. In such areas detailed maps of the distribution of the original cover of vegetation would have great scientific and practical value not only to the forester or silviculturist, but to the ecologist, the geographer, the economist, the historian and the pedologist, and, therefore would also have a cultural educational value.

Probably in only very few instances will early surveys, local histories and records provide information adequate for reconstructing the original cover in detail. Even in a forested region as recently lumbered over as northern Michigan it is doubtful whether the original forest cover could be reconstructed in detail on the basis of existing vegetation in conjunction with early surveys and records of lumber companies.

The idea occurred to the writer a few years ago[1] that in such cases the original cover of vegetation might be mapped by assuming that vegetational types possess a distributional equivalency to soil types. The steps in the reasoning were, in brief: (1) The distribution of vegetation in general is a function of climate; (2) Climate is also a causal factor in the character and distribution of soils; (3) Moisture and temperature are primary factors determining the nature of vegetation, and these same factors cause local differences in soils, that is, given the same moisture and temperature conditions prevailing over a great period of time, soils would have certain common characteristics regardless of the rock or parent material; (4) Studies on the evolution of soils suggest that there is a simultaneous development of soils and vegetation; (5) Plants obtain a great part of their nutrients from the soil and a certain nutrient condition, together with physical and chemical conditions, is more favorable or unfavorable for one particular species or group of plants than for another; (6) The time in general has been sufficient for adjustments to take place between the soil and the plant. The soil, especially the mature or normal soil for a pedologic province, should be a perfect expression of the action of the same natural factors which have determined the vegetation. On the basis of the preceding postulations one arrives at the conclusion that the reconstruction of the original vegetation may be accomplished simply by employing the boundaries of soil types for corresponding types of vegetation.

In the practical application of the idea, however, one is forced immediately to make provisos and reservations. At the outset it is prerequisite that at least a few remnants of the original cover be available, in order that relationships between soil and vegetation may be established. The accuracy of the soil mapping must be presupposed since the vegetation map would, a priori, inherit the errors of the soil map. If the ecologic scheme of classification is made independently, the phytogeographic units and the units on the soil maps must be of the same order.

The soundness of the idea, in practical application, very evidently will depend largely upon the degree of consistency with which a particular type of forest is restricted to a particular type, or to types, of soil. In order to obtain some kind of statistical data which would tend to verify or disprove assumed relationships, notes were made from "use-of-the-land" surveys in different parts of southern Michigan. In this survey, strips one-half mile wide were run at irregular intervals, in which every separate field and tract of land was outlined and classified. The total surveyed amounted to 528 miles and was distributed over five counties.[2] The land surveys were compared with soil maps and the frequency with which any particular forest type occurred on each soil type was noted. The results are presented in Table I, and the phytogeographic units employed in the mapping are given in Table II.

Our studies indicate that a dependable but by no means perfect correlation exists between the forest types here outlined and the units, or types, of soils ordinarily shown on soil maps made on a scale of 1 or 2 inches per mile. In the table there are a number of instances of inconsistency in relation to soil. Though some of these can be accounted for by errors of location in both the soil mapping and land mapping, and some by errors in soil classification, there are other more important factors.

TABLE I

FOREST TYPES IN RELATION TO SOILS

Soil types (Closely related groups)	Forest types (Number of instances)						
	Maple beech	Oaks hickory	Oaks	Elm, ash, basswood	Silver maple, elm, ash	Pin oak, red maple	Tamarack
Miami	109	18	20	4	0	0	0
Plainfield	5	5	35	13	0	0	0
Bellefontaine, Coloma	25	3	71	3	0	0	0
Fox	3	0	13	3	0	0	0
Brookston	5	1	0	160	20	0	1
Berrien	13	6	5	39	3	4	2
Gilford	14	1	1	26	27	0	0
Bronson	11	3	11	5	8	0	0
Newton	2	0	1	21	9	3	0
Napanee, Conover	52	17	0	88	15	0	0
Griffin	0	0	1	41	16	7	0
Hillsdale	27	3	28	3	0	0	0
Carlisle muck	0	0	0	38	162	0	26
Rifle peat	0	0	0	0	9	0	27

The correlation appears to be closest where the separate soil types appear in relatively large and uniform bodies, but, on the other hand, where the soils occur in small bodies complexly associated there is more likely to be a mixture of forest types and frequent occurrence of some particular species on a site where it is not normally found in considerable numbers. Where this condition exists it may be possible to work out corresponding soil and vegetational complexes. Where one soil occurs as a very small body included in a large body of another type, the vegetation of, the dominant soil is very likely to spread over the minor. This is the explanation of most of the instances of the elm-ash-basswood type of forest on Plainfield sand. The sand occurred as very narrow elongated strips on land composed predominantly of wet clay soils.

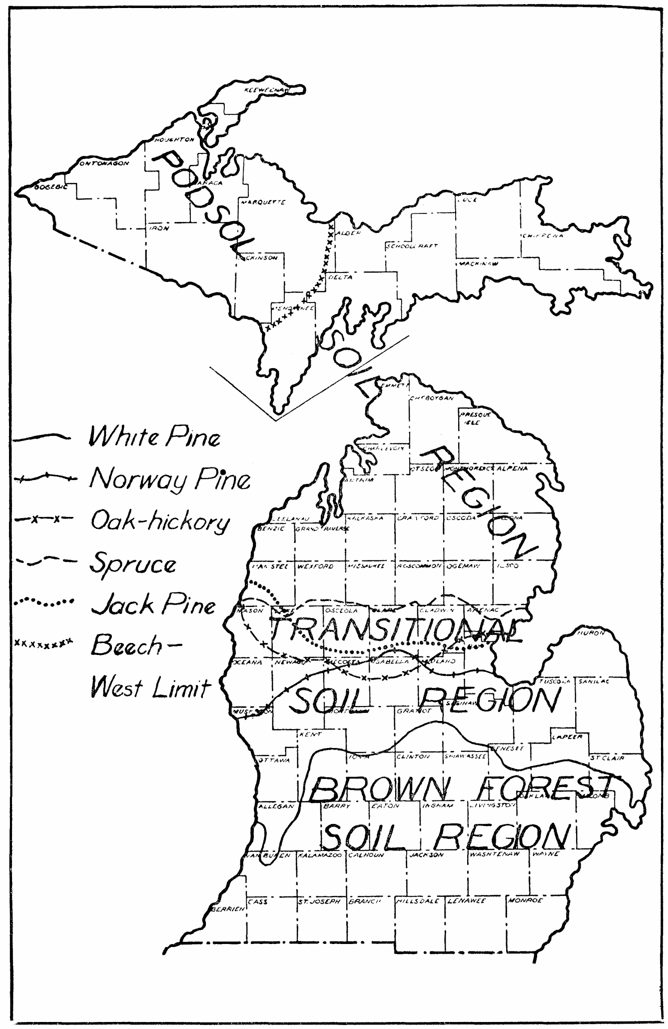
TABLE II

PHYTOGEOGRAPHIC UNITS OF SOUTHERN MICHIGAN

(Adapted to mapping on a scale of 1 to 2 inches per mile)

	DOMINANT CHARACTERISTIC	MINOR CHARACTERISTIC
FOREST	1. SUGAR MAPLE, BEECH	Oaks, hickory, elm, basswood
	2. OAKS, HICKORY	Elm, ash, basswood, sugar maple, beech, cherry
	3. OAKS	Hickory, beech, sugar maple
	4. ELM, SILVER MAPLE, ASH, BASSWOOD, SHAGBARK-HICKORY	Swamp white oak, beech, sugar maple, walnut, butternut, cottonwood, aspen, tulip, sycamore, tupelo
	5. PIN OAK, SWAMP WHITE OAK, ELM, RED MAPLE	White oak, aspen, white birch (conifers occasional to common)
	6. SILVER MAPLE, ELM, ASH	Tamarack, aspen, willow
	7. TAMARACK	Aspen, red maple, elm, willow, shrubs
	8. COMPLEXES OR MIXED TYPES (Various designations according to plants or sites)	
SHRUB	9. OSIER, BLUEBERRY, ILEX *	Tamarack, aspen, willow, sedges
	10. ASPEN, WILLOW, BIRCH *	
PRAIRIE MARSH BOG (Classification incomplete)	11. GRASS (dry prairies)	Burr oak
	12. CAREX — BLUEJOINT	Willow, aspen, tamarack
	13. LEATHERLEAF, BLUEBERRY, SPHAGNUM	Tamarack, aspen, spruce
	14. BUTTONWOOD (ponds)	
	15. CAT-TAIL	
	16. WATER LILY	
	17. LAKE BULRUSH	

* There is some question whether these types represent original cover.



MAP 2. Map of Michigan showing limits of forest species and types in relation to the transitional belt of soils. The western limit of beech nearly coincides with a physiographic boundary and a boundary between two geologic groups of soils.

The geographic extent of any established correlation will have to be worked out by observation. As mapped at present, it is extremely doubtful whether any particular soil type is precisely the same in its chemical and physical characters throughout its range, nor is it at all likely that it will occur everywhere in exactly the same association with other soils. The areal extent of any particular correlation will probably be found to conform pretty closely to natural land divisions, which are homogeneous in physiography, topography and soils, or which may be described as "soil associations." In Michigan the forest on the Miami types of soils is not the same in detail in the central part of the state as in the extreme southern part or as in Indiana and Ohio. Nor is the forest the same on certain sandy types in the southern part of the state as on those types in the central part, since in the first oaks, oak-hickory and certain species, as chestnut in the extreme southeast, may dominate or characterize the areas, whereas in the second white pine appears as an important constituent of the forest. It is probable that in our soil classification we have recognized too few soil divisions rather than too many in transitional belts, and therefore it is hardly to be expected that a perfect concordance in detail will be found in soils (as mapped in current and old soil surveys) and vegetation in transitional zones. In general, however, there should be a fairly close correspondence between transitional belts of vegetation and transitional soils. There is a strong suggestion of this in Michigan, as is shown on the accompanying map (Map 2).

It is the opinion of the author that it is possible to reconstruct the original cover of vegetation from a soil map with perhaps as near an approximation to the truth as by any other means. A sound knowledge of both ecology and pedology, as well as judgment and experience on the part of the worker, are presupposed.

MICHIGAN STATE COLLEGE
EAST LANSING, MICHIGAN

[1] Veatch, J. O., "Reconstruction of Forest Cover Based on Soil Maps," *Quarterly Bulletin*, 10, No. 3, Michigan Agricultural Experiment Station, February, 1928.

[2] The field mapping was done under the direction of the author by R. E. Pasco and Arnold Baur, graduate students in soils, Michigan State College, partly as independent work in connection with soil surveying, and partly in cooperation with the Game Division of the Department of Conservation, State of Michigan.