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PART II: ZOOLOGY

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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS

EUGENE S. MCCARTNEY
WILLIAM C. STEERE

VOLUME XXVII (1941)

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

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CONTENTS

ILLUSTRATIONS

PLATES

FIGURES IN THE TEXT

PLEISTOCENE MOSSES FROM THE AFTONIAN INTERGLACIAL DEPOSITS OF IOWA*

WILLIAM CAMPBELL STEERE

INTRODUCTION

MOSSES and liverworts occur as fossils less frequently than any other large group of plants. The most important reason for their rare fossilization is their relatively delicate and fragile structure, caused by the lack of hard tissues or resistant materials in the walls of individual cells. Furthermore, the plants are small and inconspicuous and, consequently, extremely easy to overlook in fossil material. As a result, only a few traces of the undoubtedly well-developed bryophyte flora of past epochs have been discovered.

The few species of bryophytes which have been reported in a truly fossilized condition (Knowlton, 1902, 1919; Dixon, 1927) date, without exception, from pre-Pleistocene times and occur principally in Tertiary deposits. By far the great majority of fossil mosses thus far reported date from the Pleistocene or very shortly thereafter and are, strictly speaking, in only a subfossil or "humified" condition. Isolated fragments of leaves, branches, and stems have been found embedded in old river and lake silts, and whole plants have been discovered *in situ* in ancient peats and forest beds.

Comparatively little importance has previously been attached to the study of Pleistocene mosses in this country and, as a consequence, few species have been reported. In the glaciated parts of Europe, on the other hand, many accurate and significant studies have been made. The number of species of bryophytes which have been reported from Pleistocene or post-Pleistocene deposits amounts to the rather surprising total of well over three hundred, of which somewhat less than ten per cent are hepatics (Dixon, 1927; Gams, 1932).

In this country the majority of Pleistocene mosses have been reported, not from the most recent deposits, but from the most ancient interglacial deposits, a brief history of which follows (cf. Kay, 1924, 1929; Kay and Apfel, 1928).

After the retreat of the Nebraskan ice sheet, which, so far as is known, was the first to invade the Mississippi basin, and before the coming of the next or Kansan ice sheet, there was a long interglacial interval. Evidence of this is given by the widespread occurrence in Iowa and neighboring states of weathered sands and gravels, old soils and forest beds, and layers of peat and muck, which rest upon the Nebraskan drift, but which in turn are buried by the Kansan till sheet. Since these ancient soils and peat beds were first discovered and studied near Afton, Union County, Iowa, the first known interglacial interval, which probably began nearly a million years ago and lasted over a hundred thousand years (Leverett, 1930), was named "Aftonian."

Subsequent to their original discovery and identification Aftonian deposits have been reported from nearly forty counties in all parts of Iowa, as well as in Missouri, Nebraska, South Dakota, Minnesota, Wisconsin, and Illinois. The deposits have been uncovered in excavations and gravel pits, in road and railway cuts, and have frequently been penetrated by wells, but are only rarely exposed in nature.

One of the most characteristic features of Aftonian deposits is the very common occurrence in them of large quantities of well-preserved mosses. As a result of earlier studies of Aftonian material several mosses are already known from various parts of Iowa. From Dodge Township in Union County (the type locality) have been reported *Camptothecium nitens* and *Drepanocladus fluitans* (Savage, 1903, 1905); from Oelwein in southern Fayette County, *D. fluitans* (Beyer, 1896; Macbride, 1896), *D. revolvens* and *Calliergon Richardsonii* (Holzinger, 1903); from Iowa City in Johnson County, D. *fluitans* var. *glaciale* (Holzinger, 1903); from Mud Lake, Emmet County, *D. fluitans* var. *Jeanhernati* (Grout, 1930); from Wallingford in Winnebago County, *Camptothecium Woldenii* (Grout, 1917). This last-named species is known only from this one locality, and is apparently now extinct. According to Dr. Grout, the species to which it is most closely allied (*C. pinnatiftdum*) is not now found east of the Rocky Mountains.

In addition to the definite, well-authenticated records just cited many references to bryophytes exist in the literature concerning the Aftonian deposits. Since they are mentioned simply as "mosses" or as occurring in "moss-bearing layers," it is impossible to determine what species are represented (Tilton, 1910, 1911; and others). In the geological surveys of the various counties of Iowa reports of ancient soils which bear mosses occur especially frequently.

In addition to the bryophytes from deposits which are almost certainly Aftonian there are reports of several species which somewhat doubtfully belong to that horizon. Under this heading come the Dichelyma from Bloomington, Illinois, which, although considered by Dr. T. P. James to be a new species, was not described as such because of its sterile condition (McGee, 1891); and *Drepanocladus aduncus* from Davenport, in Scott County, Iowa (Pratt, 1876).

An interesting collection of Pleistocene mosses was made in Minneapolis, Minnesota, from which have been reported *Calliergon giganteum;* a new species of Drepanocladus, *D. minnesotensis;* and a new genus, Neocalliergon, erected for *N. integrifolium* (Williams, 1930a, 1930b; Cooper and Foot, 1932). Although it is stated that this material came from deposits believed to date from late Pleistocene, the novelty of such a large part of it arouses a suspicion that they might possibly be Aftonian. Leverett (1932) remarks that Aftonian deposits have been found relatively close to the surface farther south in Minnesota. He says: "At several places in southeastern Minnesota and neighboring parts of Wisconsin and Iowa there are soils and beds of peat and muck between till sheets, which have been commonly referred to the Aftonian interglacial stage. Among the earliest brought to notice are those of western Fillmore County and southern Mower County, Minnesota, discussed by Winchell. As a rule the bed of muck and peat is found at the moderate depth of 20 to 30 feet. The greatest depth noted is 50 feet; the least is only 7 feet." "Another exposure of a peaty bed between tills is found in a cut on the Chicago, Rock Island & Pacific Railroad 2 miles southeast of Fairbault, Minn. Above the soil is 20 feet of bluish till . . . ."

Professor C. O. Rosendahl, of the University of Minnesota, has told me (*in litt*., 1939) of collecting plants in deposits of Aftonian age in Minnesota, and I have seen mosses from these collections.

Other deposits which might possibly be relics of Aftonian times are those in the vicinity of Toronto, from which several species of mosses have been reported (Hinde, 1877; Dawson and Penhallow, 1890; Penhallow, 1896, 1900; Coleman, 1894, 1895). These deposits are so close to the gathering grounds of the ice sheets that much of the evidence for their position in the Pleistocene is lacking. Consequently it is exceedingly difficult or impossible to correlate exactly these deposits with those at the margin of the glaciated area.

Mosses which certainly date from interglacial stages in the Pleistocene later than the Aftonian have been reported from Ohio (Orton 1870), Wisconsin (Cheney, 1930, 1931; Wilson, 1932, 1935, 1936), Minnesota (Winchell, 1888), Alaska (Cooper, 1923), District of Columbia (Williams, 1933), and Louisiana (Steere, 1938b).

The few records of fossilized postglacial mosses in North America occur principally from travertine or tufa deposits in Oklahoma (Emig, 1918) and Utah (Flowers, 1933).

MATERIAL

The material to be discussed here was collected in the type locality of the Aftonian interglacial stage near Afton, Iowa, during the summer of 1933. Since the collectors, Dr. Ethel B. Hansen and Dr. Gladys West, were primarily interested in the identification of the species of higher plants, the large collection of mosses was turned over to me for study.

The mosses occurred in thin layers in a clayey silt, which is clearly varved. They were not equally distributed through the whole section, which was several feet thick, but were highly localized. The layer in which they were most abundant was called by the collectors "Layer C," and from it came the great majority of the species listed in this paper. The thinness of the varves and the types of mosses preserved indicate the margin of an ancient boggy lake or a slow-moving bog stream.

The moss-containing fragments of clay were carefully washed in a sieve or strainer, to remove most of the dirt from the plant debris, which was then sorted. The mosses were received for study in this cleaned condition, but had not been given chemical treatment of any kind. The specimens were yellowish to clear reddish brown when wet, and so fragile that they could be handled only by small brushes. When dry, they were light, dusty brown and crumbled into fragments if touched.

In order to facilitate the study of the specimens each fragment of branch or stem was partially dissected to show all diagnostic details of the leaves necessary for identification, as, for example, their attachment to the stem and the cellular areolation of base and apex. The dissections were mounted in a dark glucose syrup ("Karo") under a glass cover slip. This technique for mounting fossil materials, which was originated many years ago by Professor H. H. Bartlett, results in hard, permanent mounts. In the thin layer under the cover glass the dark syrup is entirely transparent and appears colorless. The advantage of the dark syrup is that it never crystallizes which is the greatest fault of water-glass or pure glucose-syrup mounts.

In general, the material is in remarkable condition, especially since it must have been carried about by water currents before being finally covered with silt. Many of the stems are exceedingly flattened, so that their cell structure and arrangement are not easily recognizable, and the apices of occasional leaves have been frayed or destroyed. Rarely, fungous hyphae are visible (Pl. V, Fig. 5). The wonderful preservation of mosses in Aftonian deposits, approximately a million years old, has excited considerable comment. Grout (1917) remarks upon the unusual condition of specimens of *Camptothecium Woldenii:* "The material is somewhat coated with fine soil, although Mr. Wolden says he washed it out from lumps of earth. Otherwise it might have been collected one hundred days ago instead of having been preserved one hundred thousand years, more or less. The plants are green, although no cell contents are observable, and the leaves are perfectly preserved, even to all details of cell structure. In fact it seemed so incredible that a moss could have remained so well preserved under such circumstances, that I wrote again to Mr. Wolden for additional details."

Professor Macbride (1896) gives an even more graphic (and extravagant) description: "The bottom of the seam is a compact mass of moss, compacted and pressed together no doubt, but absolutely untouched by putrefaction or decay, perfect in every leaf and fiber as any herbarium specimen in the world. Specimens you may examine show this perfectly. You may see the stem, the attachment of the leaves, the innovations, the form of each leaf, nay, the very areolation of a leaf apex and base, quite as absolutely defined as in the case of any freshest specimen one may bring in now from any living turf or forest bed. For this reason, we are able with much confidence to identify the species concerned, although, so far, we have seen no smallest sign of capsule or fruit. So far, also, all the material seems to represent but a single species, a *Hypnum*, probably *Hypnum fluitans* . . . ."

In the following list of mosses which have been recovered from the Aftonian material collected by Dr. Hansen and Dr. West four species seem sufficiently distinct from their known modern relatives to deserve specific recognition, and so are here proposed as new species. Of course, there are widely divergent methods of considering the extent and limits of species in fossil material (Bailey, 1933), just as there are in the the study of modern plants. In modern bryology suitable and fairly satisfactory diagnostic criteria and concepts of specific boundaries exist, which, fortunately, can be readily adapted to Pleistocene material. It is difficult to agree with Gams (1932), however, who says somewhat arbitrarily: "None of the more experienced bryologists of today venture to create new Quaternary species of the polymorphic Amblystegiaceae, which seem to have existed in Europe almost unchanged since the Miocene." In the first place, the majority of species reported from Pleistocene deposits are known from the Tertiary in North America and, furthermore, many which are called preglacial are very probably really interglacial in age, but from outside the limits of glaciation, or else from deposits not yet recognized as being interglacial, so that Gams' statement seems unfounded. In the second place, two of the most experienced bryologists in this country have named new Quaternary bryophytes. Dr. Grout, an authority on the family Brachytheciaceae, has named a new species of Camptothecium from Aftonian material, and R. S. Williams, also a widely recognized bryologist, has described not only two new species, but also a new genus from Pleistocene material, and all of them in the Amblystegiaceae. It is remarkable that so small a number of North American collections should contain so many interesting species, when many more years of careful and intensive study of European subfossil bryophytes have brought to light a smaller number of new types, which are not even generally accepted. This conspicuous discrepancy between the moss floras of the earliest known interglacial stages of the two hemispheres is difficult to understand, and is of considerable significance.

It is probable that, just as with the phanerogams, whole groups which existed in Tertiary times, but which are now nearly or completely extinct, persisted into the early part of the Pleistocene. There has been sufficient time for many changes to have taken place since the beginning of Pleistocene times, which was, according to one of the most recent calculations (Leverett, 1932), at least a million years ago. Baker (1920) says: "It is believed that upwards of a million years have elapsed since the first great field of ice covered the country, a period of sufficient length to permit great changes in the species of plants and animals inhabiting the region." This is well shown by the tremendous differences which have occurred in the mammal fauna since early in the Pleistocene. During this time more than ninety-five per cent of the species of mammals have become extinct. Nevertheless, the gastropods, or at least their shells, have not been modified appreciably during the same time, which is accounted for by the fact that a shell is an exceedingly conservative structure whose evolution throughout geological history has been very slow. In the amount of change which they have undergone the mosses occupy a place intermediate between the very plastic mammal group and the nearly static gastropod group. The history of the phanerogamic plants, especially in North America, is so imperfectly known that very little can be said concerning the changes which they have undergone, except that their representation in Tertiary times was, both specifically and geographically, considerably different from the situation now.

TAXONOMIC DISCUSSION OF THE MOSSES

Most of the fossil mosses studied here have been identified with the help of various descriptive manuals designed for present-day species, especially Grout's *Moss Flora* (1928-40), and through comparison with modern specimens. In order to facilitate the comparison with such a large bulk of material, permanent slides were made of a series of the modern species most closely related to the fossils.

The Sphagna occurred as small tangled mats of branches and stem fragments; very rarely as complete leafy stems. They could usually be easily distinguished from the other mosses macroscopically because of their grayish appearance, even when wet, instead of the reddish-brown color of the other mosses. Since the stems and leaves were flattened and extremely fragile, it was impossible, in the usual manner, to make the sections of leaf and stem necessary for exact specific determination. It was in general possible, therefore, to recognize only the group to which the species belongs, or the "large" species. A detailed investigation of this material by means of regular histological methods would undoubtedly make possible the identification of many more species. It would be necessary, however to section material embedded in paraffin or celloidin.

LIST OF SPECIES

SPHAGNACEAE

SPHAGNUM SQUARROSUM Crome. — Branches of this species were easily recognized by the large, squarrose branch leaves.

Present distribution. — Greenland, Labrador, Alaska, Canada, south to the northern United States.

SPHAGNUM ACUTIFOLIUM Ehrh. (*sensu lato*).

SPHAGNUM CYMBIFOLIUM Crome (*sensu lato*). — These long-recognized "species," as understood by the earlier bryologists, are now believed to consist, in reality, of whole groups of species, most of which have a decidedly northern range.

FISSIDENTACEAE

FISSIDENS SP. — Only one specimen belonging without question to this characteristic genus was found (Pl. I, Fig. 1). The plants are badly damaged, but show the typical sheathing leaves, which are unbordered (Pl. I, Fig. 2) and have cells 10-12 μ in diameter. The specimen is somewhat small to agree well with any of the modern boreal American species having these same characteristics. Nevertheless, I suspect that it is some form of the variable *Fissidens osmundioides* Hedw., which is widely distributed through the northern United States and Canada.

DICRANACEAE

DICRANUM BERGERI Bland. — The specimen so named has the upper leaf cells nearly as broad as long, the costa not reaching the leaf apex (Pl. I, Figs. 3-4), and bears only a few serrations on the dorsal side of the leaf at the apex (Pl. I, Fig. 5). It is certainly not in the relationships of the ubiquitous and protean *Dicranum scoparium* Hedw., whose forms have elongated and pitted leaf cells.

Present distribution. — In bogs, Labrador to Alaska; Canada; southward into the northern United States; a boreal to sub-Arctic species.

BARTRAMIACEAE

PHILONOTIS SP. — Only one very small specimen was found, which was recognized by the unbordered leaves and characteristic papillae formed by projecting angles of the wall at the ends of the cells. It does not agree very well with any of the modern species in its plane leaf margins and the rather blunt leaf apex (Pl. II, Figs. 1-3), but any attempt either to propose a new species or to identify an old one from such imperfect material would not repay the trouble. The representation of this genus here is of significance, however, since the species of Philonotis grow in very moist places, or even in water, although never in running water.

AULACOMNIACEAE

AULACOMNIUM PALUSTRE (Web. & Mohr) Schwaegr. — This species was well represented in the collection by many specimens in various states of preservation. Even when the leaf apex (Pl. I, Fig. 6) was lacking the species could be recognized easily by the characteristic thick-walled cells with a central papilla (Pl. I, Fig. 7) and by the tomentose stems. In view of its present common and widespread association with *Aulacomnium turgidum* (Wahlenb.) Schwaegr. in sub-Arctic America, it is surprising not to find it represented in the Aftonian material.

Present distribution. — On the ground in swamps and bogs; North America from the Arctic Archipelago south to Florida in the east and to California in the west.

FONTINALACEAE

FONTINALIS SPP. — Since only small pieces of plants belonging to this genus were found, it was impossible to determine whether or not they originated from the main stem or from the branches. Hence it was considered unwise to attempt to name them, although at least two different species are present in the collection. All modern American species of Fontinalis are aquatic, growing typically in running water, and are characteristic of temperate regions, not reaching even the sub-Arctic zone.

THUIDIACEAE

ANOMODON ATTENUATUS (Hedw.) Hüben. — There is no doubt about this identification, since the areolation, the leaf shape, and the characteristic attenuate branches (Pl. II, Figs. 4-5) agree very well with those of modern material.

Present distribution. — On soil, base of trees, rotten wood, and rocks; very widely distributed in temperate North America.

THUIDIUM DELICATULUM (Hedw.) Mitt. — This identification is beyond question, since the several specimens show the bipinnate and tripinnate branching of the stem, the characteristic papillae of the leaf cells, the paraphyllia, and the stem leaves typical of the species (Pl. V, Figs. 1-2). The most closely related American species is *Thuidium recognitum* (Hedw.) Lindb., which grows in rather dry places.

Present distribution. — On soil, rotten wood, and rocks, usually in moist or wet places; widespread throughout North America east of the Rocky Mountains.

AMBLYSTEGIACEAE

CALLIERGON STRAMINEUM (Brid.) Kindb. — Slender, unbranched plants with leaves imbricated above and spreading below, obtuse and somewhat cucullate at the apex, the costa ending well below the leaf apex, and the alar cells well developed, were placed here. In none of the specimens did I see the radicles produced from the dorsal side of the leaf apex, typical of living material.

Present distribution. — In bogs at high latitudes and high altitudes; Greenland to Alaska, southward to the northernmost United States.

CALLIERGON CORDIFOLIUM (Hedw.) Kindb. — Plants with little-branched stems, spreading leaves with the costa percurrent or nearly so, and the alar cells inflated, but not sharply demarcated from the adjoining cells, were so named. Many of the specimens compared very well with modern material.

Present distribution. — In swamps and bogs; throughout boreal North America, extending southward into the northern United States.

CALLIERGON RICHARDSONII (Mitt.) Kindb. — Many forms were found which resembled *Calliergon cordifolium* in many ways, but in which the leaves were shorter and broader, and the costa extended only about half the length of the leaf. Such forms are grouped together here, although there may be at least two species or subspecies represented.

Present distribution. — In bogs and on wet rocks in the mountains; a truly boreal species; Newfoundland, Prince Edward Island, Greenland, Hudson Bay, south to the very northernmost United States.

CALLIERGON GIGANTEUM (Schimp.) Kindb. — The branch leaves of this species are much longer and narrower than the stem leaves, so that isolated branches, which make up the greater part of the material, could have been named only doubtfully if they had not been checked against present-day material. When whole plants occur, however, the pinnate branching, the percurrent costa, and the sharply demarcated auricles of inflated alar cells make the determination certain (Pl. V, Fig. 6).

Present distribution. — In bogs; a distinctly boreal species widespread in northern North America, extending southward to the northern United States.

Calliergon aftonianum, sp. nov. — Plant apparently large, pinnately branched, with the habit of *Calliergon giganteum;* basal leaves oblong, obtuse, 1 mm. long and 0.5 mm. wide (Pl. III, Figs. 1-2); costa very short or even lacking; apical leaves of branch longer and narrower, lanceolate, up to 2 mm. long and 0.3 mm. wide, costa extending about one half the length of the leaf, but never percurrent. Known only from isolated branches. Slide 64 is designated as the type.

This species is closest to *Calliergon giganteum* in its mode of branching and in the similar alar cells, but differs conspicuously and consistently in the longer, narrower, less triangular leaves, which have a much shorter costa.

Calliergon Hansenae, sp. nov. — Stems long, lax, irregularly pinnate, with somewhat attenuate branches; leaves narrowly lanceolate, 1-1.7 mm. long, the average length about 1.5 mm.; costa short, to one half the length of the leaf; apex obtuse to obtusely acute; alar cells very conspicuous. Type, slide 106.

This species is probably most closely allied to the preceding one or to *Calliergon giganteum*, but is very lax and much resembles some of the forms of Drepanoeladus; from this it differs however, in the peculiar arrangement of the apical leaves, which are mostly obtuse and not at all secund (Pl. III, Figs. 3-4). It approaches Drepanoeladus especially in the elongated alar cells (Pl. III, Fig. 5), a feature not ordinarily found in Calliergon; also in the long, narrow leaves and short costa.

CALLIERGON TRIFARIUM (Web. & Mohr) Kindb. — A number of specimens of this species were recognized through their broad, imbricated leaves, which lacked well-defined alar cells and in which the costa was not percurrent. The spirally trifarious leaf arrangement easily seen in living specimens was not obvious in the fossil material, because of the flattening.

Present distribution. — Greenland, across Arctic Canada to Alaska, reaching only the very northernmost United States.

CALLIERGON TURGESCENS (Schimp.) Kindb. — The abundant specimens of this species were easily recognized from their large size and the very much inflated, turgid appearance of the leafy stems. Under the microscope the leaves show the porose, thick-walled alar cells, the short, thin costa, and the minutely apiculate apex. The curious apiculus is usually missing from older leaves, but may be demonstrated in the terminal leaves, which are not only younger but also better protected from fraying.

Present distribution. — In cold bogs; Greenland, Arctic and sub-Arctic Canada.

Calliergon Kayianum, sp. nov. — Leafy stem relatively large, turgid, 3-5 mm. in diameter, in fragments 0.5 to 2 cm. long, rarely branched, usually bearing at the apex a caducous, budlike structure; leaves widely ovate to nearly orbicular, 2-3 mm. long, 1.5-2.0 mm. wide, averaging 2.5 mm. long and 1.7 mm. wide, but narrowed to the somewhat clasping insertion; apex broadly rounded, not at all acute or apiculate, costa completely lacking (Pl. IV, Figs. 4-7).

This species, which is one of the most common in the collection, and certainly the most conspicuous, much resembles in habit both *Scorpidium scorpioides* and *Calliergon turgescens*. From the former it differs in the symmetrical, not at all secund, leaves, and from the latter, to which it is most closely related, in the nonapiculate leaves with no trace of a costa. An interesting relationship to *C. turgescens* is shown by the production of extremely easily detached buds at the end of the large main stem. According to Grout (1931), *C. turgescens* has the habit of “reproducing asexually by the falling off of the terminal buds of slender stolons.” The big detached buds of *C. Kayianum* make up a great part of the Aftonian material. From the very large variety *gigantea* of *Fontinalis antipyretica* it differs in that the leaves, although concave, are not at all keeled-conduplicate.

Calliergon Kayianum belongs, perhaps, in Williams' new genus Neocalliergon (Williams, 1930a, 1930b), but in view of the great variability, which was apparently characteristic of the complex which we now call Calliergon, during Aftonian and perhaps during later interglacial stages, it is somewhat unsafe to draw too finely the lines between genera. There were apparently whole groups or lines of development which have not persisted into modern times. In the Calliergon material several types apparently represented other unknown species, but were insufficient in quantity or too poorly preserved to be described as new. A study of Calliergon from a much larger collection than this might shed a great deal of light on the origin of the genus and its relation to Drepanoeladus. Many specimens were found which possessed characteristics of both Drepanoeladus and Calliergon, and appeared intermediate between them. This fact seems to point to a common ancestry for both groups rather than to a parallel development as a reaction to the same environment, as is believed by many bryologists.

DREPANOCLADUS ADUNGUS (Hedw.) Warnst. — Forms with entire leaves and large groups of well-developed alar cells are placed here. Although a great number of forms, including the so-called varieties *Kneiffii* and *polycarpus*, were found, no attempt was made to separate them, because of their infinite variability.

Present distribution. — Widespread almost throughout northern North America; usually in water.

DREPANOCLADUS FLUITANS (Hedw.) Monkem. — Forms with serrulate leaves and relatively small areas of alar cells are grouped here.

Present distribution. — Common throughout Canada and the northern United States.

DREPANOCLADUS EXANNULATUS (Gumb.) Warnst. — Specimens with serrulate leaves, a strong costa, and conspicuous auricles of alar cells are placed here.

Present distribution. — Distinctly boreal; Greenland, Canada reaching only the northernmost United States.

DREPANOCLADUS REVOLVENS (C. Mull.) Warnst. — This species is characterized mainly by the strongly falcate-secund leaves which have no well-differentiated alar cells. The dark red to nearly black characteristic of living plants persists in the fossil specimens.

Present distribution. — A rather uncommon species of boreal bogs; throughout northern Canada, but reaching only the northernmost United States.

Drepanocladus apiculatus, sp. nov. — Stems rather robust, little branched; leaves 1.5-2.0 mm. long, 0.5-0.7 mm. wide, ovate, tapering to a gradual acumination, at the termination of which is a narrow, often recurved apiculus (Pl. V, Figs. 3-4); very concave, falcate-secund, not plicate; alar cells thick-walled, but otherwise not much differentiated; costa very short, to one half the length of the leaf, rarely more (Pl. V, Fig. 5). Type, slide 183.

This species is apparently most closely related to *Drepanocladus revolvens*, but differs in the peculiarly recurved apiculus and the short costa. So far as I know, no modern species of Drepanocladus has an apiculus on its leaves, although this characteristic still persists in Calliergon.

In the Drepanocladus material there are countless variations and forms which might have been identified, or at least named, most of them under *D. aduncus* and *D. fluitans*. The genus Drepanocladus is still so variable and so plastic, however, that it was considered inadvisable to attempt to segregate varieties and forms from material which grew under conditions which are still not fully understood. As Grout (1931) says of the modern specimens: “Nearly all grow in water or very wet places, and the amount of water and other conditions of their immediate environment appear to modify their growth profoundly. Sometimes two well marked varieties can be found on the same plant.”

It appears that, although the genus Calliergon has become somewhat stabilized during the past million years, perhaps by the extinction of intermediate forms, Drepanocladus is still nearly as plastic now as it was during Aftonian times.

SCORPIDIUM SCORPIOIDES (Hedw.) Limpr. — This large species, although not common, is represented by several specimens, which are easily recognized by means of their large size and the secund leaves without a costa.

Present distribution. — In swampy and boggy streams and pools; Canada and the northern United States, across the continent.

AMBLYSTEGIUM JURATZKANUM Schimp. — Only a single fragment of this small but easily recognized species was recovered. The spreading leaves and the characteristic alar cells are distinctive.

Present distribution. — Widespread through the northern United States and Canada; on rotten wood, moist humus, and stones.

LEPTODICTYUM RIPARIUM (Hedw.) Warnst. — The specimens placed here agreed in most respects with modern material, except that some of the leaves are distinctly serrulate, especially toward the base. The apical cells are frequently much shortened, and the remaining cells are shorter than is usual in Drepanocladus, which seems to preclude that genus, a view substantiated by the lack of inflated alar cells. This identification was not considered to be completely beyond question, but the material is too fragmentary to justify the creation of a new species.

Present distribution. — Common throughout the United States and southern Canada.

CAMPYLIUM STELLATUM (Hedw.) Lange & C. Jens. — The large leaves with costa short or absent and the numerous quadrate alar cells are well shown in the very large number of specimens present in the Aftonian material (Pl. II, Fig. 6; Pl. IV, Fig. 3). Reasonably long branches occur which have the typical leaf arrangement.

Present distribution. — Throughout Canada, from the Arctic Archipelago south to the northern United States.

BRACHYTHECIACEAE

CAMPTOTHECIUM NITENS (Hedw.) Schimp. — This species was apparently very common and abundant in Aftonian times, to judge from the quantities of it which are found in fine condition in this material. The plications of the leaves and the abundant tomentum on the stems are extremely well preserved.

Present distribution. — From the Canadian eastern Arctic southward to the northernmost United States.

CAMPTOTHECIUM WOLDENII Grout. — Although the type specimen was not seen, several specimens were found which seemed to agree completely with the original description of this species (Grout, 1917).

HYLOCOMIACEAE

HYLOCOMIUM SPLENDENS (Hedw.) Bry. Eur. — This species is one of the best preserved and most easily recognized in the- whole collection. Even the paraphyllia on the stems are still beautifully preserved, and the double costa is conspicuous (PI. IV Figs. 1-2).

Present distribution — Canada and the northern United States; still occurs in Iowa.

POLYTRICHACEAE

POLYTRICHUM STRICTUM Banks. — The identification of this species is facilitated through the tomentose stems and the well-preserved leaves with clearly incurved margins, as well as through the mosses associated with it, since they are bog species. *P. juniperinum*, although very similar, lacks the tomentum on the stem and grows in fields and woods, not ordinarily in bogs.

Present distribution. — Distinctly boreal, growing in Sphagnum bogs and swamps; Greenland, Canada, northern United States.

THE MECHANICS AND CHEMISTRY OF MOSS PRESERVATION

A curious and striking feature of the material just described is the complete and conspicuous lack of certain species, genera, and even whole families of mosses, and of the entire group of hepatics which should certainly be expected on the basis of modern association and distribution of bryophytes. For instance, in our modern boreal bogs there are usually associated with the mosses listed above such genera as Leucobryum, Pellia, Cephalozia, Calypogeia, Lophozia, and Mylia. Since these forms are completely unrepresented in early Pleistocene deposits, it is of course possible to conclude that they were actually lacking during Aftonian times. This conclusion would be almost certainly incorrect, however, because the groups just mentioned are highly developed ones, and, furthermore, to judge by their present wide distribution, must be ancient ones. Since the fossil species occurred in the same associations in which they are still found in nature today and since the hepatics are an old group, it is reasonable to suppose that the missing species were then present, hut for some reason were not preserved. The lack of certain characteristic bog mosses, such as Leucobryum, is so consistent that it appears not to be by accident, but through some idiosyncrasy of the species. The matter of which species are preserved seems to be correlated definitely with the chemical constitution of their cell walls, which in general are much less resistant to hydrolysis than those of higher plants. The cell walls of mosses and hepatics are not made of as permanent and resistant materials as those which compose the cell walls of higher plants, but consist in large part of hemicelluloses, which are usually more easily broken down than true celluloses (Muller, 1905). Hepatics contain even less true cellulose than mosses — only one sixth as much (Lohman, 1903)

According to the long-accepted views of botanists and geologists, peat formation simply amounts to the accumulation of celluloses, hemicelluloses, and their oxidation products. The complete acceptance of this view is reflected by many workers. Weyland (1925) says: “Die schlechte Erhaltung und das Fehlen fossiler Moose überhaupt wird durch die chemische Zusammensetzung der Zellmembranen der Moose erklärt, die zum grössten Teil nicht aus echter Cellulose bestehen und daher leichter zersetzlich sind . . . .”

Rather recently, however, the theory that lignins and their derivatives and, to a much lesser extent, resins and waxes are the materials which persist and accumulate (Fischer and Schrader, 1921) has been gaining ground, especially among chemists. The term “lignin” has been restricted in the past by plant anatomists and morphologists to a somewhat obscure material which is located in secondary thickenings of cell walls and which can be identified by microchemical tests. The same term is used by chemists in a much broader yet specific sense, to cover the aromatic constituents of the cell wall which are characterized upon degradation by the methoxyl group (Fuchs, 1926). This widely conflicting usage and concept is strikingly illustrated by comparing the older chemical analyses of bryophytes by qualitative microchemical methods with more recent analyses on the basis of quantitative tests. None of the early analyses show (Roberts and Haring, 1938) the presence of lignin in bryophytes, whereas the latter demonstrate large amounts of lignins or their derivatives, as determined from the methoxyl content. In fact, more “lignin” is reported for mosses than from some phanerogams! For example, Waksman and Stevens (1928), in a study of peat-forming materials, report that “*Hypnum*” contains 21.13 per cent of lignin, whereas “*Sphagnum*” in the upper, growing portion and the lower, dead, portion, contains, respectively, 6.97 and 19.15 per cent of lignin. In *Sphagnum cavifolium* and *S. medium* have been reported, respectively, 9 2 and 16 14 per cent of lignin (Stadnikow and Baryschewa, 1930a, 1930b).

Czapek (1899, 1913) reported the occurrence of aromatic constituents, which are now considered to be lignin derivatives, in the cell walls of bryophytes, and found that there is a distinct correlation between the habitat and the type of aromatic compound present. In mosses living in the water or in moist or deeply shaded places he found a material which he named "sphagnol" and which was demonstrated to be strongly toxic to bacteria, fungi, and other organisms. In truly xerophytic mosses, on the other hand, sphagnol is lacking. There occurs a tannin, called "dicranic acid" by Czapek, which is toxic, like sphagnol, but to a lesser extent. In the hepatics, however, there seems to be very little relation between the chemistry of the cell wall and the habitat of the species.

Since peat formation, which is the accumulation of plant residues, probably of an aromatic nature, can take place only under anaerobic conditions (Waksman and Stevens, 1928), the aquatic species obviously stand a much better chance of becoming preserved. In the list given earlier, for example, nearly all the species are either actually aquatic or from very moist habitats. All species which are prevented from being deposited under water, even though they contain the necessary lignins or lignin derivatives, will still not be preserved. As a result, species of the moist but rarely inundated forest floor are found in a fossil or subfossil condition much less often than aquatic species. Progressively, xerophytic mosses such as Grimmia and most species of Rhacomitrium are preserved only under exceptional conditions, and could not be expected to occur in peat at all. For this reason the two most important factors which determine preservation of mosses are their deposition in water and the presence of lignins or related compounds in their cell walls.

Weyland, in his discussion of the poor preservation of mosses in general, has placed significance upon the fact that the moss plant is a gametophyte and thus is ontogenetically different from the ferns and the phanerogams. Although this viewpoint opens some interesting philosophical questions, the moss sporophyte apparently does not have a more resistant cell wall than the gametophyte. This is well illustrated by the almost complete lack of moss sporophytes in known fossil material. It has also been shown that the young sporophyte, at least, contains materials which are easily decomposed (Ziegenspeck, 1926). The true cause of the poor preservation of mosses is undoubtedly that both generations lack the large amounts of resistant vascular and cuticular tissues that are characteristic of the higher groups.

THE CLIMATE OF THE AFTONIAN INTERGLACIAL STAGE

In addition to its purely taxonomic phase, the study of Pleistocene mosses has considerable bearing on the problems of climate and plant distribution during the interglacial intervals. Most mosses are very sensitive to the various environmental factors and, furthermore, usually have a fairly restricted geographical range, as has been pointed out in some detail during the last few years (Steere, 1937a, 1937b, 1938a; Sharp, 1939). Consequently fossil mosses make accurate and convenient indicators of the climatic and ecological conditions under whose influence they grew. Their value in climatic studies of the past has not been sufficiently recognized.

The question of the nature of the climate and life of the interglacial stages is an exceedingly fascinating one, which has had several different and more or less conflicting answers. Savage (1903) says of the plant remains from Dodge Township, Union County, Iowa: "The scarcity in these deposits of fragments of our deciduous forest trees and the presence, in abundance, of leaves and twigs and pieces of wood of cone-bearing trees, such as live at present at higher latitudes, is significant. The absence in these beds of the aquatic moss species that predominate today in the lakes and pools of Iowa, and the occurrence there of species of mosses which now flourish further northward, furnish strong evidence that during the Aftonian age the climate of our state was favorable for the growth of a more boreal vegetation than at present." He continues: "The conclusion seems warranted that many of the plants which are found in the present flora of our state had no place there during the earliest interglacial interval, and that, at our latitude, the climate never became so mild and genial throughout this period as that which the region enjoys during the present age."

Later, Savage (1905), while discussing more Aftonian plants, this time from Oelwein, in Fayette County, Iowa, supports and extends his original opinion, saying: "It is worthy of note that the moss species, whose remains were found in the second member of the section, as well as the pieces of larch wood that came from the horizon of the old Aftonian surface, are forms that thrive at present in more northern latitudes. It is probable that the climatic conditions of the Aftonian interglacial age were, at least toward the close of the interval, less mild and genial in this portion of our country than those which the region has enjoyed in recent times." This view is convincingly supported by the plant materials that have been studied since; in fact, it seems impossible to interpret the evidence otherwise.

Little has been said concerning the vegetation of the Aftonian interval as a whole. Shimek (1910) speaks of "plant-covered land areas similar to those which now prevail in the region," and Baker (1920) considers that "the Aftonian was a time of luxuriant forests."

The Mosses

The modern bryophyte flora of Iowa has been somewhat intensively studied during the last few years, and therefore is rather well known (Bessey, 1884; Savage, 1898; Shimek, 1898, 1907, 1915; Conard, 1912, *et seq*.; Wolden, 1919; Cavanagh, 1921, *et seq*.; Blagg, 1927, *et seq*.; Grout, 1928; Conard and Wolden, 1932; Sayre, 1934).

The great majority of the present Iowan mosses are the same ones that are found in similar habitats throughout Illinois, Indiana, Ohio, and southern Michigan and Wisconsin. Fewer species are reported from Iowa than from any of the states adjacent to it on the east, probably because of the relative scarcity of proper habitats in Iowa and its smaller annual rainfall. As might be expected on the western side of the Mississippi, a slight but perceptible western or southwestern element occurs in the moss flora. The most characteristic indications of such an element are all in the family Funariaceae, namely: *Physcomitrium Hookeri* Hampe, *P. Drummondii* E. G. Britton, *Pyramidula tetragona* (Brid.) Brid., and *Funaria calvescens* Schwaegr.

The relatively small number of species reported from Iowa and the scarcity of unusual species are directly related to the widespread occurrence of only two main types of habitat: prairie, either wet or dry, and occasional open woods. Naturally the mosses are types characteristic of these habitats, with very few bog or aquatic species presented. In one region of Iowa, and there only, the moss flora departs from this simple formula and is really diversified. This is in the so-called unglaciated area in the extreme northeast corner of the state, where a number of interesting species have been reported (Blagg, 1928a, 1928b; Conard, 1932a, 1932b, 1938). The wonder not however, that interesting species have been found there, but that there are so few of them, when one considers the large number of unusual mosses collected by Dr. Holzinger at Winona, Minnesota, not a great deal farther north in the same driftless strip along the Mississippi River. *Bryoxiphium norvegicum*, for example, is almost certain to turn up in northeastern Iowa (Steere, 1937b).

One of the most characteristic features of the present-day Iowa moss flora is the scarcity of aquatic and bog bryophytes. Pammel (1909) says: “There are none of the typical moss bogs found in this state . . . . *Sphagnum* has not been found anywhere in the bogs of northern Iowa.” Even though two species of Sphagnum, *S. medium* and *S. cuspidatum*, have recently been reported from Iowa (Cavanagh, 1929a, 1929b), Pammel’s last statement still holds true, since they came from wet banks in woods in Muscatine County, which is in the easternmost part of the state and outside the Wisconsin drift area. Thus the bogs are apparently of a nature quite different from those farther north. Beyer (1909), in discussing the peat bogs of Iowa, with special reference to their economic importance, says: “While in high latitudes and high altitudes the club mosses, sphagnums and hypnums contribute very largely toward the accumulation of peat, grasses and sedges are much more important in Iowa peat bogs. Mosses are present occasionally, but play a secondary role.” This essential and fundamental difference between the modern bogs of Iowa and the extinct boreal ones is very noteworthy. The boreal type of bog, as exemplified in northern Minnesota, Wisconsin, and Michigan, and from there north into the Arctic, abounds in all types of bryophytes and is probably richer in species than any other type of habitat in the glaciated region, a striking contrast to vegetation in Iowa today.

All the mosses yet reported from Aftonian deposits, together with those discussed in another section of this paper (pp. 82-90), have been species quite characteristic of boreal bogs. This is emphasized by the fact that most of them, including the Sphagna, no longer occur in Iowa. An examination of their present geographical distribution should demonstrate convincingly that the majority of them are boreal or sub-Arctic species. The most characteristic northern mosses from Aftonian deposits in Iowa are: *Dicranum Bergeri*, *Calliergon stramineum, C. giganteum, C. cordifolium, C. Richardsonii C. trifarium, C. turgescens*, *Drepanocladus exannulatus, D. revolvens, Scorpidium scorpioides*, and *Camptothecium nitens*.

Higher Plants

During the Aftonian interglacial stage nearly the whole state of Iowa must have been covered by a dense coniferous forest of a strictly boreal nature. At least this is the conclusion to be drawn from the fossil material recovered from Aftonian deposits. It is demonstrated by the widespread occurrence of wood fragments, logs, and stumps, as well as leaves, twigs, and cones, in an area where there is no natural forest now. In parts of central and southern Iowa, where there have been no forests within historical times, the old forest bed is so well preserved that fully fifty per cent of the excavations penetrating to its depth reveal it in situ, whereas nearly all the rest contain battered logs and sticks (McGee, 1891; Baker, 1920). In some places the water in nearly every well is flavored by products of the slow decomposition going on in the forest layer which is penetrated by the wells. In fact, much of the water in such areas is rendered unfit for drinking because of remains from this forest of approximately a million years ago.

The species of conifers that have been recognized from the debris of the old forests are *Larix laricina* (Macbride, 1896), *Thuja occidentalis* (McGee, 1891), *Picea mariana* (Macbride, 1907), and *P. canadensis* (Macbride, 1907). It is important to notice that these boreal forests, which probably indicate a rather poorly drained region, extended in Aftonian times to the southernmost edge of Iowa and perhaps into Missouri. In fact, the earliest known and best examples of old soils, peats, and forest beds of Aftonian age are found toward the southern edge of the state and, further, the type locality of the horizon is in Union County, which is next to the southernmost tier of counties in the state.

At present, of course, the forest cover of the state is very slight, and much of it is secondary. Even the bogs and swamps are unique in the almost total absence of trees and shrubs. Of the characteristic inhabitants of boreal bogs during the Aftonian none is still found in Iowa. The principal coniferous species of the state now are the highly localized *Abies balsamea*, which grows on cold, wet limestone in the unglaciated northeast corner (Pammel, 1907; Conard, 1938), *Pinus Strobus*, in small and isolated areas; *Juniperus communis*, *J. virginiana*, and *Taxus canadensis*, all of which have a more southern range than the species found in Aftonian deposits. It is rather surprising that the tamarack should be completely lacking in Iowa (Pammel, 1907)

CONCLUSIONS

It is only fair to remark here that there are several criticisms which may be brought to bear on the thesis that the plant remains of the Aftonian deposits present positive evidence that the climate of the interval was boreal.

In the first place, it is evident that topography has a very considerable influence on vegetation, and particularly on the distribution of bogs. The surface of the Kansan drift has been exposed to the elements for an enormous length of time, during which several glacial and interglacial stages have elapsed. As a result, the area in which the Kansan drift is exposed has a well-developed drainage system. The same thing is true of the surface of the Iowan drift and loess, but to a somewhat lesser extent, since they are more recent. It is only within the areas in Iowa which were covered by an ice sheet during the Wisconsin glaciation that one finds a really youthful topography, with its characteristic lack of drainage, which results in numerous lakes and ponds. Even so, bogs are limited to the margins of the Wisconsin drift, where, because of the moraines, the topography is more irregular. Beyer (1909), in his discussion of the distribution of the peat bogs throughout the state, says: ". . . all the peat bogs of commercial importance are confined to the Wisconsin drift sheet. The deepest bogs tested are in those morainal tracts where the surface is most broken. Away from the morainal belt the basins become shallower and the peat thinner, and as a general rule poorer in quality."

Thus it might be said that the lack of boreal mosses and forests may be caused by the lack of suitable habitats. It would be a much more valid argument if the deep bogs in the moraines of Wisconsin drift in the northern part of Iowa had such a flora. But since they do not and since the typical boreal bogs of northern Minnesota Wisconsin, and Michigan are also on the surface of the Wisconsin drift sheet, it would appear that climate, or perhaps only some single factor such as temperature or rainfall, is the deciding point, rather than topography. It is probable that earlier in postglacial times boreal species existed in the bogs of Iowa, but have since disappeared as the climate ameliorated with the gradual withdrawal of the Wisconsin ice sheet, which took a good many thousand years (Antevs, 1928). The obsolete, filled-in bogs on the weathered surface of the ancient Kansan drift sheet are an interesting subject for research. Their stratigraphical and biological make-up could be investigated without difficulty by means of borings. Although strictly speaking, these bogs might be considered postglacial, in a temporal sense they are interglacial, and are so considered by the European glaciologists. Such obsolete interglacial bogs have been carefully studied in Jutland and in northern Germany (Jessen and Milthers, 1928) and the advance and regression of the different floras during two glacial epochs clearly demonstrated. A study of the superficial interglacial bogs of Iowa, with their records of plant and animal inhabitation, might provide some interesting and illuminating data on the question of climates during the different interglacial stages in North America.

In the second place, it might be argued that the boreal bogs of the Aftonian were simply boreal islands in a warm temperate climate, as the isolated tamarack and spruce bogs of southern Wisconsin, Minnesota, and Michigan are frequently considered today. This argument may be refuted in three ways: (1) the genuinely boreal nature of many of the Aftonian species of mosses, which do not now live in the southernmost coniferous bogs; (2) the lack of remains of a really temperate flora, which would certainly have been blown or washed into the bogs, if present; and (3) the enormous areal extent of the Aftonian deposits.

In the third place, the objection might be raised that the boreal species reported from the Aftonian are from the beginning or the end of that epoch, when, as is perfectly obvious, a boreal type of climate must have prevailed, or even an Arctic type in the vicinity of the ice front. The forest beds, with the roots and stumps still in place, which have often been described from the Aftonian deposits, most certainly represent the very end of that interglacial interval, when the Kansan ice sheet spread its load of debris over the remains of the old forest. In general, however, the plant remains known from the Aftonian so far are to a surprising degree those of distinctly boreal species. Below the forest bed are often other layers of muck and peat which likewise contain traces of plants. Sometimes many feet of exposed fossiliferous strata rest at the bottom on Nebraskan drift and are covered at the top by Kansan till, thus apparently representing a record of a large part of the interglacial period. Yet from such deposits no species of deciduous trees of a true southern nature have been reported. The most temperate type of vegetation was apparently the pine forests; at least, fragments of pine wood have been found in the deeper strata. That traces of more southern types would have persisted, if they had originally been present, is shown by the occurrence of such material in deposits from the second or Yarmouth interglacial interval, after the Kansan glaciation.

In conclusion, it seems to me beyond doubt that the climate of the part of the Aftonian interglacial interval whose deposits have go far been found was much colder and more humid than the present climate of Iowa. Positive evidence of this difference is given by the abundant remains of boreal mosses. To judge from a rough average of the present geographical ranges of the species of plants and animals which have persisted from Aftonian times, the climate of that stage must have approximated the climate which now prevails in the same longitude between five hundred and a thousand miles farther north.

SUMMARY

1. Earlier reports and records of fossil bryophytes, especially those concerned with Pleistocene material, are reviewed.

2. The remarkably fine preservation which has been reported for Aftonian moss specimens is corroborated and illustrated.

3. An annotated list is given of the thirty-three species of mosses (in nearly twenty genera) which have been recognized and named in a large collection of Aftonian material.

4. Four species were so distinct from the most nearly related modern species that they are here proposed as new.

5. Evidence is presented to show that some genera, especially Calliergon and Drepanocladus, were probably more closely related during Aftonian times than they are at present, through a now extinct series of intermediate forms.

6. The absence of many species, which, on the basis of present distribution and association of species, should have been found this material, is correlated with the chemical composition of the cell walls of the missing species.

7. The great importance of fossil mosses as indicators of the climatic conditions under which they lived is pointed out and their use in climatic studies of the past suggested, since in Pleistocene deposits there are often more species of mosses than of any other group of plants.

8. The temperate and subboreal nature of the modern moss flora of Iowa is contrasted with the boreal and sub-Arctic species of Aftonian times.

9. It is finally concluded that the Aftonian interglacial stage, so far as can be judged by the abundant moss material which has been discovered in its deposits, was much colder and wetter than at present, with a climate like that now existing five hundred to a thousand miles farther north.

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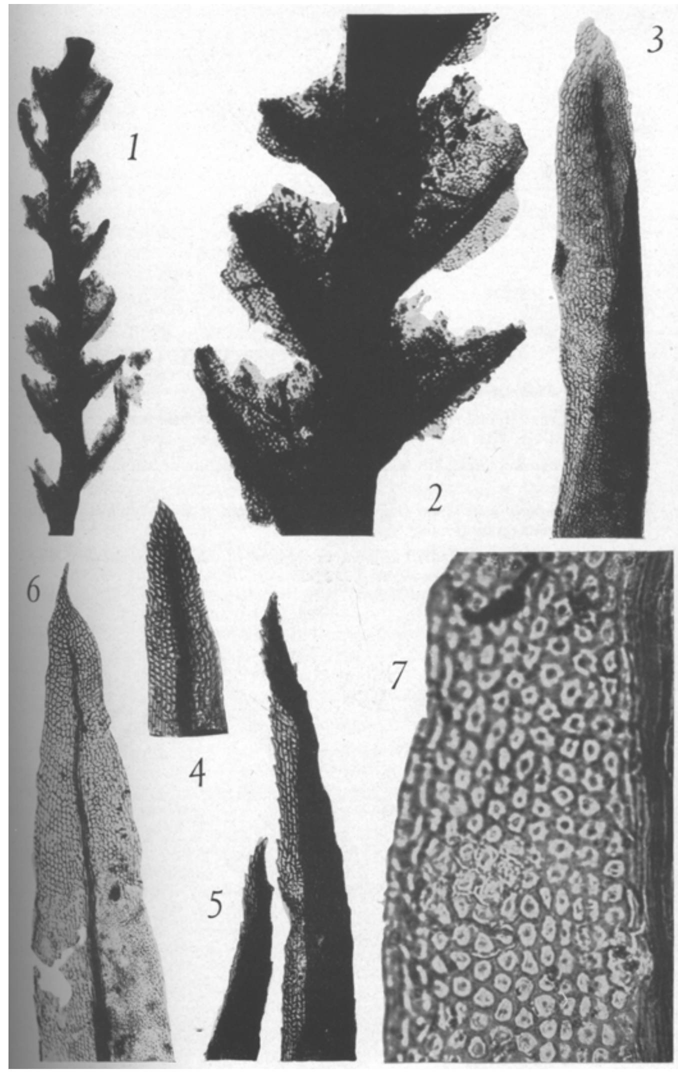
STEERE PLATE I



Pleistocene mosses

EXPLANATION OF PLATE I

FIG. 1. *Fissidens sp*. The entire fragment, which shows the characteristic distichous leaf arrangement. x 25

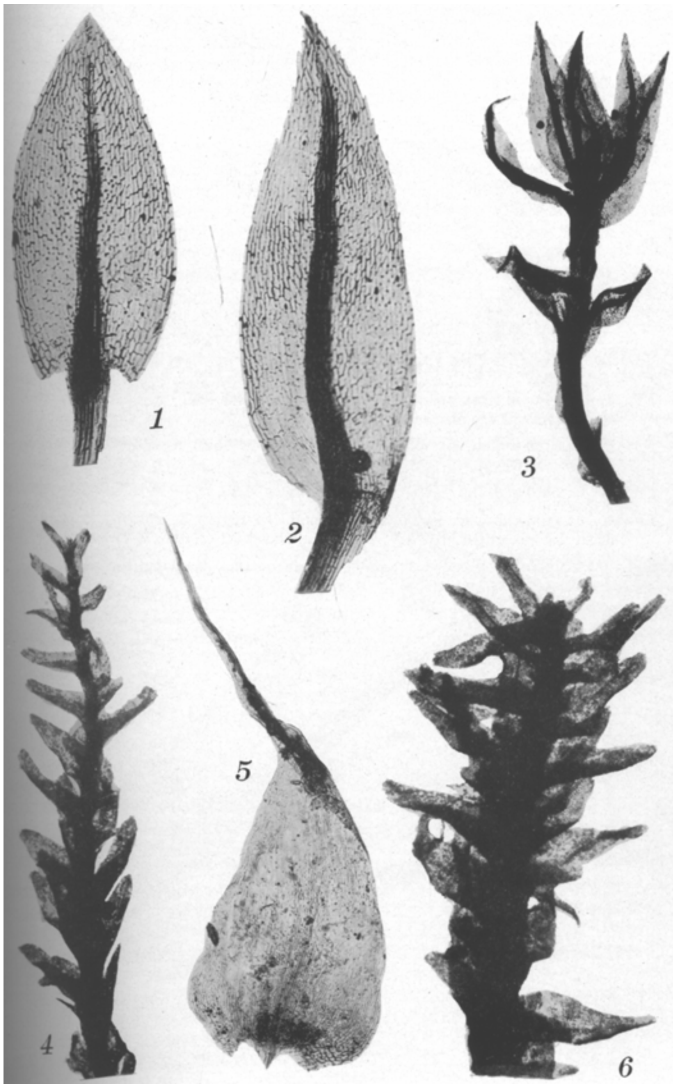
FIG. 2. *F. sp*. Detail of part of stem shown in Figure 1. x 77

FIGS. 3-4. *Dicranum Bergeri* Bland. Upper part of two leaves, showing the typical short cells and the costa ending below the apex. x 77

FIG. 5. *D. Bergen* Bland. Profile view of two leaves. The serration of the dorsal side of the costa is well shown. x 77

FIG. 6. *Aulacomnium palustre* (Web. & Mohr) Schwaegr. Upper part of leaf. x 77

FIG. 7. *A. palustre* (Web. & Mohr) Schwaegr. Detail of same leaf, showing the thick-walled unipapillose cells. x 332



Pleistocene mosses

EXPLANATION OF PLATE II

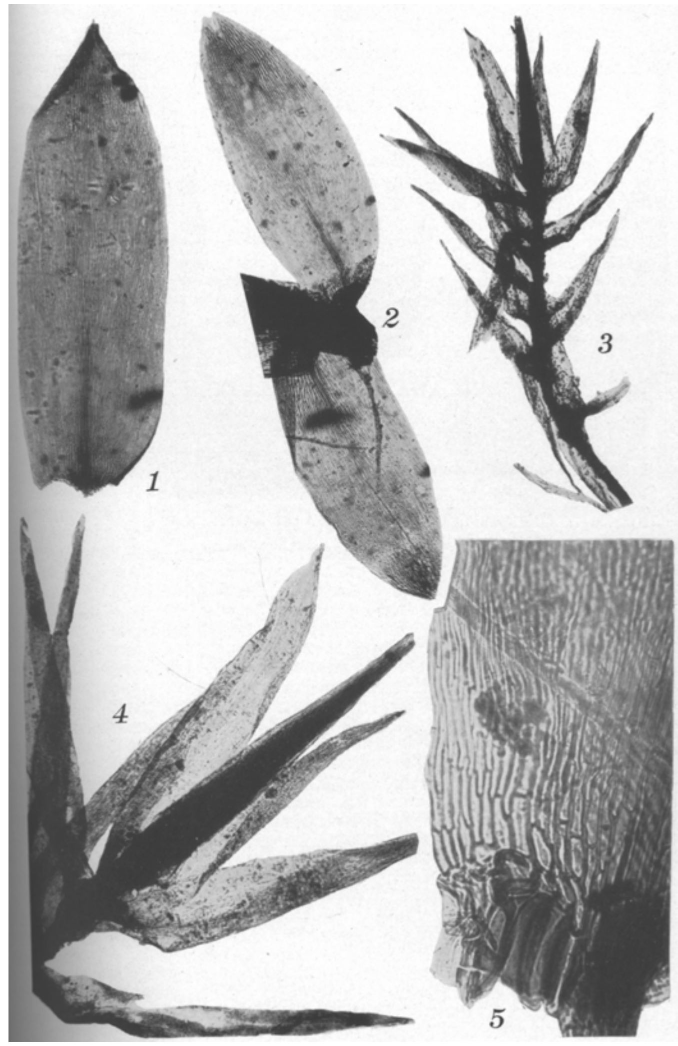
FIGS. 1-2. *Philonotis sp.* Single leaves. x 77

FIG. 3. *P. sp*. Habit of whole specimen, from which several leaves have been removed. x 20

FIG. 4. *Anomodon attenuatus* (Hedw.) Hüben. Characteristic attenuate branch x 25

FIG. 5. *Campylium stellatum* (Hedw.) Lange & Jens. A singe typical leaf with conspicuous quadrate alar cells. x 77

FIG. 6. *A. attenuatus* (Hedw.) Hüben. Fragment of main stem, showing more detail of leaf shape than Figure 4. x 25



Pleistocene mosses

EXPLANATION OF PLATE III

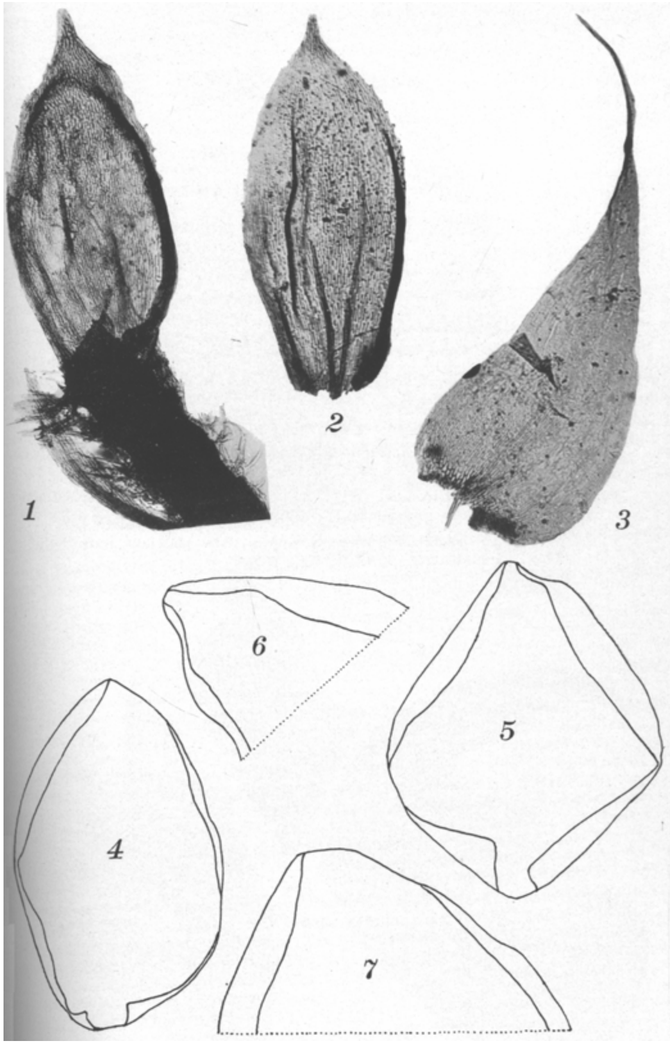
FIG. 1. *Calliergon aftonianum*, sp. nov. Single branch leaf. The leaf shape and the short costa are characteristic. x 77

FIG. 2. *C. aftonianum*, sp. nov. Leaves with very short costa from base of a branch. x 60

FIG. 3. *C. Hansenae*, sp. nov. Habit of plant. x 20

FIG. 4. *C. Hansenae*, sp. nov. Apex of plant in Figure 3, showing in greater detail the stern apex, the leaf shape, and the short costa. x 77

FIG. 5. *C. Hansenae*, sp. nov. Basal angle of leaf, showing the elongated, Drepanocladus-like alar cells. x 332



Pleistocene mosses

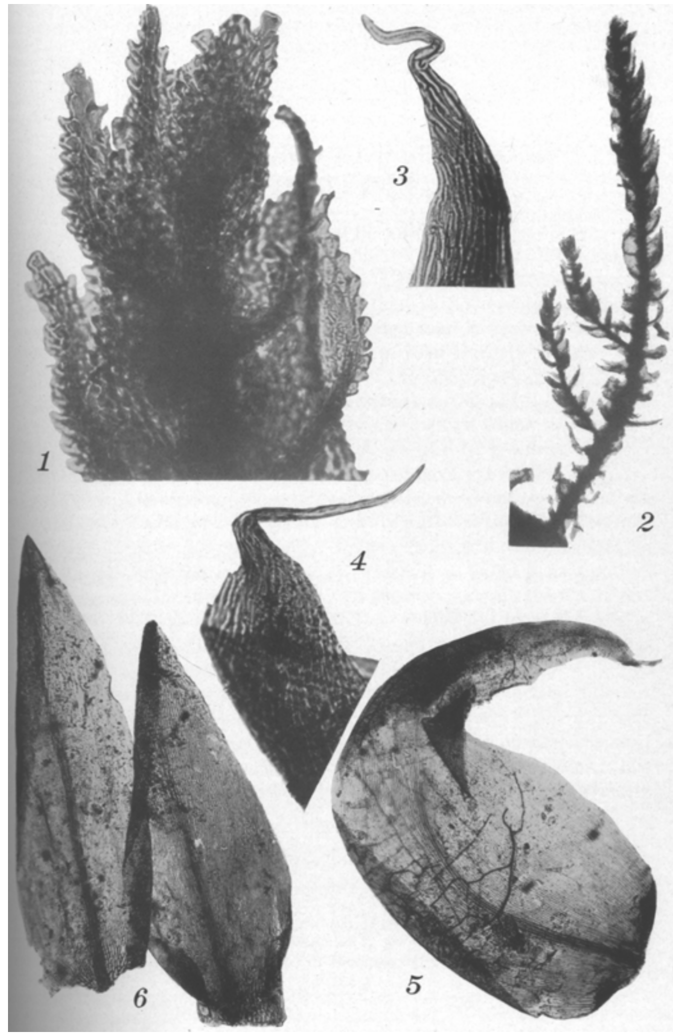
EXPLANATION OF PLATE IV

FIGS. 1-2. *Hylocomium splendens* (Hedw.) Bry. Eur. Leaves, showing the typical double costa and the paraphyllia. x 77

FIG. 3. *Campylium stellatum* (Hedw.) Lange & C. Jens. A single leaf. x 77

FIGS. 4-5. *Calliergon Kayianum*, sp. nov. Whole leaves. x 24

FIGS. 6-7. C. KAYIANUM, sp. nov. Apex of two leaves. x 40



Pleistocene mosses

EXPLANATION OF PLATE V

FIG. 1. *Thuidium delicatulum* (Hedw.) Mitt. Apex of ultimate branch, showing the well-preserved papillae on the leaf cells. x 332

FIG. 2. *T. delicatulum* (Hedw.) Mitt. Habit of branch. x 20

FIGS. 3-4. *Drepanocladus apiculatus*, sp. nov. Characteristic apiculus from two leaves. x 332

FIG. 5. *D. apiculatus*, sp. nov. Whole leaf, showing the costa, the undifferentiated alar cells, the apiculus, and the fungous hyphae. x 77

FIG. 6. *Calliergon giganteum* (Schimp.) Kindb. Alar cells and well-developed costa of branch leaves. x 77

LAKE-SHORE INVENTORY AND CLASSIFICATION

NEAL M. BOWERS, KENNETH C. MCMURRY, AND KATHERINE M. STAHL

MICHIGAN'S shore line, facing four of the Great Lakes and extending over. 1,600 miles,[1] is longer than that of any other water-bounded state in the Union. The property along this shore is largely held in private ownership, frequently for speculation and often with the mistaken notion that all frontage has relatively high value.

This paper, growing out of work done at the University of Michigan Geography Camp during the summer session of 1940, represents an effort to discover what items make up shore complexes, to arrive at a system of classification based upon these items, and to determine the extent of types derived from this classification along the shore under study. It must be recognized that this report is a record of progress, covering investigation of a small area. Much more work in the field will be necessary before any final classification of value to both state and private interests can be reached. The strip of shore in question is located along the northwestern coast of Emmet County, between McGulpin Point and the little village of Goodhart (Fig. 1), and is approximately fifty miles long.

The intensive recreational usefulness of any shore is best expressed in terms of public demand. Bathers want sandy beaches with sandy foreshores, wide strips of shallow water in which children can wade and splash, and deep water not too far from shore for swimming. Those who sail ask for safe anchorages and wide stretches of water free from rocks and sand bars. Campers need dry sites, sufficiently well drained to insure proper sanitation. Accessibility is another factor to be considered. The fluctuation of water levels from one year to another must also be noted in evaluating shores for such use.

The character of the shore line depends upon the nature of the land and the length of time the water has been working along the shore. An approach to the problem of shore classification from this point of view would give, however, a genetic system of little value in terms of shore types for recreational use. In order to picture most completely the physical nature of the shore and to include the many diverse geographic, physiographic, and botanic elements the classification must be empirical.

In undertaking a systematic study of shores it was necessary to adopt a definite terminology. The water line was defined as the line at which the land and the water meet. Landward from this line to the limit reached by waves during storms is the beach, the strip over which the water washes. Still farther landward is the backshore, a zone of indeterminate width. Lakeward from the water line is the foreshore, a water-covered strip of varying width, arbitrarily marked on its outer margins by the five-foot water contour. The combination of these three elements, the backshore, the beach, and the foreshore, makes up the shore.

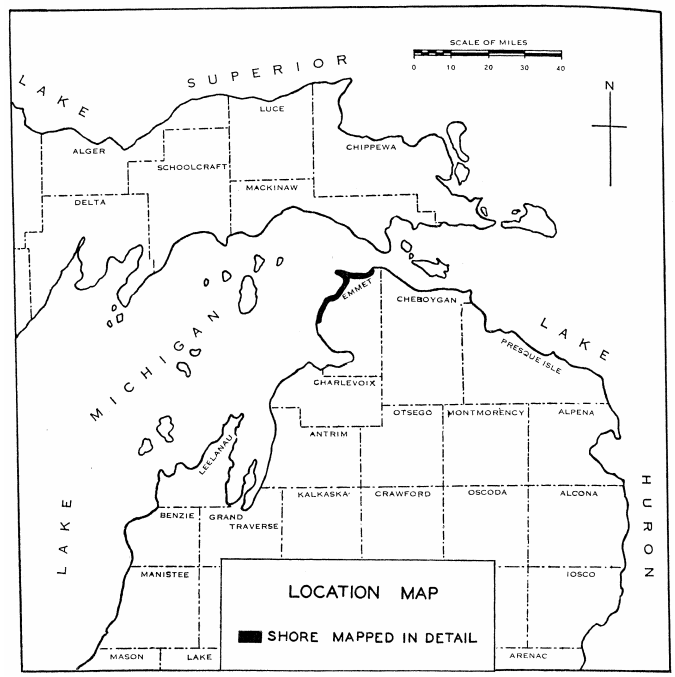


FIG. 1

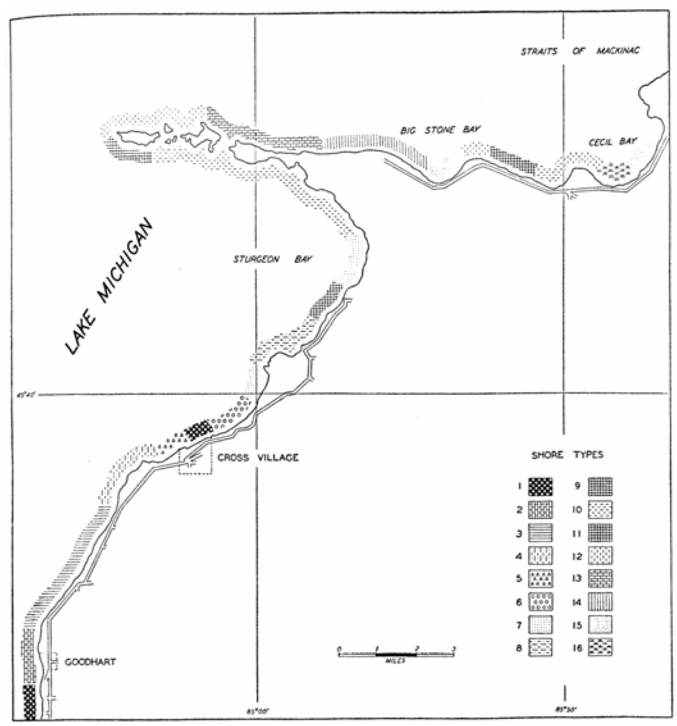


FIG. 2

So many factors contribute to the suitability or the unsuitability of a shore for various recreational purposes that it was necessary to consider the shore features in detail. Mapping was done on a scale of eight inches to a mile, covering the backshore, the beach, and the foreshore. Surface configuration, drainage, vegetation, and the nearest roads were mapped on the backshore, surface materials and vegetation on the beach, bottom materials and water depths on the foreshore. The width of the beach and the distances from the water line to the one-foot and five-foot water contours were also indicated on the field sheets. Note was made of any recreational development along the shore — cottages, hotels, tourist camps, and state parks.

TABLE I

Lake Michigan Shore Types along the Northwestern Coast of Emmet County, Michigan

Type	Backshore	Beach	Foreshore
I	Bluff, strip 3 to 8 chains wide between beach and base of bluff, covered by small sand dunes Mixed hardwood	Sand; 1 to 4 chains wide	Gravel, pebbles, cobbles, boulders; 6 to 20 chains wide
II	Bluff, strip 3 to 8 chains wide between beach and base of bluff, covered by small sand dunes Mixed hardwood and conifer on face of bluff, hardwood on top	Sand, cobbles, boulders, marsh patches; 1½ to 5 chains wide	Sand, cobbles, boulders; 5 to 10 chains wide
III	Bluff Mixed hardwood and conifer on face, hardwood on top	Sand; 1½ to 5 chains wide	Sand, cobbles, boulders; 6 to 20 chains wide
IV	Dunes, fixed Hardwood cover	Sand; 1 to 4 chains wide	Sand, cobbles, boulders; 5 to 10 chains wide
V	Bluff, strip 8 to 10 chains wide from beach to base of bluff, covered by sand ridges and small fixed dunes Hardwood cover on bluff, grass below the bluff	Sand; 1 chain wide	Sand, 5 chains wide
VI	Dunes, fixed Norway pine and white pine	Sand, pebbles; ½ to 1 chain wide	Sand, pebbles, cobbles; 3 chains wide
VII	Dunes, active dunes backed by fixed dunes Jack pine, oak, poplar	Sand, pebbles; 1 to 3 chains wide	Sand, 1 to 3 chains wide
VIII	Dunes, active dunes backed by fixed dunes, large blowouts in the active dunes White pine, oak, poplar	Sand; 2 to 4 chains wide	Sand, cobbles, boulders; 3 to 10 chains wide
IX	Dunes, fixed Mixed hardwood, poplar, birch	Sand, gravel, pebbles, cobbles, marsh patches; 1 to 3 chains wide	Sand, cobbles, boulders, mud, marl; 4 to 10 chains wide
X	Beach ridges Conifer cover	Pavement, gravel, pebbles, cobbles; marsh patches; 2 to 18 chains wide	Sand, cobbles, boulders; 15 to 25 chains wide
XI	Beach ridges Conifer cover	Cobbles, boulders, shingle; 3 to 6 chains wide	Cobbles, boulders, bedrock; ⅓ to 3 chains wide
XII	Beach ridges Mixed-conifer cover	Pebbles, cobbles, boulders; 2 to 18 chains wide	Cobbles, boulders; ½ to 9 chains wide
XIII	Beach ridges Mixed-conifer cover	Sand, gravel, pebbles; 1 to 5 chains wide	Sand, gravel, pebbles, cobbles; 5 to 15 chains wide
XIV	Beach ridges Mixed-conifer cover, poplar	Sand, cobbles, boulders, marsh patches; ½ to 6 chains wide	Pebbles, cobbles, boulders; 5 to 15 chains wide
XV	Beach ridges Mixed-conifer cover	Sand; 1 to 4 chains wide	Sand; 2½ to 6 chains wide
XVI	Beach ridges Mixed-conifer cover	Marsh; 8 to 15 chains wide	Mud, sand; 10 to 15 chains wide

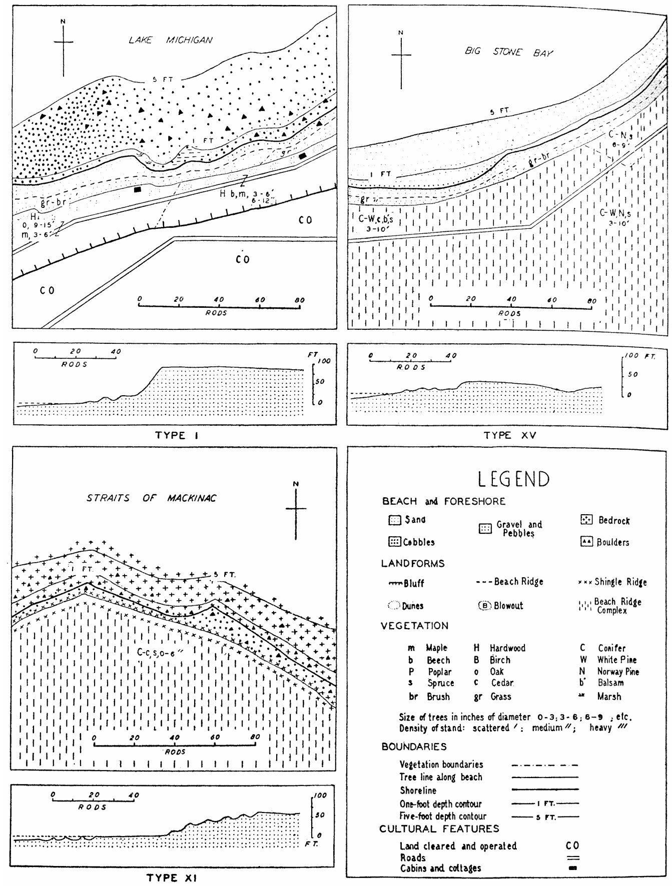


FIG. 3. Shore types

Considerable more diversity was found than was expected. In general, the backshore consisted of three surface types, dunes, bluffs, and beach ridges, with cover ranging from solid hardwood stands through various mixed associations to solid conifer. Along the beach and foreshore, mud, marl, sand, gravel, pebbles, shingle, cobbles, small boulders, large boulders, and bedrock occurred singly and in combination. Beach vegetation was composed of grasses, brush, and marsh plants. The beach varied in width from ½ chain to 18 chains; the foreshore, from $^1/_6$ chain to 25 chains.

Observation in the field and study of the maps brought out varying qualities from one shore locality to another, and characteristic backshore, beach, and foreshore types were established. Groupings of these three elements gave shore types which could be mapped as definite entities (Fig. 2).

Sixteen different shore types were established (Table I). These may be grouped under three broad categories on a basis of intensive recreational possibilities. For example, Type XV (Fig. 3), with a mixed-conifer-covered backshore of beach ridges, a sandy beach from 1 to 4 chains wide, and a sandy foreshore from 2½ to 6 chains wide, makes an ideal shore for such use. In sharp contrast to this, and falling definitely under the poor class in this relation, is Type XI (Fig. 3), with a backshore of conifer-covered beach ridges, a shingle, cobble, and boulder beach, 3 to 6 chains wide, and a bedrock, cobble, and boulder foreshore, ⅓ to 3 chains wide.

Midway between these two is Type I (Fig. 3), with a hardwood-covered bluff backshore, a sandy beach 1 to 4 chains wide, and a foreshore of gravel, pebbles, cobbles, and boulders, 6 to 20 chains in width.

Along the shore studied only six miles, or about 12 per cent of the total frontage, may be classed as good on this basis. Twenty per cent may be classified as fair; 68 per cent is definitely poor. In terms of various other uses different ratings might be developed.

In final analysis it appears that, except for limited areas, the greater part of the shore is almost worthless for those recreational uses upon which high frontage values are postulated. Our work here, which shows only an approach to the problem, needs much further extension before a final conclusion can be reached. The shore types developed are not to be regarded as representative of all shores. A continuation of work along the coast would introduce other types and thus increase the complexity of the system. Further simplification is needed, but this must be accomplished without too great loss of detail; otherwise the value of the classification will be lost.

UNIVERSITY OF MICHIGAN

[1] *Michigan Official Directory and Legislative Manual*, 1939, p. 6. Michigan Department of State.

FARMSTEADS AND LAND TYPES IN EMMET COUNTY, MICHIGAN

FRED W. FOSTER

INTRODUCTION

A METHOD of land classification in which the unit of inventory is the land type has been proposed and applied in the field.[1] The basic land types for Emmet County were established by J. O. Veatch after reconnaissance in the early summer of 1937. By the close of the field season the northern two thirds of the county had been mapped.[2] The work was completed during the summers of 1938 and 1939. With aërial photographs it was possible to revise and refine the land types outlined in the first summer. New ones were added, and some were dropped to achieve the same degree of detail.

If the land types as established are valid entities, there should be some relationship between the physical conditions they represent and the cultural patterns that develop as they are used by man. Such connections will be best expressed in terms of productivity. A complex of conditions in addition to the productivity of his land influences the ultimate success or failure of any farmer. These include ambition, alertness, available markets, and the cost of transportation. In a small area where the same general advantages and disadvantages prevail marked variations in the character of farms and farmsteads from place to place will, however, reflect the quality of the land. On the basis of this idea correlations have been made between the land types and the farms and farmsteads in Emmet County.

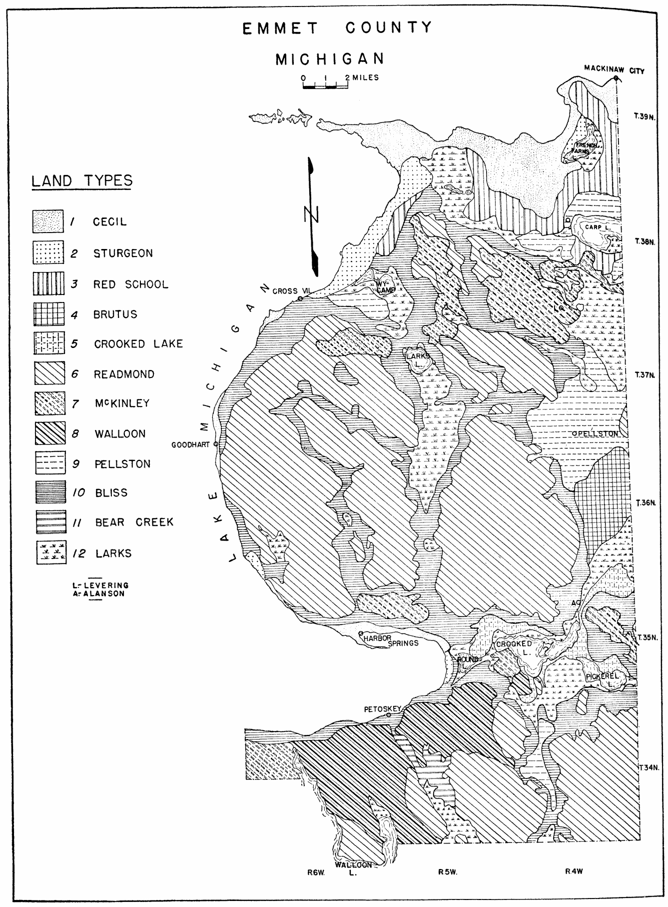


FIG. 1

DESCRIPTION OF THE LAND TYPES (SEE FIG. 1)

As Emmet County is approached from the north the land rises in a series of terraces retreating from the shore of Lake Michigan. These terraces are level or slightly inclined and are marked by relict shorelines along the lake ward margins. The nature of the drainage is dependent upon the position of the terrace and the character of the soil material. South of the benches a morainic mass stands high above a surrounding lowland area of diverse composition. The lowland is particularly evident along the east side of the county and is terraced after the manner of the benches in the north. The morainic material is shaped into drumlin-like ridges or deposited as sandy plateaus that are cut by numerous dry valleys. The plateau surface and its margins exhibit occasional kamic deposits. A number of broad flat-floored valleys transect the moraines. Their location is such that they separate the upland into a series of poorly defined ranges with a north-south trend. In the southern part of the county the eastern lowland swings to meet Little Traverse Bay. South of the depression thus formed the elevated area continues — the drumlins in the west and the sandy moraines in the east. On the varied surface described, with its complex associations of soil, slope, vegetation, and drainage, the land types are developed.

OUTLINE OF THE LAND TYPES

1. *Land Types with Small Local Relief and Slow or Poor Drainage*

CECIL
Vegetation
Major — Cedar, balsam fir, white spruce, aspen, white pine, Norway pine,red maple, alder, willow
Minor — Ash, elm, white birch, tamarack, hemlock, marsh grasses, sedges; leatherleaf bogs
Surface: Successive beach ridges with occasional flat areas
Soil[3]
Major — Alpena loam and cobbly loam, Eastport sand
Minor — Newton sand, Rifle peat, Greenwood peat, Wallace sand, Saugatuck sand and Granby sand
Drainage: Poor in swales and flats; small sluggish streams

RED SCHOOL
Vegetation: Cedar, white spruce, balsam fir, aspen, elm, ash, red maple, yellow birch, basswood, tamarack
Surface: Gently sloping toward the lake; broken by old sandy beach ridges
Soil
Major — Ogemaw sandy loam, Munuscong sandy loam
Minor — Saugatuck sand, Newton sand and Rubicon sand
Drainage: Slow; water has a tendency to stand on surface

CROOKED LAKE
Vegetation: Cedar, white spruce, tamarack, elm, ash, red maple, aspen
Surface: Level; gently sloping
Soil
Major — Bergland clay loam or loam
Minor — Newton sand, Granby sand, or Rifle peat
Drainage:
Slow on surface; ground water table high

BEAR CREEK
Vegetation: Aspen, with some conifer and red maple
Surface: Level to gently sloping, with occasional sandy ridges
Soil
Major — Antrim sandy loam
Minor — Kalkaska sandy loam, Newton sand and Saugatuck sand
Drainage: Slow to poor

BRUTUS
Vegetation
Major — Red maple, elm, aspen, ash
Minor — Cedar, spruce, balsam fir, hemlock
Surface: Level; gently rolling
Soil
Major — Selkirk silt loam, Brimley fine sandy loam
Minor — Ogemaw sandy loam, Saugatuck sand, Newton sand, Rubicon sand
Drainage: Slow to poor; seepage on some slopes

LARKS
Vegetation: Cedar, white spruce, balsam fir, ash, elm, red maple, alder, willow, aspen, tamarack, balm of Gilead, white and yellow birch
Surface: Flat
Soil
Major — Rifle peat, Newton sand, Saugatuck sand
Minor — Granby sand, Greenwood peat, Bergland clay loam
Drainage: Poor

2. *Land Types with Small Relief and Rapid Drainage*

BLISS
Vegetation
Major — Hard maple, beech, elm
Minor — Pin cherry, hemlock, aspen, basswood, yellow birch, white birch, white pine, Norway pine
Surface: Gently sloping, sometimes sharply broken at intervals, where terraces develop
Soil
Major — Kalkaska loamy sand or sandy loam
Minor — Rubicon sand, Wallace sand, Alpena cobbly loam
Drainage: Good; poor in spots

PELLSTON
Vegetation
Major — Aspen, pin cherry
Minor — Residual white or Norway pine and hard maple, bracken and grass
Surface: Practically level, occasionally broken by beach ridges
Soil
Major — Rubicon sand
Minor — Kalkaska loamy sand, Saugatuck sand, Wallace sand, Greenwood peat
Drainage: Good; poor in occasional small areas

3. *Land Types with Considerable Local Relief*

WALLOON
Vegetation
Major — Hard maple, beech, elm, basswood, yellow birch
Minor — Aspen, cherry, with cedar, balsam fir, red maple, ash, alder, and willow in depressions
Surface: Pronounced drumlin-like topography with a northwest-southeast trend, steep marginal slopes
Soil
Major — Onaway sandy loam
Minor — Onaway loam, Emmet sandy loam, Granby sand, Newton sand, Lupton muck, Rifle peat
Drainage: Poor in depressions

McKINLEY
Vegetation
Major — Hard maple, beech
Minor — Basswood, aspen, yellow birch, pin cherry, with cedar, balsam fir, elm, ash, red maple, alder, and willow in depressions
Surface: Plateau-like, or suggestive of drumlins
Soil
Major — Emmet sandy loam
Minor — Onaway sandy loam, Emmet loamy sand, Newton sand and Granby sand, Rifle peat
Drainage: Poor between many of the ridges

READMOND

Vegetation

Major — Hard maple, beech, elm

Minor — Aspen, hemlock, white pine

Surface: Dissected sandy moraine, steep marginal slopes, gentler interior slopes; surface often traversed by a maze of "fossil" valleys

Soil

Major — Emmet loamy sand

Minor — Emmet sandy loam, Onaway sandy loam, Kalkaska loamy sand

Drainage: Rapid; few streams; few if any swamp areas; some seepage on slopes

STURGEON

Vegetation

Major — Norway pine, white pine, jack pine, oak, aspen

Minor — Pin cherry, sugar plum, hard maple, white birch, grass, bracken, ground juniper; swales covered with sedges and marsh grasses

Surface: Dune topography with some fresh blow

Soil

Major — Wallace sand

Minor — Bridgman sand, Houghton muck

Drainage: Good; poor between dunes

FARMS AND THE LAND TYPE

Indians were the first agriculturalists in Emmet County. Their fields were small and widely separated; nevertheless, some corn was available for sale at the settlements along the Straits of Mackinac. The government surveyors' notes record the occasional Indian clearings on the lines of traverse. Unverified reports have mentioned Indian orchards. But despite encouragement by missionaries and the government, agriculture seems never to have supplied all the food needed. Hunting, fishing, and the gathering of wild plants supplemented the food supply. The area under cultivation was expanded as white settlers encroached upon the aboriginal domain, but the fields were never far from Lake Michigan. A good location was more important than soil fertility, and water travel was the chief means of communication. In consequence, the lake-border land types with good drainage were spotted with Indian clearings along the shoreward margins. These land types are the Bliss, Readmond, and Walloon.

It is sometimes assumed that lumbering preceded agriculture over most of the northern part of the Lower Peninsula of Michigan. In Emmet County lumbering and farming were contemporaneous. While the woodsmen cut over the Cecil, the Red School, the Sturgeon, and the Pellston land types, and parts of the Bliss, farm clearing was going ahead rapidly in other areas. The settler was not concerned with the potential value of the wood. Logs were used for cabins and barn timbers. The remaining trees were cut, hauled into piles, and burned.

From the very beginning the newcomers tilled the soil. Farm economy was based upon the production of potatoes and other root crops, grains, hay, and cattle. It is interesting to note that the early settlers predicted the decline of agriculture as the "rash" among them mortgaged their land and drove their oxen to Antrim County, where they traded them for horses.

These farmers labored under circumstances that were favorable to at least temporary success. The towns of Petoskey and Harbor Springs were growing rapidly; boats were continually docking along the shore, and the lumber industry was in full swing. Here was an adequate market for excess production. Then, too, with settlement came the resort industry and the railroad. One supplied a market that would permit of some specialization, and the other an outlet for surplus produce — not ordinarily found in pioneer areas.

Much of the land gave every indication of being extremely fertile. The yields were large. Father Weikamp's mission farm, which was not considered of especially good soil, is supposed to have furnished as a twenty-year average the following per-acre harvest: wheat, 30 bushels; oats, 60 bushels; rye, 27 bushels; barley, 26 bushels; potatoes, 400 bushels; beets, 400 bushels; carrots, 400 bushels; turnips, 500 bushels; rutabagas, 500 bushels; timothy hay, 2½ tons. The soils were rich in partly decayed organic matter, and certain amounts of accumulated soluble minerals were present. Surrounding woods held few pests, either plant or animal, to interfere with production. Prospects for agricultural development were regarded as being among the best in Michigan, and there can be no question but that farming had an auspicious start.

In the sixty-five years since the first agricultural settlement development has not progressed with the same speed or to the same degree on all the land types. Though the term "general farming" might be applied to all such activity within the county, the quality and the character of the agriculture vary from land type to land type.

Walloon agriculture. — Farming on the Walloon land type is the most successful in the county. The appearance of the farmsteads is generally prosperous. Fields, fences, yards, and orchards give an impression of being well cared for. Crops are vigorous, and the signs of a successful economy are seen everywhere.

A greater part of the surface has been cleared of vegetation. Trees grow in the steep-sided valleys that occasionally cut back into the hills and along the bottoms of the poorly drained depressions. Portions of the lowland areas have been cleared and are used for pasture. Fields are large, and the fence lines are straight. Farm economy is based upon the production of potatoes and animal products. Some acreage is devoted to alfalfa and other hay crops, as well as to corn and small grains, particularly oats and wheat. A fair percentage of the cropland is in pasture.

Despite the fact that farming here is general in character three types of specialization have developed — dairying, potato raising, and flower growing. Dairy farming, common over the land type, is most prevalent in the vicinity of Petoskey. These farms are among the best in the county. Other farmers raise quantities of potatoes. The extreme specialization is indicated by emphasis on the production of certified seed. A few agriculturalists concentrate on flowers, bulbs and seeds. The flowers are sold in the resort market and in Chicago Seeds and bulbs are disposed of through the various seed firms.

McKinley agriculture. — Farming on the McKinley land type is similar to that on the Walloon. Less of the surface is cleared of its forest vegetation. Fields are smaller, and field lines are more irregular. Use of the lowlands for pasture obtains here also. There is relatively more potato raising but less dairying. Alfalfa is not so important as a hay crop, although a larger share of the area is given over to hay and pasture.

Readmond agriculture. — Agriculture on the Readmond is not particularly prosperous. There are a few areas where a greater concentration of the heavier soils is reflected in the quality of the farms, notably east and south of Goodhart and northwest of Harbor Springs. Here the agriculture is almost on a par with that of the McKinley. Otherwise the farms are definitely inferior in quality.

The farming is confined to plateau-like areas. Slopes give indications of having been used in the past, but they are mostly abandoned today. A great many of the fields are unfenced or surrounded with barbed wire. They vary in size and shape, and it is a common practice to crop only a part of each enclosed unit. As fields are given over to hay or pasture, the bottoms of the numerous valleys may continue in crop production. Parts of the farm area remain in second growth, with irregular borders marking the boundary between forest and clearing.

Land use shows little diversification. Corn is raised in small quantities. Potatoes seem to grow better than any other crop. Wheat, oats, and buckwheat are the chief small grains, but the per-acre output of none of these crops is great. Most of the farm area is given over to hay and pasture. Natural hay, sweet clover, and alfalfa are important in the order named. The pasture land is often permanent in the sense that it may not be cropped for several years. Cattle are a part of every farm system. Adjoining abandoned farms are occasionally used for hay or pasture. The humus content of the soil has been diminished through steady use. Rapid drainage lowers the quality of the food crops, stunts the hay, and diminishes the amount of pasturage.

Bliss agriculture. — Agriculture on the Bliss is favored by the level surface. Gravelly areas are apparently more fertile than those of a sandier texture, and the successful farms are generally on this phase of the Kalkaska soil type. With the exception of two areas farming is about on a par with that of the Readmond. Through the efforts of George Gibes, a Polish immigrant, a great many Poles settled on the Bliss land type in the vicinity of Larks Lake. Here the farms are distinguished by the neat appearance of the buildings, the diversity of the agriculture, and the ubiquitous geese. North of Harbor Springs the fortunate association of farm with city has aided the development of a successful economy. Dairies occur as the resort development and the demands of the village justify their existence. Near the town a number of people concentrate on the raising of fruits, vegetables, and flowers.

Throughout the rest of the land type agriculture is little advanced beyond that of the Readmond. Production of hay and pasture is the common use of the land. Corn and potatoes are apparently better crops here. Fields are more regular, but are no better fenced. One factor that gives this land type an advantage over the Readmond is its flatness of surface.

Brutus agriculture, — Most of the Brutus land type is occupied by a religious sect — the Mennonites. Under a system based on self-discipline an agricultural economy was developed that benefited all. A prosperous farm community resulted. Today the old manner of living is giving way before the automobile age and the principles of self-gain. Though the area is still successful the evidences of agricultural decay are everywhere apparent.

A heavy clay soil, the chief soil component of the land type, is difficult to plow. Great power is needed to turn the furrow to any depth. This feature and the resultant slow drainage make it poor land for corn, which has always been stunted, with small ears. Potatoes are a fair crop, but most of the cleared land is given over to grains and hay, particularly alfalfa. Fields are large, and little of the farm area is left in forest.

Pellston agriculture. — There are few farms on the Pellston land type. They appear to function below the level of subsistence. Stump pasture and natural hay predominate. The lack of fences and the neglected fields make it difficult to distinguish, the used land from the unused. Browse lines in the small aspen groves emphasize the paucity of good grazing. Crops seldom seem worth harvesting.

Red School agriculture. — Large parts of the Red School land type are not used for agriculture. The area under cultivation appears, however, to be expanding. Here and there fields are being cleared of stumps. A stony surface and slow drainage contribute to the difficulties of farming. Though farmsteads are not prosperous-looking, continual improvement has been noted over a period of three years. The local markets at Mackinaw City and Mackinac Island may appreciably encourage the expansion of the farm area and the improvement of the farms.

Crooked Lake agriculture. — The Crooked Lake land type is handicapped by slow drainage. Land is cropped, but the farm homes are for the most part abandoned. Production is supplementary to that of the occupied farms on the neighboring land types. Hay is the chief crop, with a minor yield of small grains. Barns are large, and fences are uncommon. This land type is apparently unable to support a well-rounded farm economy, but it is unlikely that it will be abandoned so long as the contiguous areas are occupied.

Larks agriculture. — At various places within the Larks land type surface irregularities have resulted in exposures of mineral soil. These locations may be utilized for crops. There are seldom more than two or three farms in any one place. The cultivated areas are irregular and are devoted to general farming. Some farms leave one with the impression that the owners are not entirely dependent upon agriculture for their income.

Bear Creek agriculture. — Much of the cropland in the Bear Creek land type is held in farms located in large part outside the area. The farms wholly on this land type are small and ill fitted for agriculture. Hay and pasture constitute the chief use of the land. There is little indication that it will ever be more intensively used than it is today.

Sturgeon and Cecil agriculture. — The Sturgeon and the Cecil land types have practically no agricultural settlement. Apparently farming has never been attempted on the Sturgeon. On the Cecil it was maintained to supply lumber-camp horses with hay. It exists today on a subsistence or part-time basis.

Certain conditions have developed in the county that are both favorable and unfavorable to the success of agriculture. It is difficult to view each situation in terms of its direct relationship to a land type; nevertheless, correlations can be suggested.

Part-time farmers are found throughout the county. Many activities in addition to farming claim their attention from season to season. Exploitation of the second-growth forest is one source of outside income. The cement plant, the highway department, the seasonal demands of the resort areas are all sources of employment. Many people work in the factory cities of the southern part of the state during the winter months. It can be assumed that the amount of part-time farming decreases as the land type under consideration is more productive.

Many farms are developed with money obtained from other sources. Frequently the funds derived from the sale of the farm timber were used to build the house and barn and supply other improvements. Some farms are maintained as a hobby or a place of retiral should business fail or industrial production close down. The buildings and improvements on such farms often fail to reflect the agricultural productivity of the areas where they are located.

In the vicinity of Harbor Springs and Petoskey and, to a lesser extent, throughout the county, the resort trade has increased farm income. The purely seasonal character of this business makes it difficult, however, to adjust supply to demand. If sales throughout the year could be maintained near the summer level, farmers in the county would have few financial problems.

There has been some change in the method of farming during the last few years. Small grains are giving way to corn. At the same time the number of silos has increased. Dairying is becoming more important every year. In 1939 every farm in the county had, on an average, seven cows of milking age. A great deal of stress is laid on the growing of potatoes for certified seed. In 1939 approximately 3,400 acres were in potatoes.

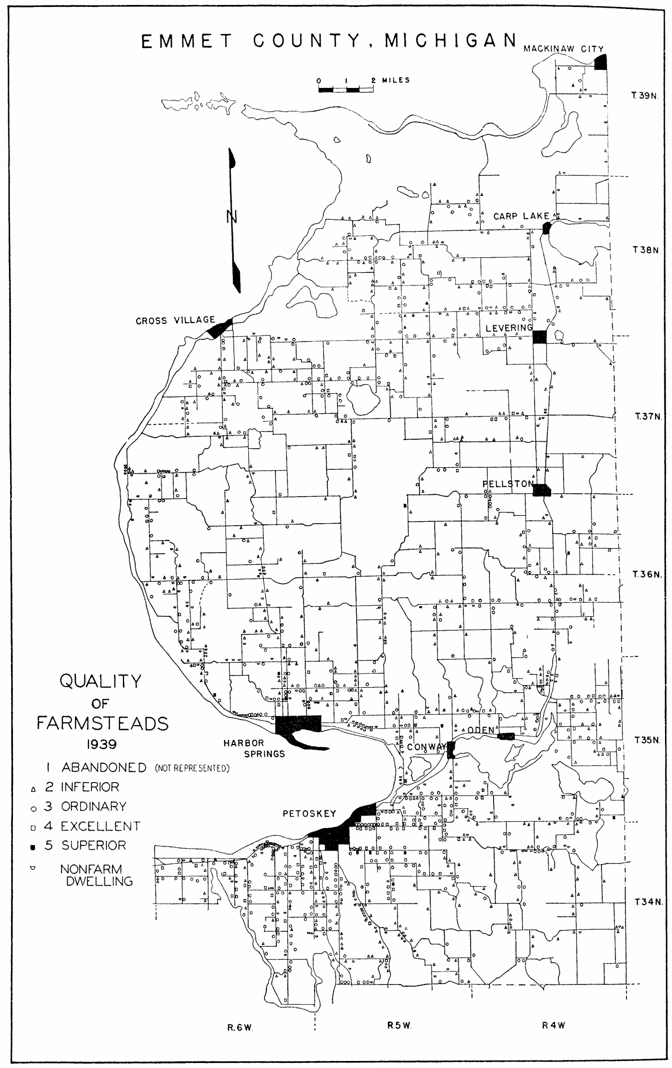


FIG. 2

FARMSTEADS AND LAND TYPES (SEE FIGS. 1-2)

It was felt that the number of occupied dwellings and the comparative quality of the farm buildings and farmyard units might indicate to some degree the success of agricultural enterprise in each of the land types. It is not enough to say how many operating farms occur per unit of land. Analysis must go further. Are the farmers barely able to supply the needs of home and family, or is there a surplus available to be used for the improvement of farm and buildings? Without doubt, personality and circumstance enter the picture, but it can be safely assumed that all the poor families were not concentrated on the poor land types from the very beginning. Consequently, a classification of all the rural dwellings in the county was made. The system used was a modification of the ideas presented in a bulletin published by the Cornell University Agricultural Experiment Station.[4] Occupied rural farmsteads were estimated on the basis of their quality. Nonfarm dwellings were classified at the same time. The evaluation of farmsteads was carried on without reference to the land types. Five classes of farmsteads were established. Class 1, abandoned farmsteads, will be discussed in a later paper. The other four classes are:

Class 2. — Farmsteads of inferior quality. Such farmsteads might be regarded as barely holding their own, or else they are clearly in the process of deterioration. Buildings are generally unpainted and roofs are in poor condition. Dilapidation of one sort or another prevails everywhere. There is usually little or no attempt to make the surroundings presentable. Dwellings are often log cabins or tar-paper-covered shacks. These farmsteads have either degenerated from a higher classification or never have been sustaining. (See Pl. I, Figs. 1-2.)

Class 3. — Average or ordinary farmsteads. There is a general air of moderate success. All the buildings may not be in the best condition, but a definite effort is made to keep things in good repair. Paint is not necessarily new, though painting is done periodically. Roofs are usually well cared for, and gates and fences are in good order. (See Pl. I, Figs. 3-4.)

Class 4. — Farmsteads distinctly above the average. Buildings are well roofed and painted. Yards are in good condition. Fences are in first-class shape. The appearance of the farmstead indicates that there is a more or less continual expenditure of time and money on improvements. Surplus money beyond that required for the ordinary demands of living must be available to support an establishment of this sort. (See Pl. I, Figs. 5-6.)

Class 5. — Farmsteads clearly of superior quality. “House, barn and outbuildings are in optimum condition. The grounds are usually landscaped. A tone of prosperity prevails. There are very few farmsteads of this type. (See Pl. II, Figs. 1-2.)

Nonfarm dwellings. — Dwellings whose owners receive only a small part of their livelihood from tilling the soil. (See Pl. II, Figs. 3-4.)

Since the first widespread attempt at settlement agriculture has had ample time and opportunity to establish itself in all parts of the county. The possibilities of crop production have been determined primarily by trial and error. Failure and circumstance have eliminated many who attempted to till the soil. Today the density of functional farmsteads on a land type is, in some measure, indicative of the ability of the area to support agriculture (Fig. 2). The smaller the average amount of land per farmstead, the greater is the relative productivity (see Table I).

If the land types with small local relief and slow or poor drainage are considered, a marked difference in farmstead density is noted (Table I). The Cecil type, with 11.94 square miles for each farm home, stands lowest. The Larks is next, with all its farmsteads on the higher ground included within the complex. The Crooked Lake is third. Here a considerable part of the surface has been cleared, but a well-rounded farm program is apparently impossible. The Red School is fourth. This relationship may be expected to change in the near future since the process of clearing is still under way. Within the Brutus area, which is fifth in density, farmsteads are concentrated on the heavier soils. The sandy portions are, for the most part, uncleared or abandoned. The Bear Creek region is so small that the figure indicating the average area for each farm unit may not be reliable.

Two land types have been characterized as having “small relief and rapid drainage.” The density relationship is obvious: a more fertile soil and better moisture conditions on the Bliss contribute to the greater concentration. The Pellston is relatively unattractive.

The Walloon, the McKinley, the Readmond, and the Sturgeon are the land types with considerable local relief. The Walloon has the smallest average area per farmstead of any type in the county. Greater dissemination of farms definitely sets the McKinley apart from the Walloon, even though they are similar in appearance. Sandy soil, poor moisture conditions, and excessive slope have discouraged agriculture on the Readmond. The average area for each farm unit is large. It is not possible to present the figures here, but this land type is characterized also by a great amount of abandonment. On the Sturgeon, as has been said, agriculture has never been attempted.

There are a number of factors that may act to reduce the reliability of comparisons made between the different land types on the basis of average area per farmstead. For instance, on the sandier soils larger surface units are necessary to permit a balanced agricultural economy. Furthermore, the scattered ridges within the Larks offer the only farm sites there. For the Pellston one site is as suitable as any other. The comparisons might have been more critical if they could have been made according to the amount of cleared land rather than according to total areas.

Within each class the farmstead density varies considerably from land type to land type. Reference to Table I will show that this r same separation prevails when all the land types are considered together.

The small number of Class 5 farmsteads is of no great value for correlation. At least four of the fourteen listed as superior are supported by funds derived from outside sources. Many of the others are dairy farms. Money is available for maintenance and improvements partly as the result of location near a favorable market. Nevertheless, the six of this class on the Walloon indicate a high standard of farming.

TABLE I

CORRELATION OF LAND TYPES AND FARMSTEAD TYPES

In the first four columns the second figure is the percentage.

Land type	Farmstead type* Class 2 — inferior	Class 3 — ordinary	Class 4 — excellent	Class 5 — superior	Total number of occupied farmsteads	Total number of nonfarms	Number of square miles in each land type	Average number of square miles per occupied farmstead
1. Cecil	2 100	0 0	0 0	0 0	2	1	23.89	11.94
2. Sturgeon ...	0 0	0 0	0 0	0 0	0	0	8.07	0
3. Red School .	24 61.6	14 36	0 0	1 2.5	39	8	18.48	0.473
4. Brutus	9 37.5	12 50	2 8.3	1 4.2	24	2	8.45	0.352
5. Crooked Lake	4 44.4	3 33.4	1 11.1	1 11.1	9	2	7.10	0.779
6. Readmond ..	185 56.4	123 37.5	18 5.49	2 0.61	328	57	169.16	0.516
7. McKinley ..	69 40.3	82 47.9	20 11.7	0 0	171	15	34.74	0.203
8. Walloon	52 21.5	146 60.3	38 15.7	6 2.48	242	35	29.68	0.123
9. Pellston	15 83	3 17	0 0	0 0	18	7	20.44	1.13
10. Bliss	165 50.3	142 43.3	18 5.4	3 0.91	328	135	96.21	0.293
11. Bear Creek .	7 70	1 10	2 20	0 0	10	11	2.98	0.298
12. Larks	18 69.3	7 26.9	1 3.8	0 0	26	7	46.01	1.77

* Class 1 (abandoned farms) will be discussed in a later paper.

Classes 2, 3, and 4 offer the best opportunity for evaluating productivity as it is reflected in farmstead quality. The Walloon, with 15.7 per cent of the units in Class 4, 60.3 per cent in Class 3, and 21.5 per cent in Class 2, is obviously the best land type for agricultural use. The McKinley has the next highest rating and is followed by the Brutus.

There is some question whether the Crooked Lake or the Bliss should come next in this classification. A greater number of functioning enterprises on the latter, however, gives it priority. After the Crooked Lake, the Readmond, the Bear Creek, the Red School, and the Larks follow. It is to be noted that the order is not valid in terms of any one class. The positions are determined rather by a joint consideration of the three classes for each of the land types named. It is doubtful whether the Bear Creek should precede the Red School.

There can be little question of the relative position of the last three. The Pellston, with 83 per cent of its farmsteads in Class 2, the Cecil, with two farmsteads in Class 2, and the Sturgeon, with no rural habitations, complete the sequence.

A major percentage of the nonfarm dwellings are distributed without reference to the quality of the land types. They are, in a sense, suburban homes built in the vicinity of Petoskey, Harbor Springs, or a place of employment. It is probable that the Bliss, the Readmond, the McKinley, the Walloon, and the Bear Creek areas may on occasion offer more suitable building sites. Otherwise the location is fortuitous.

Many of the nonfarm residents exploit the second-growth timber. Some of the best areas for cutting are found on the Bliss and the Readmond or in the poorly drained land types close at hand. Distribution of such exploitation is controlled by the lack of conditions favorable to farming.

CONCLUSION

Land types have been established with reference only to their physical characteristics. If we make allowances for the personal attributes of ambition, superior training, and home background, and if we discount the advantages that accrue from superior location with respect to market and transportation, then we may expect that the quality and number of farmsteads and the general character of farming will reflect, in some degree, the productive quality of the land type. Such a relationship is well expressed in Emmet County, where no area is at a marked disadvantage with respect to transportation and national markets. It is felt that the analysis of farming, the figures and discussion pertaining to the density of farmsteads, and the correlation between farmstead quality and the land types have indicated the connections that exist. A more detailed investigation would probably reveal closer relationships.

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[2] Stirling, M. C, "Land Types in Emmet County, Michigan," *Pap. Mich. Acad. Sci., Arts, and Letters*, 24 (1938), Part III: 55-59. 1939.

[3] For a description and discussion of the soils mentioned see Foster, Z. C, Shearin, A. E., Millar, C. E., Veatch, J. O., Donahue, R. L., *Soil Survey of Cheboygan County, Michigan*. United States Department of Agriculture, Series 1934, No. 15 : 1-47. 1939.

[4] Tyler, H. S., *An Economic Study of Land Utilization in Chenago County, New York*. Cornell University Agricultural Experiment Station, Bulletin 654. Ithaca, New York, 1936.

FOSTER PLATE I

FIG. 1

FIG. 2

Class 2 farmsteads. Note the tar-papered house

FIG. 3 FIG. 4

Class 3 farmsteads. That shown in Figure 3 barely falls within this group

FIG. 5 FIG. 6

Class 4 farmsteads

FOSTER PLATE II

FIG. 1 FIG. 2

Class 5 farmsteads, on the Walloon land type

FIG. 3. A nonfarm residence

FIG. 4. An inferior nonfarm residence

SETTLEMENT PATTERN OF THE WESTERN HIGHLAND RIM PLATEAU OF TENNESSEE*

H. THOMPSON STRAW

THE Western Highland Rim Plateau of Tennessee is the upland area lying between the Central Basin and the Coastal Plain portion of the state (Fig. 1). This upland area is a part of the Interior Low Plateau province. Its summit level is mainly a remnant of the peneplain developed over the middle third of the state during Tertiary times,[1] a peneplain subsequently to be uplifted and dissected by stream action and to some extent by solution. Although sinkholes are found throughout most of the region, they occur in greater numbers in the north and become increasingly less frequent as one proceeds southward, where the rock strata are less soluble. In general, then, river cutting far exceeds karst development in determining present-day landforms.

Today in many places the plateau character of this region is not readily discernible. Rather the land seems to consist of youthful, flat-topped ridges interspersed with river valleys, the larger of which are in maturity, with well-developed valley flats. The distribution of these ridges and valleys may be seen in the physiographic diagram (Fig. 2). It can be noted that the Duck River forms a rough dividing line in that part of the region lying east of the Tennessee River. North of the Duck River the surface is gently rolling, much of the plateau level is still discernible, and the main river valleys tend to be narrower than in the south. The part of the region south of the Duck River has been deeply cut by the streams. Flat ridge-top areas are still numerous, but are broken by wide river valleys, the floors of which are covered with sand and silt.[2] The difference in surface, however, is not of great degree. Nowhere in the region is one far from a flat-topped interfluve or a silt-filled river basin. It is this combination of surface which constitutes the terrain.

The agricultural settlement of the region was accomplished in the early part of the nineteenth century by the middle-class yeoman farmers. Many moved from the earlier-settled Nashville Basin, with its better transportation facilities, in order to escape the increasing competition of the planter class.[3] With the opportunity of establishing themselves on the flat land of the ridge tops or on that of the valley bottoms, they chose the latter, with its richer soil of recent alluvium and the somewhat better transportation provided by the use of crude rafts and boats on the larger streams. In all the county units within the region there is only one that is possibly an exception to the general rule of early valley settlements, and that exception is dubious because the records do not definitely specify a location.[4] In these valley settlements a pioneer economy was to be maintained long after it had disappeared from the adjacent lowland areas, such as the Nashville Basin.

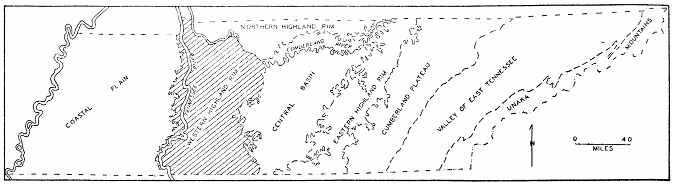

FIG. 1. Surface map of Tennessee, showing location of Western Highland Rim Plateau

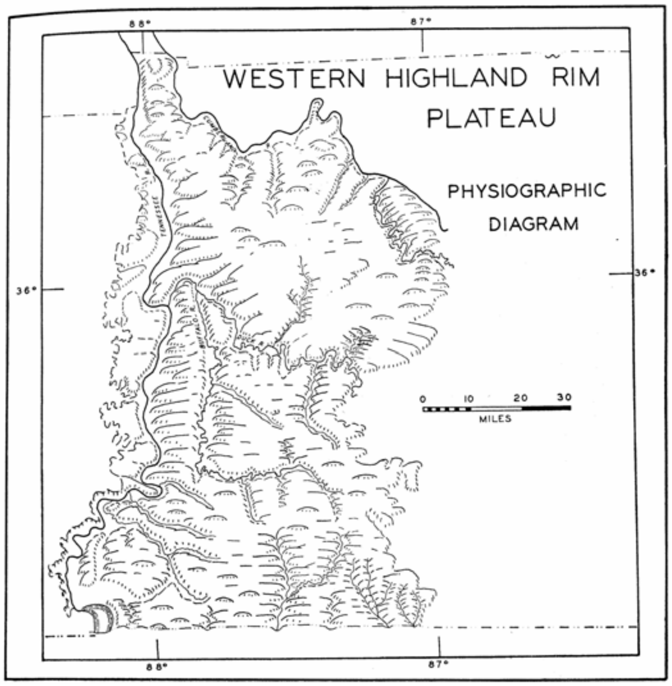

FIG. 2
Note that more of the original plateau surface is preserved north of the Duck River than south, where the river valleys tend to be wider

Similarly, the development of the mineral industries within the region was to concentrate in the valleys rather than on the ridge tops. The two minerals of greatest importance were iron ore and phosphate rock. The iron ore occurs in the form of limonite and in many places is associated with the St. Louis limestone which caps the ridge top.[5] Since it requires washing before smelting, however, the plants and related settlements were generally to be found in the valleys, where water supplied by the streams was available. The smelting plant at Cumberland City was typical of this development (Pl. I, Fig. 1). It was one of the first to be established and one of the last to close. Ore was supplied from the near-by hilltops, and charcoal was produced from the forests of the neighboring slopes. As can be seen from the illustration, the industry was always a small one, but since there were about thirty-five similar plants in the region at the time of the Civil War they were important in determining settlement location during the early days. Today, however, only two of the furnaces are in operation.

Later the mining of phosphate rock likewise tended to augment the valley settlements. Most of the phosphate is of the blue variety, is restricted to the southern half of the region, and is associated with rock of Devonian age, which occurs considerably below the ridge top capped with Mississippian strata.[6] Therefore valley sites were utilized in its extraction. Like that of limonite, the production of blue rock has ceased owing to outside competition, in this instance from the brown phosphate of the Nashville Basin.

Today most of the settlements are still in the valleys. Figure 3 illustrates the all-too-common situation — settlement pushed into this area from the Nashville Basin by way of the Duck River Valley, a section of which may be seen in the northeast part of the map. Land was cleared along Beaverdam Creek and then along the various tributary creeks which dissect the area. It should be noted that not one of the wooded hills bears a name, whereas most of the creek valleys, if wide enough to accommodate any cleared land, are named, in many instances in honor of one of the first settlers in that particular area. At the present time, with only one small exception, cleared land is restricted to these creek bottoms, although the interfluves which are flat-topped would offer approximately the same amount of level land for clearing. Indeed, only about three miles south of the area under discussion, on a terrain not particularly different, the settlements of the German Swiss (which will be mentioned later) have been located on the ridge tops. Most of the cleared land of the creek bottoms is devoted to corn, hay, and pasture. There are almost no cash crops, and nearly all of the forage crops are fed to animals, some of which are sold from the farms and constitute, with timber from the near-by hills, the major source of income, which is small at best. The majority of these farmers own their farms and appear to carry on agriculture at or near the subsistence level.

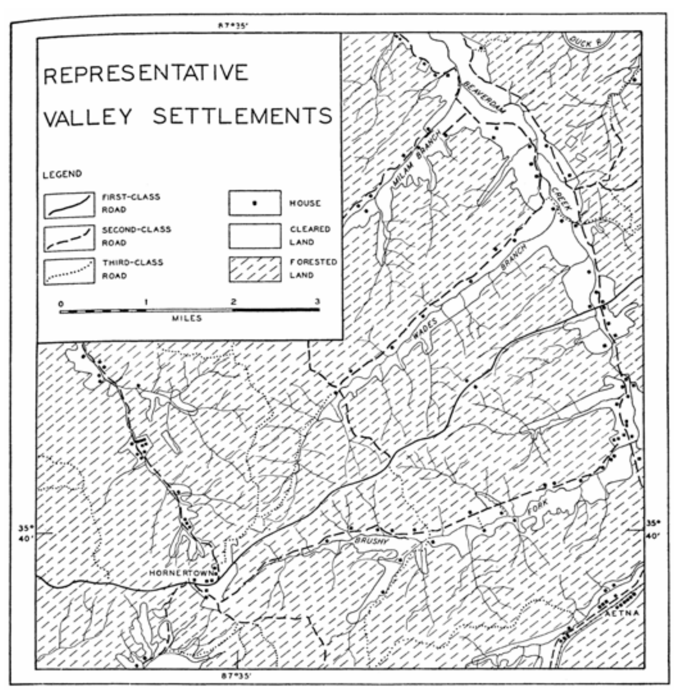

FIG. 3
Note that the valley settlements are separated from the main roads by steep valley slopes

About 1846 an iron furnace was erected at Aetna, shown in the southeast part of the map (Fig. 3). The ore was obtained from the hilltops north and west of the village. The washer was on the lower slope, and the blast furnace and charcoal ovens were in the valley. At one time about four hundred persons were employed here,[7] and the village had some fifty houses located near the plant. Today the plant is dismantled, and the site is marked by a single store, a railroad siding, and fewer than a dozen houses. But while the industry operated it augmented the valley settlement pattern, established earlier by agricultural clearings.

The one ridge-top community in the whole area is Hornertown. It is of fairly recent origin and owes its existence largely to the convergence of routes leading from the valley settlements to the main road.

The disadvantages of location in the valley were brought into sharp relief by the improvement of the main or first-class roads. These main roads have tended to cling to the flat ridge tops, since they were designed not to serve the region but to cross it. The general picture has been all too often that of a main road flanked on either side by unbroken forest, with the valley settlement isolated from it (Pl. I, Fig. 2), the only connection being an unsurfaced secondary road which traverses the steep incline of the valley side. Since such roads are impassable during the winter or immediately following a rain, this situation has meant difficulty in marketing produce and resultant low standards of living, which have in turn led to large relief loads and low tax returns for the state. Valley settlements have likewise tended to preclude the easy expansion of farmland and cropland. In the small valleys, such as that shown in Plate I, Figure 3, the area available for crops on the valley floor is insufficient. The adjacent lower slope in the background, which, naturally, was cleared after the valley bottom had been, is so steep that soil erosion has ruined the land even for pasture, and it is in the process of being reclaimed by the forest. Thus many attempts to add to the improved land and so augment the individual farm income are checked.

Ridge-top settlements are largely confined to the eastern part of the region (Fig. 4). Two factors have been of prime importance in establishing this pattern of settlement, which differs so radically from the earlier one. They are the development of cash crops — dark-fired tobacco in the north and cotton in the south — and the colonizing practices of the German Swiss within the region. Both cash crops can be grown on the valley floors, but most of the farmers seem to prefer the upland soils. In the cotton-growing southern section they fear that the valley soils will be slow to warm up in the spring and thus will shorten the growing season, which is not too long at best. In the north the farmers believe that it is easier to produce on the upland soils the heavy-bodied tobacco demanded by the Clarksville market. The more fertile valley soils tend to yield plants of more luxuriant foliage, which require more frequent topping. It is interesting to note that when Burley tobacco is grown the valley site is generally used. The German-Swiss settlers were most numerous around Hohenwald. They were established by land agents on ridge-top land which was purchased because it was cheap. Many of these settlers have now migrated; but they have left a few of their descendants, distinctive place names, and a rectangular road pattern, similar to that of the Northwest Territory. The description of land titles here, also, is essentially a modification of the range-and-township system of survey.

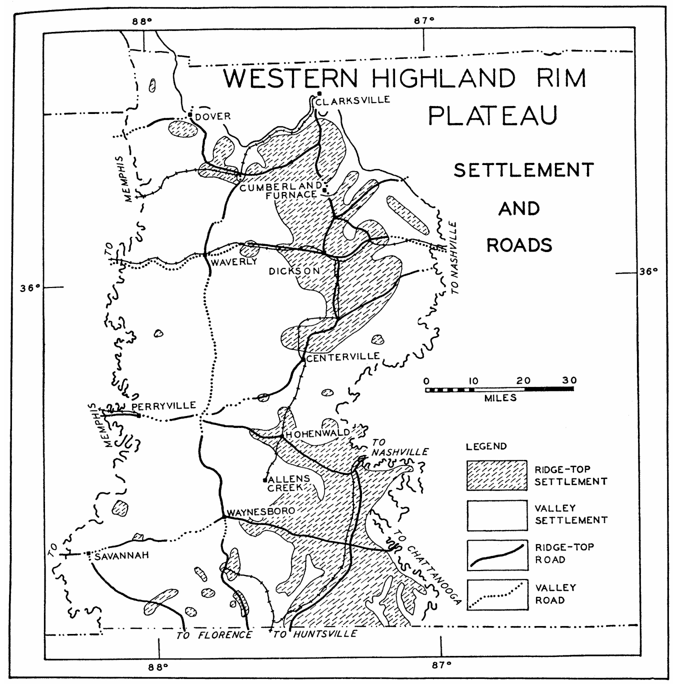

FIG. 4
Ridge-top settlements are largely restricted to areas which produce commercial crops, cotton in the south and tobacco in the north. Note the presence of ridge-top roads, which must serve valley settlements

Most of the region still remains an area of valley settlement. Cash crops are absent, and corn occupies most of the cropland. The isolated areas of ridge-top settlement generally mark the location of a convergence of secondary roads on the main highway, and here local commercial centers are usually found. It will be noted that the pattern of ridge-top settlements is obviously somewhat related to the pattern of ridge-top roads, since they tend to develop farthest along these roads. However, ridge-top roads do not necessarily mean ridge-top settlements. Rather they seem to develop as the result of specific cash crops or a historical accident, such as the settlement of the German Swiss.

In attempting to arrive at any solution of the problems which arise from the land use of the region, this pattern of settlement must be one of the basic factors considered. Not only must the condition of surface and soil and the possibilities of forest and mineral exploitation be taken into account, but the existence of this pattern and its relation to roads, established schools, and other public services, together with those which may be planned for the future, must also be studied.

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* The author wishes to acknowledge his indebtedness to the Social Science Research Council of New York for a grant-in-aid for field work which made this paper possible.

[1] For a detailed study of the geologic history and strata involved see Bassler, R. S., *The Stratigraphy of the Central Basin of Tennessee*, Bull. 38, especially pp. 3-162. Nashville, Tenn.: Division of Geology, 1932.

[2] In detail the distribution of soil and surface features within the valleys is more complicated. A succession of uplifts in late Tertiary and Pleistocene times has resulted in a series of none too sharply defined valley terraces, the older of which generally are composed of gravel, although the present flood plains are usually silts and clays. See Jewell, W. B., *Geology and Mineral Resources of Hardin County, Tennessee*, Bull. 37, especially pp. 14-17, 18-19, 49-50. Nashville, Tenn.: Division of Geology, 1931.

[3] Abernethy, T. P., *From Frontier to Plantation in Tennessee. A Study in Frontier Democracy*, p. 209. Chapel Hill, N. C: Univ. of North Carolina Press, 1932. See also Spellings, W. W., "The Spread of Population in Tennessee," M. A. thesis, George Peabody College for Teachers, Nashville, Tenn., n. d. (*in manuscript*); and *Preliminary Population Report*, Sec. IA, maps 3-4. Nashville, Tenn.: Tennessee State Planning Commission, 1935.

[4] For a convenient check list of early settlements see Allred, C. E., Watkins, S. W., and Hatfield, G. H., *Tennessee, Economic and Social*, Part II, "The Counties," pp. 6-7. University of Tennessee Record, Ext. Series, Vol. II, No. 3. 1929.

[5] Burchard, Ernest F., *The Brown Iron Ores of the Western Highland Rim, Tennessee*, Bull. 39, pp. 24-37. Nashville, Term.: Division of Geology, 1934.

[6] Straw, H. Thompson, "Phosphate Lands of Tennessee," *Ec. Geog.*, 17(1941): 93-104, especially pp. 95-96.

[7] Burchard, *op. cit.*, p. 99.

STRAW PLATE I

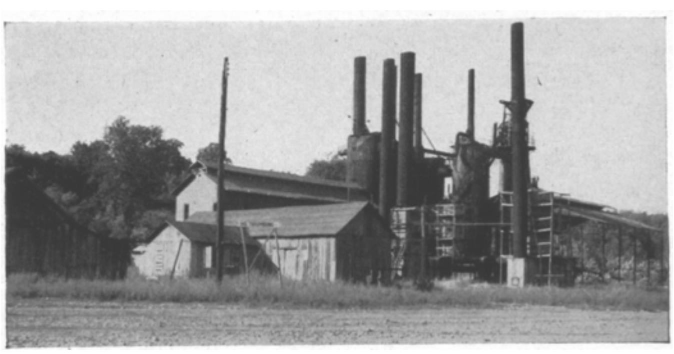

FIG. 1. Smelting plant at Cumberland City. One of the numerous small charcoal furnaces which were present in this region

FIG. 2. Ridge-top road through unbroken forest land. Most of the settlements are in valley bottoms, separated from the main road by steep valley sides

FIG. 3. Valley settlement, with pasture in the foreground and corn along the stream in the middle distance. In the background the lower valley slopes have been cleared and planted, but erosion has led to their abandonment, and they are now being allowed to return to forest land

THE RURAL ZONING PLAN OF MARQUETTE COUNTY, MICHIGAN*

JOSEPH VAN RIPER

IT IS the purpose of this paper on the rural zoning plan of Marquette County, Michigan, to present some of the problems facing the land-use planners in the northern counties of the Lake states. These problems do not concern simply adjustments to the quality of the land, but involve also a wide variety of social, economic, and geographic factors.

Rural zoning has been in practice for some years in different areas of the United States; on December 30, 1938, however, Marquette County, located in the north-central part of the Upper Peninsula of Michigan (Fig. 1), became the first county in this state to place in operation a rural zoning ordinance (Fig. 2). The plan itself is simple: it merely prohibits agricultural settlement in areas not now serviced by roads and schools; but the forces motivating it are of particular interest to geographers.[1]

PHYSICAL BACKGROUND

A quick glance at the physical background of Marquette County reveals at once that, like many regions in the northern part of the United States, it has wide areas within it unsuited to agriculture. Figure 3 shows a division of the county into areas in which the surface conditions are more or less homogeneous. The sand plains indicated here are typical scrubby sterile jack-pine barrens (Pl. I, Fig. 1). The hard-rock knob district, consisting of crystalline knobs from one hundred to three hundred feet high, which are separated by innumerable lakes and spruce swamps, is a characteristic section of Laurentian upland. Only occasionally is there a small patch of moraine free enough of boulders for cultivation. Both the sandstone uplands and the Lake Superior borderland have wide stretches of thin sandy soils and long slopes, which are not suitable for farming. Only two of the largest poorly drained areas are shown here, but fully one fourth of the county is covered by lakes and swamps, most of them small. Nowhere is there any extensive continuous area of superior soils. The Amasa rolling uplands, characterized by moraines, kames, and drumlins, is but slightly above average in the quality of its soil, and its development is hindered by its remoteness from markets and by a short growing season. The Marquette iron range, with its less pronounced relief, glacial gravels, loose slate outcrops, and accessible markets, ranks next to the dissected till and lake deposits region in the number of successful farms. The latter region has the best soil and the smallest percentage of swampland of any part of the county, and has a further advantage in its nearness to the mining centers. In terms of agriculture, fully three fourths of the county is distinctly submarginal (Fig. 4).

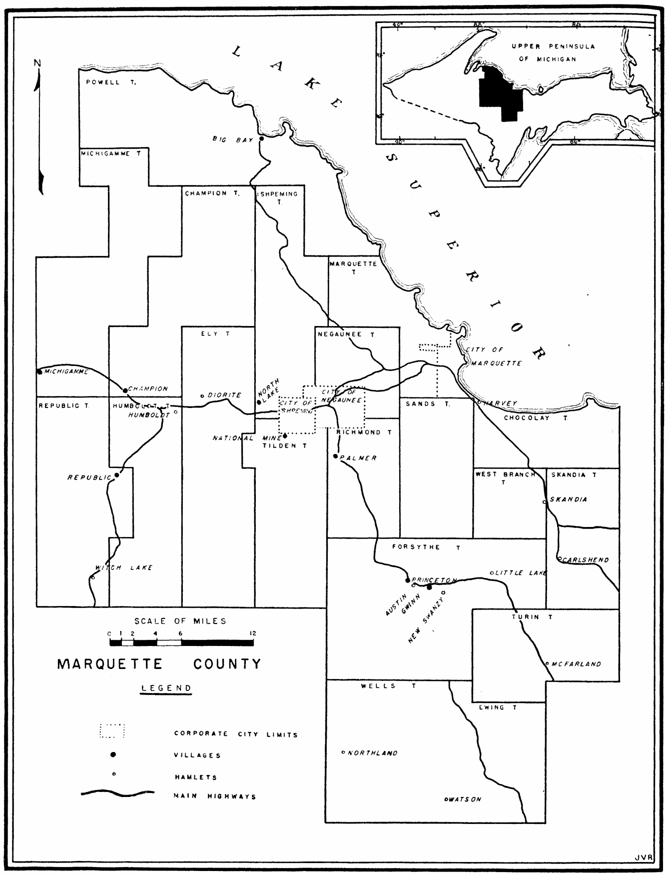

FIG. 1

Lumbering is carried on at present only in small-scale operations, and is based on motor trucking. It has little significance for permanent settlement, since the best and most readily available timber and wood products have already been removed. White pine, red pine, and hemlock were the first trees to be extensively exploited. Today only a few small stands of these trees of saw-timber size remain, and those only in the most inaccessible regions (Pl. I, Fig. 2). During recent years forest operations have consisted in cutting the upland hardwoods and the swamp conifers. The former supply lumber for the automobile industry and for furniture, flooring, and other interior trim. The swamp conifers are utilized mainly for pulpwood, posts, railroad ties, and mine props (Pl. I, Fig. 3). During recent years much of the less desirable hardwood has been used in distilling or for firewood.

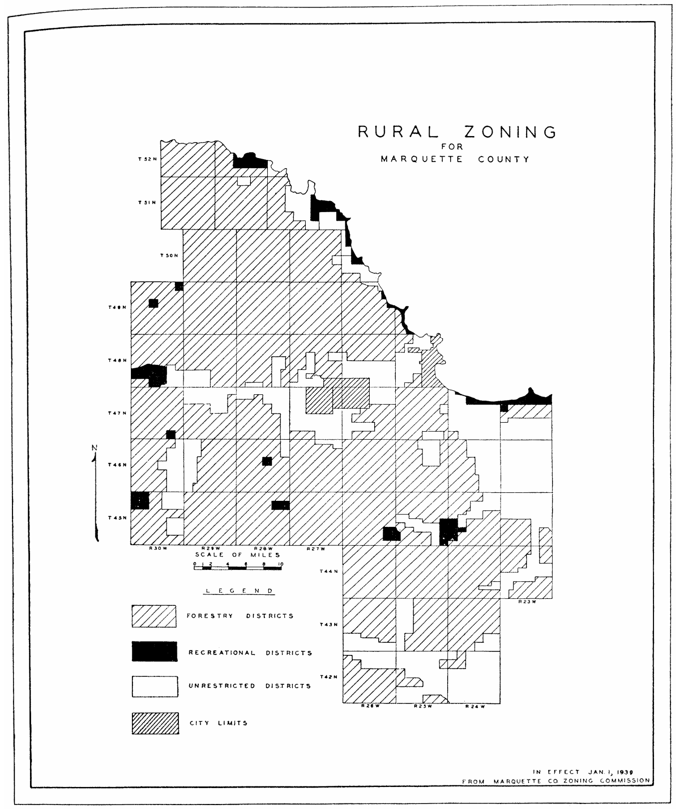

FIG. 2

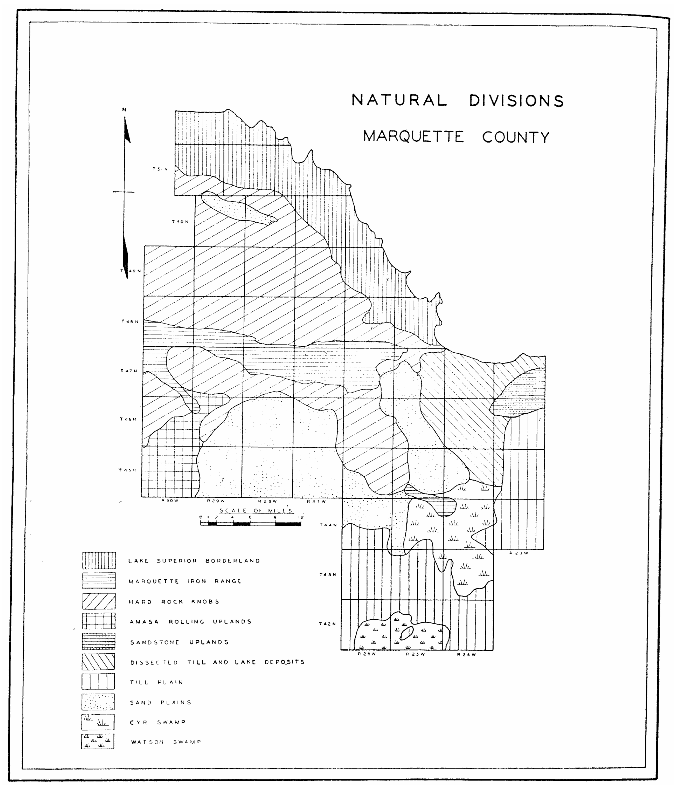

FIG. 3

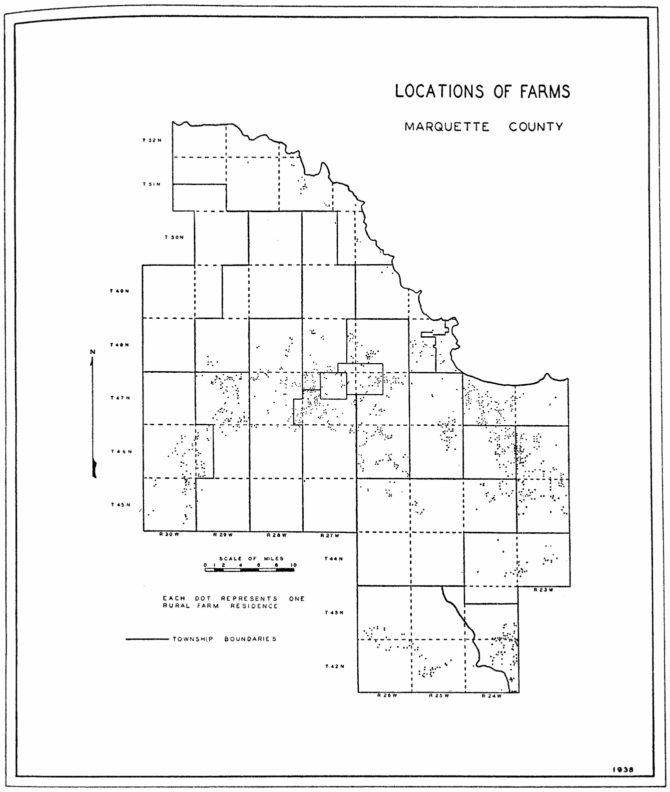

FIG. 4

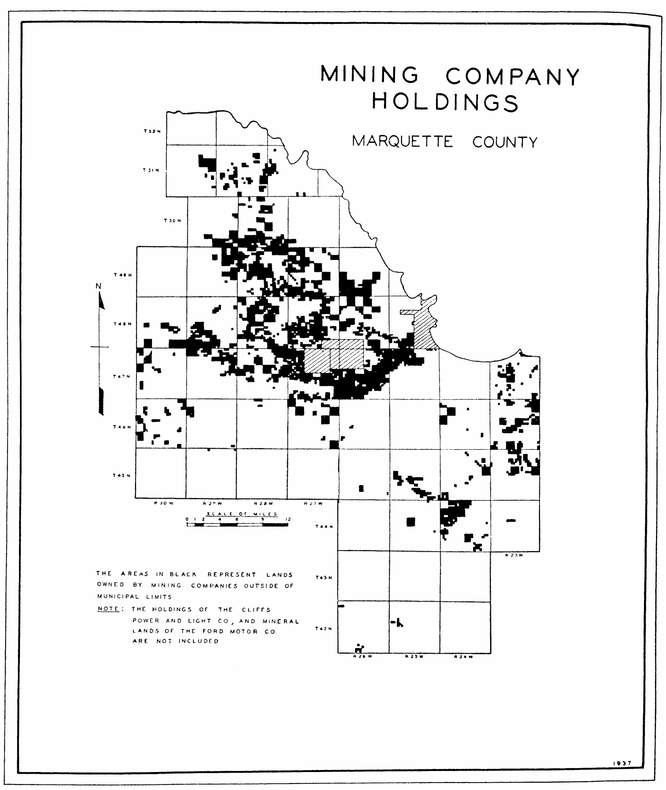

FIG. 5

Large stands of merchantable hardwood remain in only a few localities in the county, mostly in the northwestern part. Pulpwood extraction has been moving northward in the county during the past few years. Most of the swamps in the southern part have been cut over, and although cutting for pulp is still being done in this area the reserves are rapidly being depleted. The largest ones remain in the small swamps in the hard-rock knob district.

The principal industry in the county is the mining of iron ore, mostly hematite, which is found within the Marquette iron range (Fig. 5). The chief iron-bearing formation outcrops in an area approximately five miles wide in the vicinity of Negaunee and Ishpeming. West of this area the formation is deeply buried in the center and comes to the surface in a north and a south limb. The narrowness and the steeply dipping character of most of the iron-ore deposits throughout the county are not advantageous to large open-pit mining (Pl. II, Fig. 1), and, except in a few localities, underground shaft mining is the rule. In 1938 the county's mining industry employed 2,775 persons.

THE HISTORY OF SETTLEMENT AND ITS EFFECTS ON THE ZONING PROBLEM

The focus of settlement in Marquette County since the coming of the first white inhabitants has been the area containing iron reserves, where mining brought about the development of scattered large and small urban centers. Rural settlements at first were located near these urban centers and consisted of both farm and woodworking communities. The latter supplied lumber to the rapidly growing cities and towns or hardwood for the kilns which furnished charcoal to local pig-iron furnaces prior to the development of cheap transportation of ore to the lower Great Lake ports. Nearly all the few farming communities outside the iron district were situated in the areas of better soil and of slightly longer growing season in the eastern and southeastern parts of the county. According to some of the older inhabitants, these early farmers had no difficulty in selling their hay, oats, and potatoes in the urban markets. There were few dairy farms as we know them today, and part-time farms were located only in the immediate environs of the mining towns. No improved roads existed at this time, and there were few rural schools, but the people on the farms made a good living, for prices of agricultural produce were high because of the constant pressure of population in the urban centers.

The last two decades in the nineteenth century brought several events which were to have serious consequences in later years. The first of these was the absorption of the small mining concerns operating tiny open-pit mines with little capital. This absorption was the result of (1) the exhaustion of the surface deposits and the consequent necessity of using expensive underground mining methods and (2) the economic depression of the early nineties, which, with its attendant low prices, wiped out many small operators. A second event was the decline in the demand for mine labor, which came about because of competition from the new Mesabi open-pit operations in Minnesota and because of the change from hand tools to machinery. A temporary boom in local mine employment was experienced during the war years of 1914-18, but it did little to check the steady decrease both of mine employment and population in the urban centers. People living in the mining communities had either to turn to new occupations or to go elsewhere. Some of them moved to the new mining regions in the Rocky Mountain area. Many of them went into the rural sections of the county, hoping either to practice part-time farming and to supplement their income by periodic mine employment or to make a living from farming alone. The number of farms greatly increased between 1890 and 1920.

This settlement of the rural districts was made chiefly by Finnish immigrants. An examination of the county directories of 1870 and 1880 does not reveal a single Finnish name. Only a few are given in the 1890 directory, but the 1901 edition lists a large number. Many of the earliest Finns to arrive in this country went to the mining region of northern Michigan, and, although they had not been miners in the old country, they found mining lucrative and easy to learn. After a brief experience with crowded boardinghouses and after rather violent social contacts with Cornish, Irish, and French-Canadian miners, the Finns took up small plots of land near the mines. These “farms” generally consisted at first of from ten to fifty acres, one or two cows, a horse, and a pig. The cropland supported little else than a house garden, a patch of potatoes, and a small field of oats, with the remainder devoted to hay. The buildings were log cabins (usually whitewashed): a hut for living quarters, a small “crib” barn, and a “sauna” or steam bath. Sometimes the farmer worked in the mines during the winter and on his farm during the summer, or, if his family was large enough and work was available, he worked full time in the mines, the farm work being done by his family.

Since they were relatively late-comers in the farming districts and since they had little money with which to purchase land the Finns went into the poorer areas and, with the exception principally of Ewing Township, where lumbering formerly supplied a cash income, and of an area near Skandia, they settled lands that were adjacent to the mining districts. Today most of the poor, part-time farms are owned by Finns, the better farms being held by Swedes, Germans, or French-Canadians (Pl. II, Fig. 2; Pl. III, Fig. 1). Within the county, then, one of the most significant problems of submarginal settlement resolves itself into a social question, dominated largely by the degree of adjustment which the Finnish people have made to the land and to a new standard of living and complicated by the fact that the second-generation Finns have refused to be content with the low standard of living of their parents.

PRESENT ECONOMIC OPPORTUNITIES FOR RURAL SETTLEMENT

Settlement in the rural districts of Marquette County, if it is to maintain itself on the land, must in general depend upon the following types of livelihood: agriculture, forestry, mining, the provision of recreational facilities, or combinations of these.

The potentialities of the land for supporting settlement by agriculture alone are slight even in the best farming areas. The most vital factor is climate, although a soil suited to potato cultivation is also important, as well as the farmer's ability to produce and market dairy products and potatoes. Most of the successful dairy farms are located near the three cities Ishpeming, Negaunee, and Marquette. On farms remote from these cities the only dairy product that yields cash dividends is cream, which, because of its relatively high value and low bulk, is able to bear the transportation charges. A farm that depends entirely upon farm income for its support has to be exceptionally well situated and well managed (Pl. III, Fig. 2).

Part-time farming has as its basic economy an association with mining or lumbering. In general, the location of part-time farms is more closely related to the mines or to the timber supply than to land favorable for agriculture. For this reason the concentration of such farms is near the central part of the county. Nearly all the farms in Humboldt Township are of this type; their operators originally depended upon mining for their cash income, but now depend upon public welfare. These small farms are located within the hard-rock knob region, on ground that should never have been cultivated, for soil and climatic factors are particularly adverse. Under present conditions successful part-time farming can undergo very little expansion in the uninhabited parts of the county because of (1) a decrease in mine employment, (2) the too-great distance to mines still operating, and (3) a depletion of wood reserves.

Forestry as an industry supporting rural settlement is well on the decline, and stranded families of forest workers can be found here and there in the cutover parts of the county.

The recreation industry has, as in other parts of the United States, been responsible for an appreciable growth in local incomes even in the rural areas, but away from the main highways it has not been capable of supporting an increase of rural settlement.

Because of the uncertain character of mine labor few rural families depend entirely upon this occupation for their livelihood. Most of them supplement it with farming or lumbering or by providing for vacationists.

GOVERNMENTAL EXPENDITURES IN RURAL AREAS

The year 1915, approximately, marked the beginning of extensive public expenditures for roads and schools in the county. In every township the tax rate rose rapidly after this date, reached a peak in 1930, and fell sharply between 1932 and 1934,[2] a decline resulting from a 15-mill property-tax limitation passed by the state legislature in 1933.

Only a small part of the local tax burden is borne by the resident taxpayers. A study of tax-assessment rolls in five townships was made for the purpose of distinguishing between the property of residents and nonresidents. These five townships were Humboldt, West Branch, Ewing, Champion, and Turin, which represent very different combinations of physical and cultural environments. Tables I and II show the valuation and taxes levied on the property of residents and nonresidents, the tax delinquency on the part of resident property owners, and the total valuation, taxes, and tax delinquency in these townships for 1937. From this material the following conclusions are drawn: (1) The percentage of property owned by residents is low in all townships, but lowest in those that contain mineral lands and highest in the better farming districts; (2) The average value per acre of real property belonging to residents is low in all parts of the county; (3) Delinquency of taxes is highest in the nonmining areas (see Fig. 6).

TABLE I

VALUATION AND TAXES LEVIED ON PROPERTY OF RESIDENTS AND NONRESIDENTS AND TOTAL VALUATION AND TAXES LEVIED FOR 1937 IN FIVE TOWNSHIPS IN MARQUETTE COUNTY*

Township	Total valuation	Valuation on property of residents	Valuation on property of nonresidents	Total taxes	Taxes on property of residents	Taxes on property of nonresidents
Humboldt	$ 460,425	$68,750	$391,675	$ 7,046.86	$1,059.70	$ 5,987.16
West Branch	267,300	69,600	197,700	4,097.71	1,080.88	3,016.83
Ewing	107,840	31,830	76,010	2,403.98	728.60	1,675.38
Champion	1,033,780	33,840	999,940	23,635.20	771.03	22,864.17
Turin	289,250	18,575	270,675	7,663.26	516.63	7,146.63

* Data from township assessment rolls.

TABLE II

TAX DELINQUENCY ON PROPERTY OWNED BY RESIDENTS AND TOTAL TAX DELINQUENCY FOR 1937 IN FIVE TOWNSHIPS IN MARQUETTE COUNTY

Township	Taxes levied on property of residents	Percentage of property of residents delinquent	Total delinquency, in percentage*	Average value per acre of real property of residents
Humboldt	$868.15	18.08	46.83	$4.48
West Branch	777.34	28.08	18.99	9.58
Ewing	532.74	26.88	58.94	4.70
Champion	771.03	0	8.81	7.43
Turin	361.00	30.09	45.41	6.84

* Data from county treasurer's office.

Until the passage of the 15-mill tax-limitation bill in 1933 there was practically no limit to the amount of money that could be raised for public expenditures. Even now, the 15-mill limitation can be amended by a two-thirds vote within the townships. Thus, with county, state, and federal funds also available, the rural residents go blithely on their way, secure in the belief that they will be assisted in their economic difficulties. The expenditures of government within the county for 1938 totaled over four million dollars (see Table III), representing more than ninety dollars for every man woman, and child (1930 census). A third of this total was allocated to welfare relief.

Two areas show abnormally high per capita government expenditures. One of these is the iron-mining district, where the taxes on mining property having an extremely high valuation pay for a large part of the public services and ease the burden on the resident taxpayers. The mining companies seem not to begrudge superior schools and roads in the towns and villages which contain miners and their families.

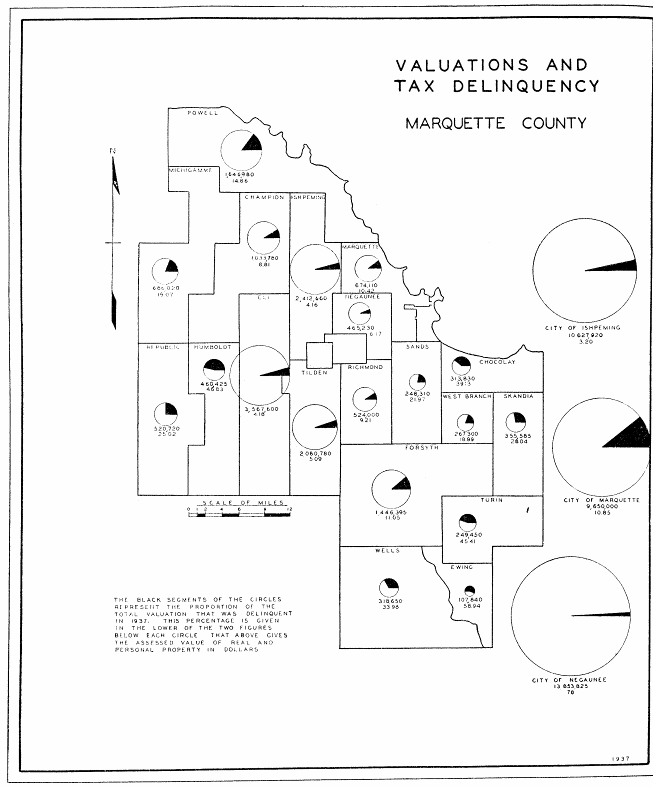

FIG. 6

The second area is composed of the rural districts that have small, widely scattered farms. In these districts the transportation of school children and the construction and maintenance of farm roads are expensive. The cost of one extra mile of snow removal in the winter usually is greater than the total amount of taxes paid by the farmer whose property the road serves. Until the present zoning plan went into effect every farmer and any other rural resident, no matter how far from schools and highways, could demand, and was entitled to receive, road and school services.

TABLE III

LOCAL GOVERNMENTAL EXPENDITURES FOR 1938 IN MARQUETTE COUNTY

County general fund	$ 781,214.50 *
Emergency relief (Emergency Relief Administration)	116,261.42 *
Total school expenses	1,132,267.58 *
Township administration	66,587.02 †
Municipal government expenditures	1,050,534.01 ‡
Works Progress Administration	895,795.11 §
National Youth Administration	23,342.48 §
Old-age assistance	91,410.30 §
Total	$4,157,412.42
Per capita expenditure (1930 census)	$94.50

* From the *Annual Report, Marquette County Board of Supervisors,* 1938.
† From data furnished by the Marquette County Board of Supervisors, committee on taxation and finance.
‡ From data furnished by the city treasurers of Ishpeming, Negaunee, and Marquette.
§ From data furnished by the county Emergency Relief Administration office.

The continuance of high governmental expenditures in the areas outside the iron district will be a difficult problem in the future. At present a large share of the local taxes in these areas is paid by nonresident owners of timberlands. But since much of this timber is already cut the land will soon revert to the state as tax delinquent, and thus be removed from the tax rolls.

Immediately the tax burden, formerly assumed by the owners of such land, will be transferred to other property owners in the township. Finally, either the tax rate will rise or public expenditures will be reduced. Delinquency has already mounted in the cutover lands in the southern part of the county (see Fig. 6), but little of the area has as yet reverted to state ownership (see Fig. 7).[3] The delinquent properties are still on the township assessment rolls, and their tax levies are still listed as assets, although many of the taxes will never be paid. The blow has not yet fallen on the other taxpayers in these townships. When it does come, it will be felt not through greatly increased tax rates (because of the 15-mill tax-limitation act), but through the only other alternative — reduced public expenditures. This will affect the good agricultural districts as well as the poor, the only difference being that they will be better situated financially to withstand it.

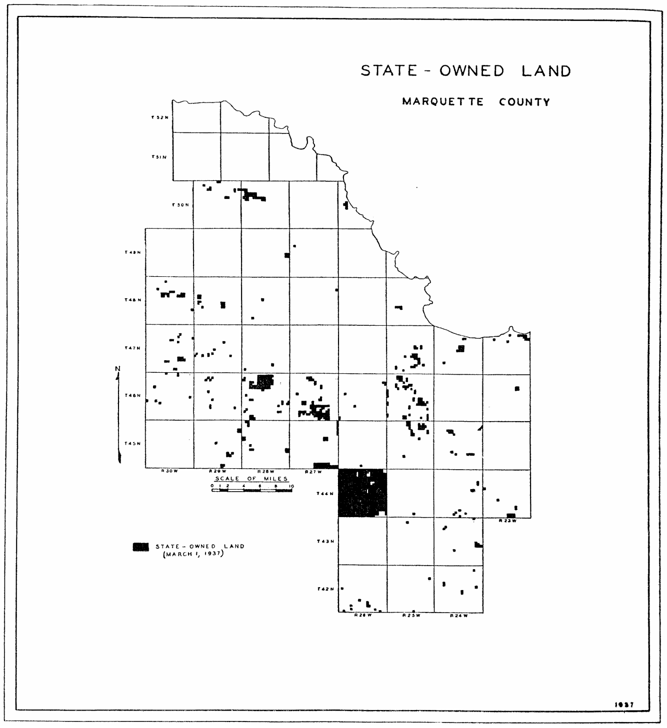

FIG. 7

CONCLUSIONS

The rural districts of Marquette County have always been marginal areas for settlement. Environmental factors produce certain conditions unfavorable for agriculture. The principal disadvantages are the shortness and coolness of the growing season and the small amount of soils of high natural productivity. Physical circumstances such as these have, however, influenced to a great extent only those farms whose operators make their entire living by farming. Such farms are located mainly in the eastern and southeastern parts of the county and in a few scattered areas elsewhere. Settlement over most of the county has been influenced much more by relationships with mining, lumbering, or recreational developments. Only the sand plains seem to have been avoided or abandoned by all types of permanent rural occupation.

Part-time farms and rural nonfarm homes have penetrated many of the areas that do not have favorable environmental conditions for their continued support. The principal motivating force in this movement has been iron mining. People, especially the Finns, moved out of the cities near the beginning of the present century to combine the advantages of subsistence agriculture with employment in the mines and the urban centers. When mining ceased to occupy as many men as before and when the urban centers started to lose population rapidly, such part-time farms began to have financial difficulties. The economic frontier of settlement had retreated. A similar situation resulted with regard to the part-time farms associated with lumbering. Although these settlements were not so numerous as those based on the mining-farming relationship, they experienced the same difficulties when the timber resources were depleted. But the part-time farms in the county have not been abandoned, and their occupants have not migrated to areas of greater economic opportunity. These people still enjoy certain advantages. All of them are able to demand and receive public services in the form of roads, schools, and welfare relief. If their cash income fails they are certain of public aid. The costs of such services are not paid by these settlers nor, to any great extent, by their more prosperous neighbors. Instead they are being met by nonresident owners of property within the local areas and by county, state, and federal-government funds.

Growing uneasiness at the large expenditures for public services initiated the rural zoning movement in Marquette County. The plan, which, as has been said, merely prohibits agricultural settlement in areas not now serviced by roads and schools, has been criticized because it did not take into consideration differences in the quality of the land. That the procedure followed was urgent and justifiable is supported by much of the data accumulated during the preparation of the research dissertation of which this paper is a summary. Even in the best agricultural areas public expenditures far exceed local tax returns. Future scattered settlement in some of the better unused parts of the county would necessitate too great an outlay of government funds in comparison to the value of the improved land resulting from such settlement. The zoning ordinance is elastic, however, and provides for amending the restrictions if necessary. The county officials have stated that such amendments would be made providing new settlement is made in large blocks, so that the difference between land values and governmental expenditures would not be excessive.

Marquette County well illustrates the pitfalls that can beset attempts to interpret human occupance solely on the basis of environmental factors or to draw zoning lines with reference merely to the quality of the land. Environmental factors set limits within which the economic frontiers fluctuate. In areas such as Marquette

County, which are dominated by mineral exploitation, changes in that industry have violent repercussions on the social and economic structures. These are transmitted to the cultural landscape in diverse ways. Here, the decline in mine employment and the depletion of the timber reserves were indirectly responsible for the rural zoning movement. Whether an upturn in the mining industry or the regrowth of pulpwood in certain areas will mean a widespread iteration of the zoning plan in the future remains to be seen; both developments are possibilities. Enough land serviced by roads and schools and unrestricted in the zoning plan remains, however, to provide for any normal growth of rural settlement.

Here, at least, is something new in Michigan, and not common in other states — a frontier of settlement established by law. The principal factors responsible for this fixed frontier were not differences in the quality of the land, but certain social and economic conditions.

It is interesting to speculate whether or not abnormally high governmental expenditures in other mining and lumbering areas often maintain "parasitic" settlement beyond normal frontiers. The answer to this question can come only through similar studies elsewhere.

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* This article is a condensation of a thesis submitted in partial fulfillment of the requirements for the degree of doctor of philosophy at the University of Michigan.

[1] It must be clearly stated that the promotion of the zoning plan was at all times carried on by residents of the county.

[2] See *Annual Reports of the Marquette County Board of Supervisors*, 1912-37.

[3] Since 1938 the acreage of state-owned land in the county has greatly increased.

VAN RIPER PLATE I

FIG. 1. Characteristic jack-pine vegetation in the sand-plains area

FIG. 2. An original stand of mixed white pine-balsam-paper birch, with a beaver dam in the foreground

FIG. 3. A pulpwood logging camp north of Champion. Both light and heavy trucks are now necessary

VAN RIPER PLATE II

FIG. 1. One of the few open-pit iron mines near Palmer (courtesy of L. H. Halverson)

FIG. 2. A typical part-time farm

VAN RIPER PLATE III

FIG. 1. A recently settled part-time farm west of Marquette

FIG. 2. One of the modern dairy farms near Skandia

COMPARISONS OF CRITERIA FOR THE RATING OF AGRICULTURAL LAND*

JETHRO OTTO VEATCH AND IVAN F. SCHNEIDER

IN A realistic world, where self-interest is a controlling motive, values of different kinds of land are not equal, whether the kinds are evaluated for the same use or for different uses. Therefore demands arise for the classification of land on a quality basis, and it follows that individuals or organizations will attempt to satisfy the demands.

When individuals or government agencies have made classifications on an economic basis, the results have never been entirely acceptable to all interests affected, and therefore questions arise about the validity of criteria and the value of the data which are used. Since there is no generally accepted procedure, it occurred to the writers of this article that a comparison of two different methods of composing an economic rating of agricultural land for the same area might be of some value, or at least be of academic interest, since the study is concerned with a critical comparison of a few of the possible criteria which may be employed.

The area selected for comparison is the State of Michigan. One classification is based upon the average value per acre of land and buildings by counties as given by the United States Census of Agriculture for the years 1930 and 1935. In accepting this basis for rating the land in the separate counties of the state it is necessary to start with the assumption that the selling price, or exchange value, is, after all, a true reflection of inherent values of land or its productive capacity, and is therefore the proof of the pudding. A second plan of rating the counties is based upon an agricultural land-classification map recently completed by the Michigan Agricultural Experiment Station.[1] This has a physical basis in that it represents an interpretation of natural land types in terms of agricultural use. From yields of plant growth and response to agricultural management, so far as these are known for natural land types, or soil types, qualitative ratings are assigned to each land type and the ratings extended throughout the geographic range of a type whether or not the land is in cultivation. The money value of land and the economic environment are not primary considerations. In the publication referred to all the land of the state is separated into four classes, and the acreage of each class is estimated for individual counties.

TABLE I

Comparison of Agricultural Land Ratings for Michigan

Basis 1930 U. S. Census			Basis physical land classification *			Basis 1935 U. S. Census		
Rank	County	Average acre value	Rank	County	Rating value	Rank	County	Average acre value
1	Wayne	$425.04	1	Clinton	32.16	1	Wayne	$136.04
2	Oakland	194.33	2	Eaton	32.08	2	Berrien	99.79
3	Macomb	183.64	3	Lenawee	31.60	3	Macomb	78.17
4	Berrien	149.95	4	Huron	31.50	4	Monroe	76.60
5	Monroe	128.57	5	Sanilac	31.20	5	Oakland	68.42
6	Washtenaw	104.98	6	Gratiot	30.48	6	Van Buren	68.08
7	Ottawa	92.34	7	Ionia	30.48	7	Bay	65.24
8	Gogebic	90.98	8	Genesee	30.24	8	Genesee	62.85
9	Van Buren	89.51	9	Hillsdale	30.23	9	Washtenaw	60.72
10	Bay	87.61	10	Shiawassee	30.11	10	Ottawa	60.34
11	Kent	85.76	11	Lapeer	29.52	11	Saginaw	60.16
12	Saginaw	84.48	12	Bay	29.52	12	Lenawee	59.17
13	Lenawee	81.78	13	Macomb	29.10	13	Kent	58.57
14	Gratiot	80.53	14	Branch	28.83	14	Ingham	58.12
15	Genesee	79.38	15	Washtenaw	28.80	15	Gratiot	56.91
16	Ingham	76.89	16	St. Clair	28.52	16	Allegan	55.60
17	St. Clair	74.70	17	Calhoun	28.45	17	Kalamazoo	54.99
18	Allegan	73.52	18	Tuscola	28.14	18	Gogebic	53.49
19	Clinton	72.67	19	Saginaw	28.12	19	Muskegon	53.39
20	Kalamazoo	72.36	20	Ingham	27.90	20	Eaton	52.36
21	Shiawassee	71.91	21	Kent	27.65	21	Clinton	51.06
22	Muskegon	69.72	22	Berrien	27.50	22	Jackson	49.58
23	Livingston	67.12	23	Kalamazoo	27.40	23	St. Clair	48.57
24	Eaton	65.06	24	Monroe	27.26	24	Ionia	48.28

* From a map published in Special Bulletin 231, *Agricultural Land Classification and Land Types,* Michigan Agricultural Experiment Station, 1941

Rank	County	Average acre value	Rank	County	Rating value	Rank	County	Average acre value
25	Lapeer	$ 64.87	25	Livingston	26.72	25	Shiawassee	$ 47.75
26	Tuscola	61.74	26	Jackson	26.57	26	Branch	45.45
27	Jackson	61.48	27	Oakland	26.34	27	Huron	45.37
28	Ionia	61.45	28	Wayne	25.71	28	Cass	45.32
29	Cass	58.93	29	Barry	25.60	29	Tuscola	44.89
30	Huron	57.33	30	Isabella	25.49	30	Hillsdale	44.45
31	Calhoun	57.05	31	Ottawa	24.96	31	Calhoun	42.62
32	Branch	56.69	32	Montcalm	24.90	32	Grand Traverse	42.17
33	Grand Traverse	56.45	33	St. Joseph	24.67	33	St. Joseph	41.82
34	Hillsdale	56.25	34	Van Buren	24.46	34	Montcalm	41.11
35	Isabella	54.18	35	Cass	24.12	35	Lapeer	40.59
36	Oceana	53.53	36	Allegan	23.62	36	Livingston	40.32
37	Iron	52.66	37	Ontonagon	23.34	37	Iron	39.93
38	St. Joseph	52.64	38	Leelanau	22.87	38	Mason	39.21
39	Montcalm	52.59	39	Alpena	22.11	39	Oceana	38.15
40	Mason	52.40	40	Antrim	21.77	40	Isabella	37.78
41	Barry	50.46	41	Arenac	21.58	41	Barry	36.21
42	Midland	49.92	42	Osceola	21.49	42	Midland	35.27
43	Leelanau	47.40	43	Houghton	21.42	43	Alger	33.09
44	Dickinson	46.07	44	Charlevoix	21.14	44	Sanilac	32.52
45	Sanilac	45.41	45	Oceana	20.20	45	Baraga	32.32
46	Baraga	44.84	46	Midland	19.82	46	Leelanau	29.37
47	Ontonagon	44.41	47	Presque Isle	19.79	47	Newaygo	28.67
48	Alger	41.13	48	Mecosta	19.78	48	Marquette	28.06
49	Newaygo	40.45	49	Gogebic	19.72	49	Houghton	27.79
50	Menominee	38.76	50	Menominee	19.48	50	Menominee	27.25
51	Houghton	37.99	51	Dickinson	19.27	51	Delta	26.17
52	Delta	37.79	52	Grand Traverse	19.10	52	Dickinson	26.12
53	Marquette	37.31	53	Gladwin	18.58	53	Arenac	25.78
54	Mecosta	36.25	54	Iron	18.56	54	Keweenaw	25.03
55	Benzie	35.81	55	Emmet	18.45	55	Ontonagon	25.01
56	Arenac	35.29	56	Missaukee	18.44	56	Schoolcraft	25.01
57	Charlevoix	34.39	57	Cheboygan	18.42	57	Charlevoix	24.73

TABLE I (*Concluded*)

Comparison of Agricultural Land Ratings for Michigan

Basis 1930 U. S. Census			Basis physical land classification			Basis 1935 U. S. Census		
Rank	County	Average acre value	Rank	County	Rating value	Rank	County	Average acre value
58	Manistee	$33.44	58	Mason	18.29	58	Mackinac	$24.44
59	Chippewa	32.88	59	Wexford	18.11	59	Roscommon	23.18
60	Mackinac	32.06	60	Alcona	18.10	60	Benzie	22.70
61	Schoolcraft	31.39	61	Ogemaw	17.92	61	Manistee	22.57
62	Emmet	31.00	62	Alger	17.72	62	Ogemaw	22.52
63	Alcona	30.60	63	Clare	17.50	63	Luce	22.33
64	Alpena	30.07	64	Delta	17.11	64	Iosco	21.98
65	Missaukee	30.06	65	Chippewa	17.05	65	Mecosta	21.88
66	Osceola	29.75	66	Newaygo	16.96	66	Alcona	21.37
67	Gladwin	29.61	67	Manistee	16.60	67	Osceola	20.98
68	Antrim	29.57	68	Baraga	16.21	68	Chippewa	20.80
69	Cheboygan	27.44	69	Muskegon	16.08	69	Emmet	20.52
70	Keweenaw	27.43	70	Kalkaska	15.81	70	Antrim	20.40
71	Luce	27.40	71	Otsego	15.60	71	Alpena	20.36
72	Iosco	27.19	72	Montmorency	15.09	72	Presque Isle	20.00
73	Montmorency	27.02	73	Iosco	15.02	73	Gladwin	19.19
74	Roscommon	26.81	74	Benzie	15.00	74	Clare	18.73
75	Lake	26.53	75	Marquette	13.41	75	Missaukee	18.58
76	Ogemaw	25.88	76	Mackinac	13.32	76	Lake	18.43
77	Wexford	25.71	77	Oscoda	12.69	77	Crawford	17.63
78	Presque Isle	25.55	78	Roscommon	12.44	78	Wexford	16.97
79	Clare	25.52	79	Luce	12.38	79	Cheboygan	16.80
80	Oscoda	24.63	80	Lake	12.27	80	Otsego	16.60
81	Otsego	22.21	81	Crawford	11.82	81	Montmorency	16.55
82	Crawford	21.47	82	Schoolcraft	11.80	82	Kalkaska	16.02
83	Kalkaska	20.47	83	Keweenaw	11.32	83	Oscoda	16.00

In order to place this scheme on a comparable basis with that derived from the Census each of the four land classes is given an arbitrary, but uniform, value per acre. The average acre value thus obtained is used solely for the purpose of arranging the counties in order of their rank. The two classifications are presented in Table I to facilitate comparison. From a study of the table it is evident that no close agreement exists between the two. Consequently, doubts may arise in the mind of the reader about the soundness of either rating or both. In the Census rating there is a strong suspicion that the figures do not necessarily represent actual agricultural values. Extraneous factors, such as speculative values for nonagricultural uses, have certainly determined the high rank of Wayne, Oakland, and Macomb counties, for by any other tests these counties would have a lower rating.

The physical classification is also vulnerable to adverse criticism, since it is not precisely mathematical, but, on the contrary, is in a large measure qualitative and subjective. Also, there is a basis for the contention that the two schemes are not properly comparable, since the physical classification embraces all land and the Census only that which it designates as agricultural. However, even in those counties which are almost entirely in farms there is no close agreement. If, in the physical classification, the counties are ranked according to the amount of first-class agricultural land which they contain there is still no agreement with the Census figures.

Inasmuch as neither the selling price, or exchange value, of agricultural land nor the values on a physical basis are entirely acceptable, the possibility of use of other criteria may be considered. Possible criteria for a qualitative classification of land on an agricultural basis are: (1) net income from land, (2) money value of agricultural products, (3) measured yields of crops, (4) selling price of land, (5) values assessed for taxation purposes, (6) value of farm buildings, (7) physical character of the land.

Logically, net income from land should be the best test of quality but any extensive classification on this basis is impracticable because net income is an elusive thing and published data are not available. Even if farm-management accounts have been kept for a period of years for units as large as a township the resultant land classification would be defective unless other factors were considered, such as the competence of operators, the type of farming, and the size of farm units. Further, income would not provide any basis of agricultural classification of land not in farms.

The gross value of agricultural products is a possible basis or test of a classification, but is objectionable as a single criterion, since values fluctuate widely, are difficult to obtain for all products, and are reported by political units instead of by land types.

Yield of crops has some virtue not possessed by other criteria. These data, however, are not very dependable if relied upon alone, since statistics are not complete and-are available only by political units.

Selling price of land and assessed values may be considered together and dismissed as not being entirely trustworthy, for in too many instances extraneous factors determine the figures. Figures vary widely for the same kind of land, inasmuch as economic environment and political conditions may be controlling factors rather than actual agricultural worth.

Farm buildings and other farm improvements reflect the quality of the land either well or poorly. In some older settled regions, where sufficient time has elapsed for trial-and-error adjustments to take place, farm improvements are a reflection of the worth of the land. However, for certain types of farming which are based upon a single crop, for absentee ownership of land, and for pioneer regions, this criterion may have little or no value.

The physical character of land may serve as a basis of economic land classification by assigning ratings to soil types or other natural units of land. The ratings are tacitly based upon experience in land use and involve some one or all of the preceding criteria. The physical basis has an advantage in that all land, whether in farms or not, may be classified; and that favorable qualities or limitations for agricultural use may be inferred from the chemical and physical properties of the soil which may not be revealed at a particular time by selling price, assessed values, yield of crops, or farm improvements.

Judged by strict standards, any economic land classification covering states or regions and based upon the criteria listed above cannot be precisely mathematical. Nevertheless, qualitative, or more or less subjective, classifications may be made which can have considerable value for the inventory of land resources and for land planning if a combination of criteria is involved in making them rather than a single factor.

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* Authorized as Journal Article No. 517 (N. S.) from the Michigan Agricultural Experiment Station.

[1] Veatch, J. O., *Agricultural Land Classification and Land Types of Michigan*, Special Bulletin 231 (Revised), Mich. Agric. Exper. Station, 1941.

THE DISTRIBUTION OF DRUMLINS IN MICHIGAN

STANARD G. BERGQUIST

INTRODUCTION

ALTHOUGH drumlins make up a relatively small part of the glaciated landscape in Michigan they are rather widely dispersed in both the Northern and Southern peninsulas (Fig. 1). Of the nine areas described in this report only two, the Grand Traverse and Menominee districts, carry sufficient drumlin forms to compare in importance with the areas of concentration in New York and Wisconsin. The drumlins in Michigan present a rather wide variety of form and outline, ranging from low, poorly developed oval drumlinoids to the elongated linear types which display striking asymmetry of stoss and lee slopes. They are all superposed upon areas of till plain and were formed by the activity of readvancing ice.

Drumlins are associated with each of the various lobes that played a part in developing the surface features of both peninsulas of the state. In general, the forms are aligned with trends more or less parallel to the glacial striae in the bedrock and perpendicular to the axis of the moraines from which the ice sheets readvanced. On the Lake Huron side of the state, however, there is a marked discordance between the trends of the axis of the drumlins and the moraines and likewise in the markings in the rock pavement. This unusual relationship reflects multiple activities of the ice sheets as they deployed over the surface.

No attempt has been made in this report to account for the origin of the drumlins in Michigan. This general problem has been under discussion for the past seventy-five years, with the result that many theories have been advanced to explain their development. None of them seem adequate, however, to satisfy all the requirements involved in this complex problem.

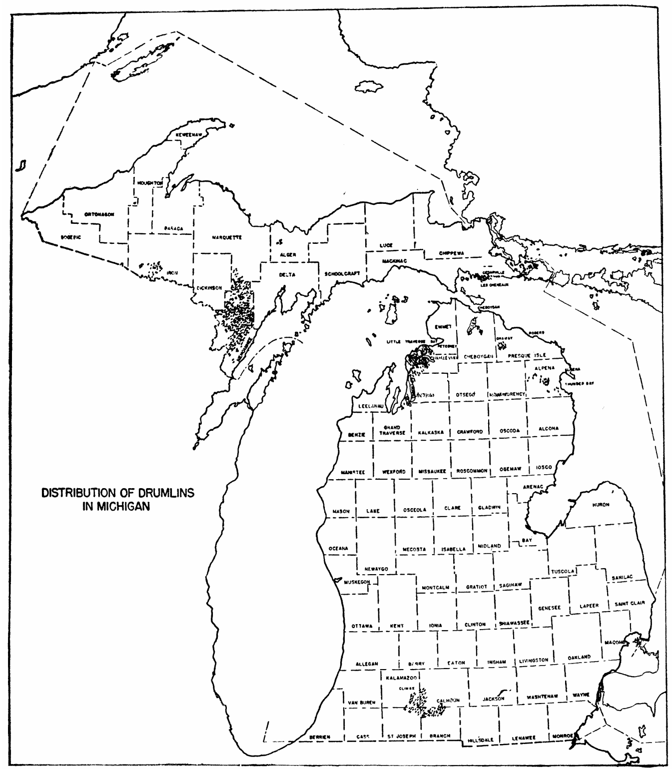

FIG. 1

DRUMLIN AREAS IN THE SOUTHERN PENINSULA

The Climax — Union City Area

A cluster of small drumlins and drumlinoid ridges is spread out on the interlobate till plain situated just outside the Tekonsha moraine in parts of Kalamazoo, Calhoun, St. Joseph, and Branch counties. The plain stands at an elevation of 900 to 960 feet above sea level and was formed by the combined activities of the Michigan and Saginaw lobes when the ice front retreated from the Sturgis moraine. After the ice moved forward to form the Tekonsha moraine there was a readvance of the Saginaw lobe over the till plain, the surface of which was then resculptured into a series of more or less parallel ridges which now feature the landscape. From the direction of trend of the ridgelike hills it is apparent that the drumlin-shaping process was due in large measure to the activities of the Saginaw lobe. It seems probable that, while this ice front was readvancing over the till plain, the Michigan lobe held its position without much movement on the west limb of the Tekonsha moraine. Since the final retreat of the ice from this area the till plain has been sliced into a series of parallel strips by streams whose southwest courses were unquestionably influenced by the drumlin trends.

The drumlinoid hills of the area are composed of clayey till, similar in composition and texture to that which makers up the plain upon which they are superposed. The hills are roughly oval and more or less symmetrical in outline. There is no appreciable difference in the degree of slope on the stoss or front and the lee or tail ends. The majority of the forms are rather low, with crests rarely exceeding 30 or 35 feet above the surface of the plain. They range in length from one eighth to three quarters of a mile and in width from one tenth to one fifth of a mile. The general trend of the drumlinoid hills ranges from S. 30° W. on the west edge of the plain south of Climax to S. 40° W. on the east edge of the area near Union City.

This is the oldest of the drumlin areas in the state and was developed shortly after the Saginaw lobe had made its second important halt upon recession into Michigan.

Alpena County

Several small clusters of drumlins are distributed over the till plain in the region to the south and west of Alpena. The forms are rather widely scattered in the area, extending from near Hobson to the southeast portion of the county. They were developed on a till plain, with an elevation of 700 to 800 feet above sea level, that was formed in the retreat of the Huron lobe from the main ridge of the Port Huron moraine.

In the areas directly south of Dafoe and west of Ossineke the drumlins have a trend which is generally S. 35° E. They are aligned more or less parallel to the shore of old Lake Algonquin, and it seems probable that a fairly large portion of the original drumlin section on the east side of the district may have been cut away by the waters of that lake.

In general, the drumlins trend parallel to the axis of the morainic ridges and hence also to the retreating ice front that formed the moraines of the area. It may be inferred from this relationship that they were formed by an ice movement different from that which was responsible for building up the moraines. The glacial striae and grooves in the rock pavement to the north of the drumlin area bear generally S. 55° E. Thus it may be seen that there is a marked discordance of trends between the drumlins, the bedrock markings, and the major axis of the moraines, the implications of which will be discussed in a later paragraph.

Presque Isle County

A series of well-defined elongated ridges with distinct troughs between them is situated on the till plain immediately east of Onaway. The drumlins in this area are composed of bouldery till containing a heterogeneous mixture of all types of material, much of it of local derivation. The till plain which carries the drumlins stands at an elevation of 800 to 900 feet above sea level and was formed by the ice of the Huron lobe as it retreated basinward from the main axis of the Port Huron moraine.

On the western edge of the plain, near Onaway, the ridges are low and somewhat drumlinoid in character. They increase in size to the eastward and attain a relief of nearly a hundred feet on the east side of the area. The drumlins are lined up with their major direction more or less parallel to the axis of the morainic ridges in the area. They trend generally S. 40° E., whereas the glacial grooves and striae in the bedrock exposures near by bear S. 27° E.

In this section, as in the Alpena district, there is a definite discordance in trends between the drumlins, the rock markings, and the alignment of the morainic ridges. It is obvious that the ice movement that produced the drumlins was not the same one which was responsible for the scratches on bedrock or for the construction of the morainic features. The author is inclined to the view that detailed mapping of the till plain will reveal the presence of numerous drumlins not indicated in Figure 1.

Cheboygan County

A small cluster of rather well defined drumlins is situated in the clayey lacustrine plain near Aloha, on the east side of Mullet Lake. They appear to have been formed on a till plain that was spread out by the Huron lobe upon its retreat from the inner ridges of the Manistee moraine to the position of the Cheboygan ridge. The latter moraine marks the final stand of the Huron lobe in the Southern Peninsula previous to its retirement into the lake basin.

The drumlins in this area protrude above the clayey plain, whose elevation ranges from 600 to 650 feet. They were completely covered by the waters of Lake Algonquin, the shore of which is marked by features that stand at a level of 740 feet above sea level. During this stage of inundation the forms were thoroughly washed by water, and in all probability much of the finer material was carried away. Again, in the Nipissing stage of lake development the portion of the plain below the level of 625 feet was covered by water, with the result that certain of the drumlins were further scrubbed by waves.

The drumlins in this area bear generally S. 40° E. They are aligned in a direction more or less parallel with those near Onaway and Alpena farther south and were undoubtedly formed by the same ice movement which was responsible for their sculpturing. The Aloha drumlins have a trend which is roughly parallel to the morainal ridges that mark the position of the retreating ice border. They do not conform with the glacial grooves and striae whose bearings on the rock pavement at Tower dam and Marvin quarry are S. 27° E. These drumlins are the youngest in the Southern Peninsula and were formed by the Huron lobe in its final readvance before leaving the Straits of Mackinac.

DISCORDANCE OF TRENDS A REFLECTION OF MULTIPLE ICE ACTIVITY

The lack of alignment between the trends of the drumlins and the morainic ridges in the Alpena, Onaway, and Aloha districts may be referred to a conflict of activities in the ice sheets which deployed over the area. The discordance of these trends as related to the bearings of the glacial markings on the rock pavement further complicates the picture.

It is the opinion of the author that at least three episodes of ice movement were involved in the development of the features expressed in the area. The first and major advance of the Huron lobe is related to the activities which scored the rock surface. The ice which was responsible for the formation of the Huron lobe had its origin in the ice-filled Superior basin. It deployed across the lowlands of the Northern Peninsula and found its way into the Huron depression in the region to the east of the Straits of Mackinac. This advance of the ice is marked by grooves and striae which run in a direction ranging from S. 27° E. in Cheboygan County to S. 50° E. in Alpena County.

After the main ridge of the Port Huron moraine had been formed the Huron ice retreated slightly to the north of eastward across the northeast portion of the Southern Peninsula. Pivoting on the Port Huron moraine, the ice front melted back into the Huron basin, leaving in its wake a succession of parallel north-south-trending morainic ridges.[1] (See Fig. 2.)

Before the final breakup of the lobe in the Huron basin there was a readvance of the ice from the Straits in a direction parallel to the major trends of the drumlins. The movement of this mass of ice, confined between the previously formed morainic ridges, was thus directed into Thunder Bay near Alpena. In its advance across the intermorainic plain the till was sculptured into a series of drumlins whose bearings range from S. 35° E. to S. 40° E.

Grand Traverse Drumlin Area

An extensive area of drumlins is developed on the till-plain district lying between Grand Traverse and Little Traverse bays in parts of Grand Traverse, Antrim, Charlevoix, and Emmet counties. The till plain was formed by the activities of the Michigan lobe during its retreat from the position of the Manistee moraine.

In the northern part of the district the drumlins extend inland from Lake Michigan for a distance of twenty miles. They have their best development in the section between Torch and Charlevoix lakes, where they assume the shape of linear ridges separated from one another by intervening sags. The majority of the drumlins in this portion of the plain have a length which ranges from one half to three quarters of a mile, although some of the more prominent ridges attain a length of more than one and one-half miles. In general, the drumlins range in width from one eighth to one quarter of a mile and are as much as fifty and sixty feet high. In the southern part of the district the features are rather poorly developed and assume the form of oval drumlinoids. In this sector the forms are crowded into a narrow belt of till plain immediately inside the Manistee moraine.

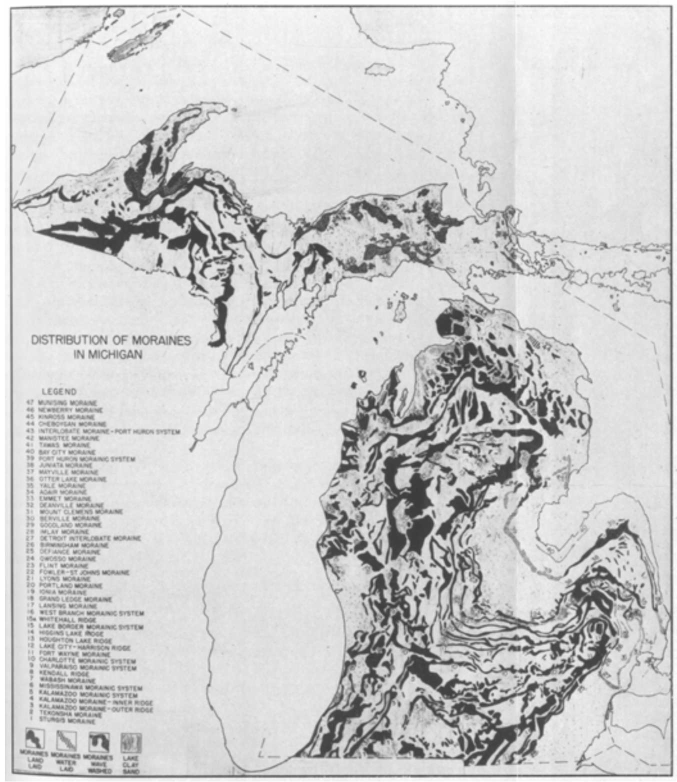

FIG. 2

Leverett[2] describes the drumlins as being "composed of very evenly mixed stony till, stones being distributed through almost every inch of the deposit. In most of the exposures the till shows indistinct partings rudely concentric with the surface."

Along the border of Grand Traverse Bay the drumlins trend slightly east of south. They run somewhat parallel to the great valleys which are occupied by Elk and Torch lakes. In the district around Lake Charlevoix the direction of trend of the ridges changes abruptly, many of the forms assuming directions which average S. 35° E. There is a marked discordance between the trend of the drumlins and the direction of movement of the ice which was responsible for scouring the basin which now contains Lake Charlevoix.

In the area between Torch Lake and the east arm of Grand Traverse Bay the ridges run generally parallel to the long axis of the marginal lakes. It is doubtful, however, whether these rock basins were embossed by the same ice advance that remodeled the till into drumlin ridges.

On the eastern edge of the till plain the glacial drift cover is very thin. Many of the ridges which feature the landscape have been sculptured out of shale by the erosional work of the readvancing ice. Near Ellsworth in Charlevoix County and also south of East Jordan in Antrim County some of the drumlins have their underpinnings in the Ellsworth shale.

DRUMLIN AREAS IN THE NORTHERN PENINSULA

Iron County

The oldest area of drumlins in the Northern Peninsula is located on a till plain which is centered in the district of Iron River. The drift of this plain may be attributed to an ice activity that was responsible for the Chippewa-Keweenaw ice tongues which were directed in their movement largely by the Keweenaw Peninsula. The Chippewa lobe was induced by the broad embayment west of the peninsula, whereas the Keweenaw tongue found its way through the narrow bay of that name to the east.

The till plain which carries the drumlins is composed of a heterogeneous mixture of drift ranging in texture from fine clay to sand. A wide variety of boulders, many of local derivation, are scattered over the surface and likewise incorporated with the material that comprises the drumlins.

Russell[3] refers to this extensive plain as having a topography which is distinctly morainic. He also separates the drift into an older red till east of the Chicaugon-Trout Lake depression and a younger overlying gray till to the west of the slough. His interpretation of the topography of this plain was incorrect, for it is obvious that the ridgelike character of the surface and its drumlin associations would indicate deposition by moving ice rather than marginal deposition at definite stationary stages of ice retreat.[4]

The general alignment of the ridges and valleys in the plain, together with the direction of the striae on the rock pavement, would indicate that the Chippewa lobe which sculptured the drumlins moved in from the northeast with a generally S. 20° W. to S. 45° W. trend. The ridges range from low oval, symmetrical drumlinoids to well-defined elongated and smoothly rounded forms averaging one half to three quarters of a mile in length. The drumlins are separated from one another by poorly drained sags and basins which hold numerous swamps, lakes, and minor drainage ways.

Alger County

A small cluster of drumlins is situated on the north edge of the "Trenary" till plain in the vicinity of Eben. The plain is composed of a reddish loose-textured bouldery till containing an abundance of locally derived flat blocks of limestone and dolomite. It stands at an elevation of 1,000 to 1,100 feet and was formed by the activities of the Green Bay lobe, which found its way out of the Superior ice mass through the Au Train-Whitefish depression.

The wide distribution of eskers over the surface of the "Trenary" till plain suggests an origin by ice stagnation.[5] A slight readvance of the ice across the north edge of the plain was responsible for the sculpturing of the drumlins.

The drumlins of the Eben district are somewhat steep-sided and longated in a north-south direction. They are made up of a heterogeneous mixture of reddish boulder clay and contain numerous slabs of local limestone and dolomite which are set into the structure without any definite orientation. The ridges average about twenty to forty feet in height and range from less than a half mile to more than a mile in length. They have a trend which is roughly north to south and are parallel to the direction of ice movement as shown by striae on adjacent rock exposures.

Menominee Drumlin Area

With the exception of a few small morainal ridges which mark its west and southeast borders the surface of Menominee County may be regarded as comprising a vast till plain. In his description of the area Ver Wiebe[6] states that drumlins are present in nearly every township; over six hundred individual forms have been counted in the twenty-five townships in which they are most prominent.

The drumlins occur in the form of smoothly sloped ridges, elongated in the direction of the major ice movement. The general. axial trend of the forms is S. 40° W., with a slight departure from this direction in the western part of the county. The majority of the drumlins are about three quarters of a mile long, although a few of them are extended to a length of over one and one-half miles. They have blunt stoss ends and taper off to gentle profiles on the lee or tail slopes.

Double and triple drumlins, in which two or three parallel ridges are superposed upon a single drumloidal arch, are not uncommon. Numerous eskers are associated with them. They usually occur in the troughs between the drumlins and are aligned parallel to the major axis of the ridges. Russell[7] describes a compound ridge immediately south of Wilson, where a well-defined esker is perched upon the summit of a drumlin in such a manner that the longer axes of the two features coincide. He cites "a conspicuous example of an esker extending in a direction approximately at right angles to the longer axis of the associated drumlin" in the area about half a mile northwest of the village of Spalding. The drumlins of the Menominee district were shaped by the activities of the Green Bay lobe, which deployed over the till plain as a tongue protruding from the mass of ice which then filled the Superior basin.

If we accept the viewpoints of Anderson[8] and Flint[9] that eskers are formed under conditions of stagnation, then it would seem to follow that the last ice sheet which advanced over the till plain must have stagnated after the drumlins had been formed. In all probability the ice disappeared from the area as a result of ablation and evaporation. This would lead us to the conclusions expressed by Alden[10] — that the eskers were formed subsequent to the shaping of the drumlins.

The material in the drumlins of the Menominee district is ordinarily unassorted and unstratified. In that respect it does not differ materially from the till of the plain out of which they were formed. Occasionally a section shows rude bedding planes which are parallel to the surface contour of the hills, which indicates that melt water was actively at work during the drumlin-shaping interval.

Mackinac County

A small isolated group of drumlins is situated on Les Cheneaux Islands in the district between Hessel and Cedarville. They are distributed over a surface where relatively thin drift covers the bedrock. Russell[11] describes the drumlins as being of the elongated type, in several instances from one to two miles in length and with a maximum width of five hundred to eight hundred feet. They have a height of forty to fifty feet above the intervening troughs. They are composed of a compact clayey till of reddish color and contain numerous boulders, many of which are of local derivation. The majority of the drumlins have a bearing S. 52° E. and are aligned parallel with the capes and the narrow rock ridges that make up the islands. The trend of the striae in the rock pavement conforms closely to the direction of the drumlin forms.

The drumlins are situated on an area that was previously covered by the waters of Lake Algonquin. They were also under water during the Nipissing stage, at which time they were no doubt thoroughly washed and scrubbed by waves. The prevalence of concentrated boulders and coarse material in them gives testimony to the removal of much of the finer material. Many of the outlying drumlins are today partly submerged in the waters of Lake Huron and are being subjected to lacustrine wave erosion.

The drumlins of Les Cheneaux Islands district were formed by a lobe which extended into the Lake Huron basin. They were shaped by ice which readvanced over the till plain in a direction generally S. 52° E. after the Kinross moraine in Chippewa County had been constructed. They trend more or less parallel to the axis of the Kinross ridge and show the same discordance that is manifested in the Alpena, Presque Isle, and Cheboygan areas in the Southern Peninsula. Thus it is obvious that at least two movements of the ice were responsible for the development of the features in this portion of the state.

The drumlin areas which have been reviewed in the foregoing pages represent those which are known in Michigan at the present writing. The author is of the opinion that other districts as important as many of those referred to will be discovered when the surface features of the state are worked out in more detail.

MICHIGAN STATE COLLEGE
EAST LANSING, MICHIGAN

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THE DISTRIBUTION OF MINOR FAULTS IN THE TRIASSIC OF PENNSYLVANIA

DEAN B. MCLAUGHLIN

INTRODUCTION

THE existence of numerous minor faults in the Triassic rocks of the eastern United States, particularly those of the Connecticut Valley, is so well known that it is almost taken for granted that these formations are extensively faulted wherever they occur. This view has occasionally been carried to the extreme of suggesting that there may be manifold repetition of strata, and that the real thickness of the series is only a small fraction of the calculated value.

The tracing of identifiable beds for distances of many miles along the strike, especially through pitching folds, has led the writer to conclude that unrecognized faults cannot produce more than a negligible effect on the apparent thickness.[1] The field work in a large area is now near enough to completion to permit an attack on the question of faulting from a somewhat different point of view, namely, the distribution of observed minor dislocations and of exposures of sheared or crushed rock. If there are any hidden faults of major importance, some of them ought to reveal their presence by the occurrence of disturbed outcrops.

THE STRUCTURE OF THE TRIASSIC ROCKS

The principal structural features of the Newark series from the longitude of Princeton, New Jersey, westward to Reading, Pennsylvania, will be evident from a study of the structural map, Figure 1. Directions of strike of the beds are indicated by negative contours at intervals of 2,500 feet, measured from the base of the series. These represent the stratigraphic elevations of beds which outcrop at the average land surface (about 400 feet above sea level). Only sedimentary formations have been included in the totals. The larger areas of diabase are also exhibited on the map.

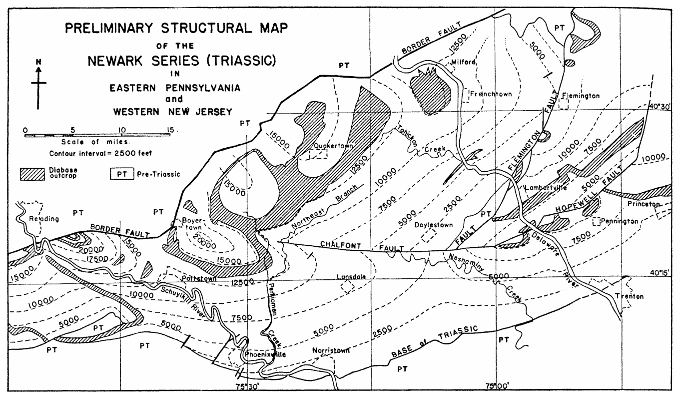

FIG. 1. Structural map of the Triassic rocks in eastern Pennsylvania and western New Jersey. The contours are negative and indicate stratigraphic elevations above the base of the series for beds which outcrop at the average land surface (elevation about 400 feet above sea level). Local uncertainties of some contours are referred to in the text. Diabase is not included in the thicknesses

In calculating the contours the Delaware River section was adopted as fundamental, and the base of the Stockton formation there was taken as zero. The Stockton-Lockatong contact lies at 4,500 feet, and it is assumed that the trace of that horizon establishes the 4,500-foot contour throughout the area in which it occurs.[2] Higher and lower stratigraphic levels were computed relative to the base of the Lockatong by means of observed dips and widths of outcrop, but these were adjusted on identifiable strata, such as the black-shale beds in the overlying Brunswick formation, wherever they occurred. Systematic effects due to errors in the measurements of strike have thus been avoided wherever key horizons were available.[3] The implied assumption that similar thicknesses of strata occur in different sections between any two given horizons is apparently not seriously in error within the region of deposition of black shales. Some systematic variations are to be expected from east to west, in view of the differences in the conditions of sedimentation.[4] It is seen that the lower half of the Stockton formation disappears westward and that the 2,500-foot contour abuts against the underlying crystalline rocks several miles west of Phoenixville.

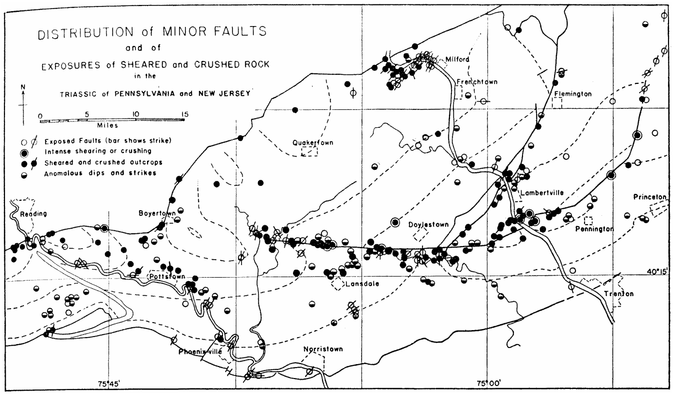

FIG. 2. Distribution map of the area represented in Figure 1, showing locations of exposed minor faults and disturbed outcrops. Only the alternate contours from Figure 1 are reproduced. Diabase areas are not shown, except for the dike which occupies a fault (lower left-hand corner of the map)

Over a large part of the region the rocks dip toward the north and northwest. Along the Delaware River northwesterly dips of ten to twenty degrees are the rule. The Hopewell and Flemington faults cut across the Newark rocks in western New Jersey and cause a large portion of the series to be repeated in three belts. Within each of the three areas the tilted strata maintain approximately the same strike for a number of miles, though some broad flexures are superimposed upon the principal monoclinal structure.

North of Pennington the Hopewell fault has a displacement of about 7,000 feet, with downthrow to the southeast. It does not bring up the base of the series; probably 3,000 feet of the Stockton formation lies beneath the surface. According to Hawkins,[5] the displacement increases to 10,000 feet about twelve miles northeast of there. The fracture nearly dies out in Pennsylvania, and the contours in Figure 1 imply an actual reversal of the direction of throw about five miles west of the Delaware, but this particular feature is uncertain.

The Flemington fault has an equally large displacement, reaching a maximum of about 10,000 feet at the Delaware River, with downthrow to the southeast. Just southwest of the river it exposes Cambrian quartzite and limestone beneath the Stockton formation in a belt several miles long. Where it crosses the river the great fracture has two branches which are joined at both ends and form a small lenticular mass between the major fault blocks.

The Flemington and Hopewell faults join a few miles southeast of Doylestown, Pennsylvania. From there westward the fracture is known as the Chalfont fault. The displacement decreases from about 5,000 feet at its eastern end until it passes into a pitching anticline about eighteen miles to the westward. For two or three miles south of the Chalfont fault the strata dip south westward. This should not be regarded as true drag; rather, the structure appears to be a faulted anticline, of which the beds that dip southwestward form the southern limb.

Farther west to the longitude of Reading the lower 10,000 feet of the series dips northwestward with broad gentle flexures which produce northeasterly dips west of Phoenixville and northwesterly in the area directly south of Reading. A large diabase dike occupies a fault near the southern border ten to fifteen miles west of Phoenixville, and pre-Triassic rocks are exposed as an inlier just north of the dike. The intrusive enters the Triassic area just east of the inlier and cuts northwestward across 10,000 feet of strata in a distance of twelve miles. Throughout that course it evidently occupies a fault whose displacement is about 2,500 feet, with the downthrow on the northeast side.

Host of the intrusive bodies of diabase occur in the Brunswick formation, the uppermost of the three principal members of the Newark series. West of the Delaware River the principal igneous mass is a sill 2,000 feet thick, with its lower contact at a variable level of 12 500 to 14,500 feet above the base of the Stockton. This sheet and the entire upper part of the sedimentary series are thrown into broad folds that are cut off by faults at the northern border. North of Flemington, New Jersey, the folding also involves the lower formations, and the base of the Stockton is exposed at the northern boundary. There the beds dip southwestward on the limb of a broad syncline. Other wide basins occur north of the diabase outcrop. One of these lies about Quakertown; the next is several miles farther southwest; and the third is east of Boyertown. It contains shales whose stratigraphic position is more than 20,000 feet above the base of the series. Between Pottstown and Reading there is a still deeper syncline on whose flanks steep dips occur. At its center, close to the border near Reading, an extrusive sheet of basalt lies at a stratigraphic level of 23,000 feet, and the shales and sandstones that overlie it are undoubtedly the youngest Triassic sediments in the entire region.

The accuracy of the contours in Figure 1 varies from one part of the map to another. They are believed to be quite precise up to 12,500 feet in the region west and north of the Flemington and Chalfont faults. Over most of the remaining area they are considered good approximations, except for local uncertainties.[6] In the synclinal basin about Quakertown, however, and in the next trough southwest of there the placing of the 15,000-foot contour is only rough.

EVIDENCES OF FAULTING

For our purpose a minor fault may be defined as one which does not have at any place a displacement equal to a large fraction of the thickness of one of the principal formations. For definiteness we may name an upper limit of roughly 500 feet.

Evidences of dislocations fall into three classes:

1. Some faults are actually exposed and produce visible displacement within a single outcrop. These require no further comment. We group with them a number of faults which have been inferred from offsetting or sudden disappearance of recognizable strata, such as the black shales within the red Brunswick beds.

2. Exposures of sheared, slickensided, shattered, and brecciated rock furnish strong evidence. Abnormal joint patterns and especially intense jointing may indicate the proximity of a fault.

3. In the Newark rocks, in which folding is on a broad and open scale, anomalous dips and strikes are very significant. Small abrupt local flexures of strata are included in this group. In general, only a strike differing from the regional value by 45 degrees or more was considered discordant, but the limit had to be varied according to the character of the rock and of the exposure, and one very conclusive discordance of twenty degrees has been taken as significant. Differences of dip without change of strike were not admitted unless they involved deviations equal to the regional dip for angles of fifteen degrees or more.

The positions of disturbed outcrops are plotted on the distribution map, Figure 2, on which the three categories described above are distinguished by different symbols. In some regions, owing to the dense clustering of faults and sheared exposures, it was impossible to plot all of them on the map, so that it falls short of representing the true intensity of the heaviest concentrations. On the other hand, all isolated localities are indicated. It would be an overstatement to say that every exposure of rock in any given area has been examined, but it is certain that a very large sample has been observed. Moreover, some regions have been traversed only in reconnaissance, whereas others have been studied with the utmost care. With these qualifications it is believed that the data give a picture of the extent of faulting in the Triassic rocks which is correct in its essential features.

Only the alternate contours from Figure 1 are reproduced in Figure 2. In order to avoid crowding the latter map the diabase areas also are omitted, with the exception of the large dike in the lower left-hand corner; its outline is shown, since it marks the course of a major fault.

RELATIONS OF DISTURBED EXPOSURES TO THE MAJOR FAULTS

Inspection of Figure 2 reveals interesting groupings of the disturbed localities. It was to be anticipated that the exposures of sheared, shattered, and crushed rock would follow the principal lines of dislocation, and this is abundantly confirmed. On the basis of the distribution of such outcrops alone, without reference to other effects incident to major faulting, we could trace the approximate courses of the Hopewell-Chalfont and Flemington fractures. Further, we may conclude that the lack of any equally conspicuous lines of crushing in other localities indicates that there are no other faults of similar magnitude in the area under consideration.

It might have been expected that the observed minor faults would show a rather haphazard distribution over the entire region, but there is no such effect. They also are strongly concentrated in the vicinity of the two major faults. Indeed, for a distance of several miles they serve to indicate the northward prolongation of the belt which is disturbed by the Hopewell fault. At the other extremity the presence of several minor dislocations and shear zones on Perkiomen Creek indicates the westward extension of the Chalfont disturbance.

It is noteworthy that the strikes of the minor faults from south of Doylestown to Perkiomen Creek show no tendency to parallel that of the major fracture. In fact, there seems to be a preference for strikes nearly perpendicular to the trace of the Chalfont fault. On the other hand, the several dislocations on the northward extension of the Hopewell fault do seem to tend toward alignment with it.

The anomalous dips also are clustered strongly toward the principal lines of fracture. These discordances are by no means obviously caused by drag; in many places the strikes are almost perpendicular to, instead of parallel with, the major faults. Such a relation, if produced by drag, must imply not only a vertical displacement, but horizontal motion as well. The general impression that is conveyed is that the directions of the anomalous dips are systematic over limited distances, but haphazard when larger regions are considered, and that no simple horizontal shearing could have produced them. Rather, they seem to represent variations of displacement of the major fault with which they are associated, or diverse tilting of the small blocks which are bounded by the minor fractures that traverse the rocks near the larger dislocations. Discordant dips which are apparently quite random in direction occur abundantly along Neshaminy Creek from a point south of Doylestown to Chalfont five miles west of there.

Besides the marked clustering of disturbed outcrops along the principal dislocations within the Triassic rocks there are groups of localities and scattered individual ones near the north border, which is determined by a major fault or system of faults. The dense group west of Milford, New Jersey, where the Delaware River enters the region of Newark outcrop, will be discussed below. The fact that there is not a strong concentration of localities all along the north border can be attributed in large measure to the character of the rock. Much of it is coarse conglomerate which is deeply weathered and, consequently, is poorly exposed, except where it has been cut through by the Delaware and Schuylkill rivers. Small faults and shear zones thus escape detection at many places along the northern boundary.

IMPORTANT GROUPS OF MINOR FAULTS AND DISTURBANCES

The significance of clusters of disturbed outcrops will now be discussed. Many of these exposures, taken by themselves, could hardly be regarded as establishing the existence of faults. But when they are considered together, their grouping and especially their alignments strongly suggest the location of previously unknown dislocations. The localities will be taken in order from east to west.

1. About one and one-half miles east of the Delaware River the Hopewell fault, as mapped in the Trenton folio,[7] makes a sudden turn southward (see Fig. 3); at the river it bends again westward and passes between Bowman Hill and Jericho Mountain. There is good field evidence in support of this interpretation, yet the most obvious line of crushing is not along the fault as mapped, but about one mile north of it. Locations of disturbed outcrops are shown in Figure 3. The zone of shattered rock passes through the Mercer County Workhouse quarry at Belle Mountain on the New Jersey side of the river and follows a course north of Bowman Hill in Pennsylvania, thence west and southwest, and it probably joins the other branch of the fault near the west end of Jericho Mountain about three miles west of the Delaware. The resultant small block of sediments, with an intrusive body of diabase (Bowman Hill and Belle Mountain), is similar to the lenticular mass between the main fault blocks north of Lambertville.

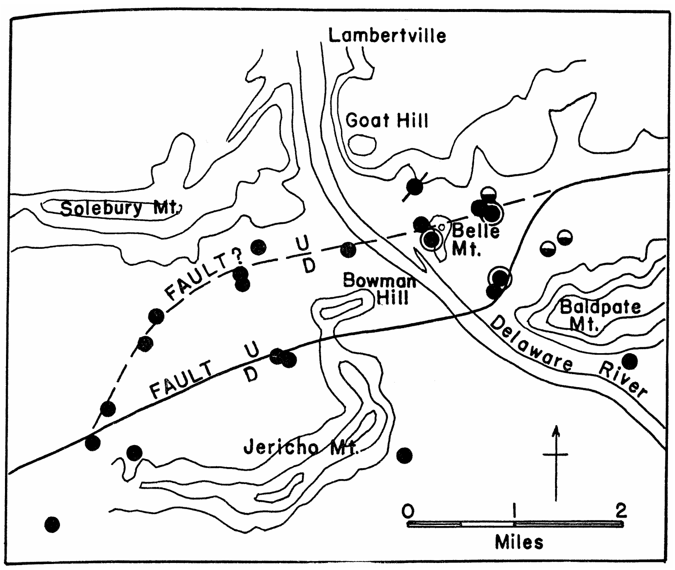

FIG. 3. Distribution of disturbed outcrops south of Lambertville, New Jersey. The 200-, 300-, and 400-foot topographic contours are reproduced to outline diabase hills (cf. Fig. 1). Half-filled circles indicate anomalous dips; filled circles, sheared or shattered exposures; circled spots, very intense shearing. The full line shows the course of the Hopewell fault as mapped in the Trenton folio; the dashed line indicates the inferred course of another branch of the fault

2. Probably the most interesting disturbed area lies west of Milford, New Jersey. In the excellent outcrops along the Delaware River and along the northward-flowing creek which joins the river about one and one-half miles southeast of the border there are many faults and shear zones. These trend northeast and north-northeast, and in the principal faults the downthrow is on the southeast side. A few examples of the reverse displacement were observed, however. A geologic map of the area is given in Figure 4. The aggregate throw of the faults which cross the river amounts to at least 500 feet, but probably does not greatly exceed this figure. Toward the northeast they are lost in a region of scarce exposures, and the eastern ones disappear southward in the large area of diabase that caps the plateau. The two which lie farthest west evidently continue southwestward and cut into a small dome of red shale, which contains two black-shale members. These faults are finally lost in a region of few outcrops. The southern of these two dislocations is actually composite. Exposures along Highway U. S.-611, which parallels the creek, show at least six faults within a distance of only a little more than one hundred yards, all with a southeasterly dip of about forty-five degrees. Similarly, where two fractures are shown to join in the conglomerate north of the river, there are five observable faults. Between this disturbed area and the north border a few shear zones occur, but they do not appreciably offset the black-shale strata, and they are omitted from the map.

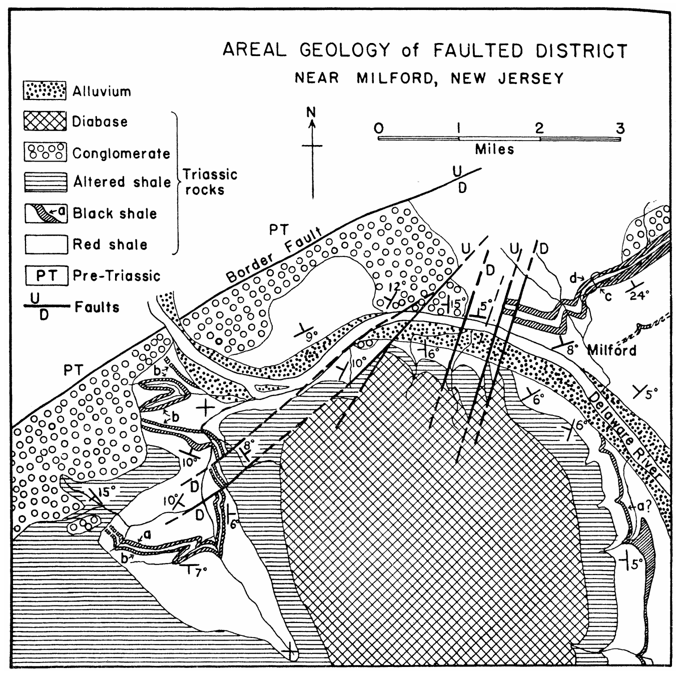

FIG. 4. Geologic map of the faulted district west of Milford, New Jersey. Boundaries between red and altered shale (baked by diabase) are gradational. Black-shale members are designated *a, b, c, d* in ascending order. Most of the conglomerate-shale boundaries are gradational (both vertically and along the strike), but the eastern end of the large conglomerate area may be determined by a fault. The northeast end of the large Haycock diabase sill lies just outside the area shown in the lower left-hand corner of the map. The northeastward extension of the altered shale along the south side of the conglomerate, shown at the left-hand side of the map, is attributed to a buried intrusion

3. Five miles west of Doylestown a zone of anomalous dips, with a few sheared outcrops, branches from the Chalfont fault and trends southwestward, passes just north of Lansdale, and disappears (see Fig. 2). Probably it marks the course of a large minor fracture. Exposures are relatively few, and it is not possible to trace identifiable beds, so that there is no reliable indication of the amount of displacement. The discordant dips are chiefly eastward, in contrast to the normal westerly to northwesterly dip of adjacent areas; hence it appears that the downthrow is on the southeast side.

4. A cluster of faults southeast of Lansdale represents the large Gwynedd cut of the Reading Railroad. Several strike faults are exposed there, and the dip of the Lockatong formation is much higher than at places east or west of that locality. According to the maps in the Philadelphia folio,[8] the width of outcrop of the Lockatong at that place is decidedly constricted. These several facts are probably related, and the abundance of strike faults in the Gywnedd cut cannot be regarded as necessarily typical of the whole region.

5. North of the Schuylkill River a line of disturbed exposures trends northwestward, passing just north of Pottstown, and appears to lead to the border northwest of there. To some extent this grouping may be fortuitous, since the sheared exposures two miles east of Pottstown are associated with a diabase dike which strikes north by east through the region. It appears possible, however, that an obscure fault passes northwestward through that area. More field work will be required to establish the character of this disturbance, which seems to bear a relation to the anticline separating the deep basins that lie northeast and northwest of Pottstown.

6. A probable dislocation is indicated by a south westward trending group of anomalous dips south of the large diabase dike and north of the pre-Triassic inlier in the southwestern part of the map (Fig. 2). The rock of the area is conglomerate and is not abundantly exposed. The discordant dips are chiefly northeastward, as distinct from the northwesterly regional dip. Two or three faults are exposed in railroad cuts within the area.

7. The recognition of the cluster of localities just south of Reading is mainly due to the better exposures there, and not to more abundant faulting than at other places along the north border.

SMALLER DISTURBANCES

Besides the evident clusterings just described there are a number of isolated localities and less obvious groups that deserve specific mention. Again we take them in order from east to west.

1. Southwest of Princeton discordant dips are associated with a sharp flexure of the Stockton-Lockatong boundary and of the 5,000-foot contour. A connection with the anomalous dips north of Pennington is suggested. It does not appear possible to decide from available evidence whether this represents a fault or a fold. The former is suggested by the disturbed outcrops near Princeton, but evidence outside that locality is limited by scarcity of exposures.

2. Anomalous dips and a small fault west of Pennington are perhaps due to a near-by intrusive mass rather than to the effect of the Hopewell fault.

3. At Point Pleasant, Pennsylvania, on the Delaware River seven miles northwest of Lambertville, and at Byram station, New Jersey, just opposite, a displacement of the Lockatong black argillite is associated with a small sill and the dike along which the magma ascended.

4. From a point on the Delaware River four miles south of Frenchtown a line of disturbed localities trends southwestward for several miles. Anomalous dips occur at the extremities of the line, and at its middle east of Tohickon Creek a thick black-shale member appears to be locally missing. A fault is inferred, with a maximum displacement of about one hundred feet, but the evidence does not appear conclusive.

5. An offset of one of the black-shale members in the Brunswick formation occurs three miles east-southeast of Frenchtown, and it is thought to be related to an anomalous dip one mile east of that borough. These disturbances are probably not connected with those described in section 4.

6. The isolated spot on the map indicating a locality of large disturbance three miles northwest of Doylestown refers to a friction breccia, fragments of which were found in the dump of the old lead mine at New Galena.

7. A fault is exposed in the Reading Railroad cut at the bend of the Schuylkill three miles southeast of Phoenixville. The same dislocation is visible in a road cut about one-half mile southwest of there and close to the base of the formation. It strikes northeast, in common with the other minor offsets which occur in the lower portion of the series south and west of Phoenixville and, like them, it has the downthrow on the east side. Several small faults are exposed in cuts of the Reading Railroad farther north along the river between Phoenixville and Pottstown.

8. West of Pottstown some exposures of sheared and slickensided rock occur near the sharp change of strike at the axis of the deep syncline. Probably no important faulting exists in that area.

9. In the Reading Railroad cut east of Birdsboro station (on the Schuylkill River midway between Pottstown and Reading) there is a fine exposure of a fault. It is the only one the writer has seen which might be called a thrust. The strike is northwest, the dip steep northeast, and drag shows that the upthrow was on the northeast side. It strikes directly toward a conspicuous offset of the diabase sill two miles to the northwest, but a connection is not established.

THE SCARCITY OF FAULTING IN THE NORTHERN DELAWARE RIVER SECTION

Probably the most significant result of this study is not the recognition of previously unknown faults and of groupings of disturbed outcrops, but the demonstration that there are large areas in which a thorough examination has failed to reveal evidence of appreciable disturbance. The best exposures in the region are those along the Delaware River from Lambertville to the north border. That section has been studied in great detail by the writer, and equally close attention has been given to the splendid section along the deep gorge of Tohickon Creek. Large disturbances near the Fleming-ton fault north of Lambertville have already been noted, and a region of intense faulting and shearing has been shown to exist near the north border above Frenchtown and Milford. But in the section between, except for a few slight disturbances which are recorded on the map (Fig. 2), there is an evident dearth of faulting throughout the 12,000-foot column from the base of the Stockton formation to the sill of traprock which caps the plateau west of Frenchtown.

Faults have a way of hiding themselves. No claim is made that, minor faults do not exist where none have been found. In the best sections there are covered stretches where small dislocations may lie concealed. But when recognizable strata are present, the magnitude of the offsets which could escape detection is definitely limited. That is the situation in large parts of the Delaware River and Tohickon Creek sections, the details of which will form the subject of a future paper. A number of interbedded red- and black-shale members have been identified in that region, and have been traced for some miles along the strike. Except for the apparent cutting out of a member for a short distance (as noted under "Smaller Disturbances," section 4) there is no indication of faulting which would materially affect the calculation of thickness of the series. The principal cause of uncertainty lies in the limits of accuracy with which the angle of dip can be measured.

RELATIVE AGES OF FAULTS

Downfaulting at the north border must have begun early in the Newark period, if not just before, and it probably continued intermittently to the end of the deposition. Near the close of the period the diabase dikes and sills were intruded; these were associated with some dislocation, as is shown by the repetition of the base of the Triassic south of Reading, where a fault is occupied by a large dike, and by the continuation of the traprock along a fault through a considerable part of the series. Finally, after the intrusion and some subsequent sedimentation, large fractures were formed across the basin, then the major blocks were tilted to produce the threefold outcrop of the stratigraphic column in the Delaware River section. Probably at the same time additional movement occurred along the north-border faults, and numerous minor dislocations were produced in the rocks adjacent to the boundary, as they are exhibited near Milford, New Jersey.

SUMMARY

Minor faults and outcrops which show other evidence of faulting are not scattered indiscriminately throughout the Triassic rocks. They cluster strongly along the major fractures that cross the area and near the north border. A few previously unknown possible faults are indicated by alignments of disturbed exposures. In the central northern part of the Delaware River section a detailed examination has revealed only a few slight evidences of dislocations, and the effect of unknown faults upon the calculated thickness is considered to be negligible.

UNIVERSITY OF MICHIGAN

[1] A portion of this evidence has been presented in earlier papers. McLaughlin, D. B., "A Note on the Stratigraphy of the Brunswick Formation (Newark) in Pennsylvania," *Pap. Mich. Acad. Sci., Arts, and Letters*, 18 (1932): 421. 1933. *Idem*, "Note on the Thickness and Structure of the Triassic Series in Pennsylvania" (Abstract), *Bull. Geol. Soc. Am.*, 44: 178. 1933.

[2] Doubtless this is not strictly true, especially west of the Schuylkill River, where the Lockatong thins and disappears. But its base is the most nearly fixed easily identifiable horizon in the lower part of the series, and until a more reliable substitute can be found (or until its variation can be measured) it appears worth while to adopt it as fixed for practical purposes.

[3] The contours on B. S. Lyman's map of a part of this area (*Penna. Geol. Surv., Final Rep*., Atlas: sheets 10 and 11. 1895) differ systematically from those determined by the writer, probably for the reason given.

[4] McLaughlin, D. B., "A Great Alluvial Fan in the Triassic of Pennsylvania," *Pap. Mich. Acad., Sci., Arts, and Letters*, 24, Part IV (1938): 59. 1939.

[5] Hawkins, A. C., "Major Faulting in the Triassic of New Jersey" (Abstract), *Bull. Geol. Soc. Am*., 51: 1994. 1940.

[6] The most important of these doubtful features are: (1) the 5,000-foot level in the southern belt where it abuts against the Chalfont fault; (2) the 7,500-foot contour west of the Delaware, just north of the Hopewell fault; (3) the 10,000-foot contour near Pennington; and (4) the 12,500-foot contour south of Flemington.

[7] Darton, N. H., and Kummel, H. B., *U. S. Geol. Surv*., Folio 167: Areal Geologic Map. 1909.

[8] Darton, N. H., *U. S. Geol. Surv*., Folio 162: Areal Geologic Maps. 1909.

CACHES OF PREHISTORIC ARTIFACTS DISCOVERED IN SAGINAW COUNTY, MICHIGAN

FRED DUSTIN

THE present paper, on caches of prehistoric artifacts found in Saginaw County, Michigan, deals with hitherto unreported discoveries. It was prepared in part from notes made years ago. My thanks for recent information are due to Mr. Ralph Stroebel, Mr. Henry Bornhoff, and Dr. R. M. Kempton, all of Saginaw, Michigan.

On May 12, 1926, three boys, Arthur and Arno Seidel and Son Glunie, while playing on the Andrews Village site, NW¼ Sec. 32, T. 12 N., R. 4 E., about sixty rods west of the Michigan Central Railroad and the same distance from the Tittabawassee River, noticed some arrow points slightly exposed in the dredge cut made by a sand excavator. They dug them out, and found that they numbered 173 triangular points measuring from one and one-fourth to two and one-fourth inches long, and made of brown chert. Triangular arrow points are scarce in this region, as is brown chert, although two acres of ground a mile southeast on the opposite side of the river are strewn with brown chert flakes, and an occasional arrow point of that material is collected there. It seems that the cache which the boys found was a hidden store, to be drawn on as needed by the owner. Mr. Ralph Stroebel named this the Kinney cache. Unfortunately it was broken up, each of the boys taking a third of the points.

As I have previously noted,[1] the Frazer mound site is remarkable for the number of caches found. Mr. Harlan I. Smith,[2] who incorrectly spelled the name "Frazier," reported two, and at least four others have been discovered since. The Frazer Village site lies east of the west Tittabawassee River Road, between it and the river, and south of Highway M-46, locally called the "Gratiot Road," and covers about forty or fifty acres. On May 9, 1910, Mr. Harry W. Armstrong, while plowing on the northerly part of this site, turned up a cache of sixty-six finely chipped leaf-shaped blades, nearly all about five and one-half inches long, none less than four and one-half; the widths ranged from one and one-half to one and three-quarters inches. The blades were remarkably uniform in shape. About half were black chert, and all except three of the remainder were dark gray chert, the three exceptions being impure quartz of an unusual variety (not chalcedony), which, when held to the light, was partly translucent, much like smoky quartz. Were I asked to classify these artifacts, I should call them cutting blades or knives. They were well chipped, and the unusual black chert from which half or more were made would lead one to believe that they were worked from a stray boulder picked up in the glacial drift and perhaps originating far north, although I have seen somewhat similar material from Charity Island in Saginaw Bay. Since I have not looked over these pieces in several years I cannot express a definite opinion; it is possible that the gray blades were from the same piece of rock. I have named this the Armstrong cache, after the young man who found it. With the exception of a few pieces it is now in the possession of Dr. R. M. Kempton.

Mr. Henry Bornhoff has informed me of a cache plowed up about 1890 on his father's farm in Saginaw County, near where the Pere Marquette Railroad crosses the line between Sections 33 and 34 in Thomas Township. It was found about three hundred feet south of the railroad track, near the road, which at that time followed the old Indian trail along the sand ridge westward, but which has since been straightened. A great sand hill close to the spot has been entirely removed. This hill was a landmark and was undoubtedly known as such by the aborigines. The artifacts were found packed together in a small space about a foot beneath the surface, and Mr. Bornhoff recalls that he and a brother gathered them up, filling a four-quart measure. There were about fifty or sixty leaf-shaped blades from two to six inches long, made of the common Bayport chert. Since they were not notched the boys did not consider them of any interest as relics, and used them for "slingstones," as Mr. Bornhoff called them, for the lads each had a two-string sling. Rounded pebbles were scarce, so they used chert flakes, defective or broken arrow points, or whatever came to their hands in the shape of a stone. As a consequence, the contents of the cache were scattered in all directions by the boys in their play. I have called this the Bornhoff cache.

Mr. Stroebel[3] has described a remarkable cache found by him on a sand knoll on the Frazer Village site, 272 feet westerly from Mr. Charles Watson's farmhouse. It numbered forty-six blades and pieces of the familiar Bayport chert. A few of the smaller flakes were not worked, but most of the group had been roughly chipped; they had apparently been stored away for future working. Their size indicates that they were struck off from a very large nodule or nodules, the lot weighing thirty-four and one-half pounds, the largest, two pounds and ten ounces. The pieces were laid compactly together in a space sixteen inches in diameter and eight inches deep, the top piece being seven inches below the surface. It is probable, since plowing and the winds have removed much of the loose sand from the knoll, that they were originally buried about two feet deep. This has been named the Watson cache. Mr. Watson has told me that he had previously plowed up two lots of small flakes or blades, but as they were not worked to any specialized form he did not pay much attention to them, and they were scattered by the plow. From his casual description I judged they were plain leaf-shaped blanks stored for future working. I learned that these two lots were in the vicinity of the Watson cache just described, a short distance northeast. I have called them Watson caches 2 and 3.

In November, 1916, while collecting on land owned by Mr. George Stroebel, in James Township, Saginaw County, on the Stroebel Village site, I noticed on a sand knoll southwest of the farmhouse four leaf-shaped blades lying close together. I had long suspected a scattered cache at this particular place, for I had found, at various times, sixteen similar blades within a space five or six feet in diameter, all of them peculiarly tinged with ocher-yellow spots and streaks, as were the four new ones. I procured a shovel and gathered seven more pieces, making a total, to that date, of twenty-seven. My field notes read: "They average about three inches long and one and one-half inches wide. They appear to have been cached near the surface, for they have been scattered by the plow; I presume others will be found the coming spring." Others were found, until those collected by me numbered fifty-eight; in addition, Mr. Ralph Stroebel collected several more. Years later, some distance from this spot, I found on a sand knoll which had been swept bare by high winds a pile of flakes and chips, together with a hammerstone that had evidently been used to strike off the flakes from nodules. This waste material was of the same chert from which the cache blades had been made, the yellow stains, texture, and lines of formation being identical. My fifty-eight blades, together with the flakes and hammer-stone, are now in the possession of Mr. Walter Hastings of Howell, Michigan. From the form of these blades, they were undoubtedly intended for later specialization as arrow points or other small artifacts, such as scrapers.

Another cache, if such it can be called, was collected by me west of the Green Point mounds, within the corporate limits of the city of Saginaw, after a spring flood which bared many relics. It consisted of seven pieces of a symmetrically round six-inch chert nodule, and comprised two thirds of the whole sphere. The pieces had been laid together; some of them showed the bulb of percussion, indicating the spot on the nodule where the hammerstone had struck. This nodule was of fine quality chert. I presume it had been buried to be used at a future time.

Several years ago a cache consisting of ten rude leaf-shaped blades about three inches long, four rough triangular points, six crude cutting blades, two well-formed but roughly chipped straight-base leaf-shaped blades, one fair cutting blade of irregular form, two chipped flakes, and a single fragment — all of dull black chert — was found "near the bridge in Bridgeport," close to the site of the Andross mound, since entirely removed. This collection, now owned by Dr. R. M. Kempton, cannot be classed as unfinished blanks or as a votive offering save by a considerable stretch of the imagination. The pieces would seem to me to have been the product of an amateur workman, or of a boy making a first essay at flint-working, although the color of the stone, not found in this part of Michigan in any but very rare migrant specimens, might give rise to the conjecture that possibly this unusual attribute was a contributing factor to their deposit from religious or similar motives.

About twenty-five years ago, Mr. William B. Mershon, of Saginaw, wrote me that in his boyhood he found a cache of leaf-shaped blades on the site of the Mershon Club House, near the present Pere Marquette Railroad tracks and north of the Saginaw city limits in Carrollton. They numbered 130 blades, each about two and one-half inches long, and were apparently blanks to be finished into arrow points. They were later scattered and lost, and Mr. Mershon could not locate any of them at the time of writing.

In 1914 Mr. Amos D. Lincoln told me that while plowing on his farm in James Township, on Section 8, eighty rods west of where the corners of Sections 4, 5, 8, and 9 meet, his plow struck what proved to be a store of chert blades. This find was made near a large pine stump on a little rise of ground. An old Indian trail formerly ran past this place down to a spot on the Shiawassee River now called Carr's Landing; it was the only place for miles up and down that stream where, in the "Great Marsh" of nearly a hundred square miles, the woods came down to the water; hence it was also an Indian landing place. Mr. Lincoln and his son carefully gathered up the blades, filling a ten-quart pail. Later, many were given away and others were lost, so that on my visit to Mr. Lincoln in 1914, only one could be found, which is still in my possession. This Mr. Lincoln stated to be typical of nearly the whole lot, although a few were notched at the base to form arrow points. The one I have is three inches long by one and one-half inches wide; it is of the ordinary leaf shape, and the material is the common gray chert. I presume that here again we have, in part, a store of blanks, although it is well to remember that a leaf-shaped blade may be an unfinished arrow or spear point, a cutting blade, a scraper, or a reject. It *might* be, if of unusual material and beauty, a keepsake or even a charm. When talking with Mr. Lincoln so long ago I was somewhat less well informed concerning matters archeological than I am at present, and my thought then was that the slightly notched forms of which he spoke might have been totemic, but Mr. Lincoln has told me within the last two months that they were just plain notched arrow points. I have named this deposit the Lincoln cache.

Many years ago, I was told of a find of a large number of arrow points at the time that the electric railway was built from Saginaw to Frankenmuth. They were discovered by workmen making a cut through a rise of ground east of Frankenmuth Junction, but my informant could neither locate the exact spot nor describe the find except to say that there was a peck or more of "flint arrowheads." To the layman "arrowhead" is a rather casual term, indicating almost anything from a chert chip to a spear point a foot long. It seems that the cache was divided among some of the men who found it or who were present when it was uncovered. As I remember, my informant was Mr. Eugene Ellis, a thoroughly reliable person (since deceased), but his information came to him rather indefinitely, so that we can only give this cache a name. I have therefore called it the Cook cache, after the man presumed to have been owner of the land contiguous to the railway.

It is quite probable that other caches have been found in this region but have not been reported, and it is not improbable that other deposits will be brought to light by the farmer's plow or the archeologist's spade, or casually discovered otherwise, for the present Saginaw County was perhaps the greatest center of Indian population in the state, where converging streams formed natural highways and where great trails came to a common center — a crossroads; indeed, the Chippewa designation for the tract of land now called the city of Saginaw was *Kah-bay-shay-way-ning*, “the gathering place.” Here the annual Corn Feast was held and councils decided momentous questions of tribal policy or government. Here generations lived and died, leaving their remains for our study and investigation.

SAGINAW, MICHIGAN

[1] “A Notable Prehistoric Village Site in Saginaw County, Michigan.” Unpublished MS; read before the Anthropology Section, Michigan Academy of Science, Arts, and Letters, March, 1938.

[2] “The Saginaw Valley Collection,” Suppl. to *Am. Mus. Journ.*, Vol. 7 (1901), No. 12.

[3] Stroebel, Ralph, “A Cache of Chert Blades in Saginaw County, Michigan,” *American Antiquity*, 3 (2): 186-187. 1937.

INDIAN TRADE OBJECTS IN MICHIGAN AND LOUISIANA*

GEORGE I. QUIMBY, JR.

INTRODUCTION

VARIOUS trade articles manufactured in Europe and European colonies were acquired by historic North American Indians from traders, explorers, and missionaries in the seventeenth, eighteenth, and nineteenth centuries. Their presence in an Indian site provides some evidence for the date of occupation because their chronology indicates the chronology of the associated native artifacts. The dating of these articles is based upon the evidence of makers' marks and styles or their presence in a documented historic site. It is possible, therefore, to obtain from the trade objects of a given site the date of the site as well as those of the objects themselves. When a site is documented and also contains suitable trade materials the two factors complement each other and provide an ideal means for dating the native artifacts.

In a previous paper I described the trade artifacts which were representative of the early and late historic periods in the upper Great Lakes region.[1] The early historic period was from 1700 to 1760; the late one, from 1760 to 1825. It must be emphasized, however, that these dates represent a working hypothesis which may have to be modified.

My present purpose is to compare the trade materials indicative of the early historic period in the upper Great Lakes region with those of the same period in the lower Mississippi Valley and to show the similarities between them, despite the considerable geographical separation of their proveniences. There are data from four different Indian sites of the early historic period, one in Michigan and three in Louisiana, and all four sites were occupied when French influence was dominant.

THE SITES

The upper Great Lakes material was collected from the site of Fort St. Joseph near the city of Niles, in Berrien County, Michigan. The fort was established and maintained by the French from shortly after 1700 until 1760. Near it were two Indian villages, one Miami, the other Potawatomi. Therefore the trade artifacts from the environs of the fort should constitute a part of the material culture of the Miami and Potawatomi tribes as they existed in the early historic period.[2]

The trade artifacts from the lower Mississippi Valley came from two historic Indian villages in Louisiana and one in Mississippi. The first of these is the Angola farm site in West Feliciana Parish. In the early historic period it was probably occupied for the most part by Tunicas.[3] Archeological investigations of the site by James A. Ford produced many trade objects accompanied by numerous artifacts of native manufacture which were diagnostic of the Natchezan culture type.[4]

The second Louisiana site is a former Bayogoula, Mugulasha, and Taensa village in Iberville Parish. The known period of occupation was from 1699 to 1706, although there were probably intermittent occupations by remnants of these tribes and others until 1758.[5] Investigations of this site also produced trade objects along with native artifacts which were of the Natchezan culture type.

Excavations at the Fatherland plantation near Natchez in. Adams County, Mississippi, have been described by Ford. European trade objects were found in association with Natchez artifacts. This site is probably the Grand Village of the Natchez, which was occupied from at least 1699 to 1730.[6]

THE TRADE OBJECTS

Glass Beads

The sites in both Michigan and the lower Mississippi Valley contained identical types of Venetian glass beads. The glass or porcelain beads traded to the Natchez have been described by Le Page du Pratz, a French writer[7] who lived among these Indians in the first quarter of the eighteenth century. His account is not very specific, but among the beads he mentions were some like those found in these early sites. The various types and their distribution are recorded in Table I.

Glass Containers

The introduction of glass bottles into the lower Mississippi Valley must have occurred prior to 1700, for a "double glass bottle" was seen in a Bayogoula temple by Iberville in 1699.[8] Fragments of Dutch gin bottles (Pl. I, Fig. 20) were found only at the Bayou Goula and the Angola farm sites. Large rum bottle fragments (Pl. I, Fig. 19) have been recorded, however, from all the sites discussed in this paper, but fragments of blown glass tumblers were discovered only at the Bayou Goula site.

Earthenware

Fragments of glazed and unglazed crockery jugs and bowls (Pl. I, Fig. 21) are represented in all the sites considered. French polychrome earthenware (Pl. I, Fig. 22) and earthenware with appliqué design have been obtained at the Fatherland plantation, the Angola farm, and Fort St. Joseph. Slightly different polychrome earthenware has been recorded for the Fatherland plantation, Bayou Goula, and Fort St. Joseph sites. And a Staffordshire-like earthenware (Pl. I, Fig. 23) has been found at all the sites. Perhaps this style of pottery represents a later introduction of British origin. It is not inconceivable, however, that English pottery was distributed by the French.

TABLE I

TYPES OF BEADS AND THEIR DISTRIBUTION

Styles of beads*	Fort St. Joseph	Angola farm	Bayou Goula	Father-land plantation
Seed				
Colorless	..	+	..	+
Monochrome (Pl. I, Fig. 1)	+	+	+	+
"Cornaline d'Allepo"	..	+	..	+
Elongate-spheroidal				
Colorless (Pl. I, Fig. 2)	+	+	+	+
Monochrome (Pl. I, Fig. 3)	+	+	+	+
Polychrome (Pl. I, Figs. 4–5)	+	+	+	+
Oblate-spheroidal				
Colorless (Pl. I, Fig. 6)	+	+	..	+
Monochrome (Pl. I, Fig. 7)	+	+	+	+
Polychrome (Pl. I, Fig. 8)	+	+	+	+
"Gooseberry" (Pl. I, Fig. 9)	+	+	..	..
"Cornaline d'Allepo" (Pl. I, Fig. 10)	+	+	..	+
Oblate-spheroidal-joined				
Monochrome (Pl. I, Fig. 12)	..	+	+	+
Polychrome (Pl. I, Fig. 13)	+	+	..	..
Oblate-spheroidal-fluted				
Monochrome (Pl. I, Fig. 11)	+	+	..	+
Decahedral				
Colorless (Pl. I, Fig. 14)	+	+	..	..
Monochrome (Pl. I, Fig. 15)	+	+	..	..
Raspberry-shaped				
Colorless (Pl. I, Fig. 16)	+	+	..	+
Monochrome (Pl. I, Fig. 17)	+	+	..	..
Tubular				
Monochrome	+	..	+	..
Polychrome (Pl. I, Fig. 18)	..	+	..	+

* Cf. Orchard, Wm. C., "Beads and Beadwork of the American Indians, a Study Based on Specimens in the Museum of the American Indian," *Contributions from the Museum of the American Indian, Heye Foundation*, Vol. XI.

Pipes

White-clay molded trade pipes, with round, flat-bottomed spurs, were discovered at all four sites. Examples with "TD" or "RT" stamped on the bowl are in the collections from the Angola farm and Fort St. Joseph. A few of the pipes at Fort St. Joseph have pointed spurs, mushroom-shaped spurs, and appliqué stamped designs, variants which do not occur in the lower Mississippi Valley sites. Iron-tooled stone Micmac pipes, on the other hand, are diagnostic of material culture at Fort St. Joseph as well as catlinite and pewter "peace pipes." A style of pipe with a glazed pottery-bowl (Pl. I, Fig. 24) was found only at the Bayou Goula site. Short-stemmed dark-clay trade pipes manufactured in Marseille (Pl. I, Figs. 26, 28) have been collected from the surface of a historic site in Point Coupee Parish, Louisiana, and although these are not from one of the historic sites in question, they are presented here because of their typological relationship with native pipes that come from Bayou Goula (Pl. I, Figs. 25, 27, 29-31).

Objects of Brass or Copper

Brass or copper kettles were present at these early historic sites in both Michigan and the lower Mississippi Valley. More common artifacts, however, were cut and hammered fragments of brass kettles. All four sites yielded objects of brass, such as disk buttons with rings for attachment, hollow spheroidal buttons with rings for attachment, thimbles, and coiled-spring ornaments. Du Pratz described these ornaments and the way they were worn.[9] A circular copper gorget with two perforations accompanied a burial at the Fatherland plantation. Brass or copper tinkling cones and hawk or Morris bells (Pl. I, Fig. 34) are reported from all four sites and, according to the journal of the frigate *Le Marin*, the Bayogoula and Mugulasha had tinkling cones as early as 1699.[10] Hawk bells worn by the Natchez are mentioned by Du Pratz.[11] Brass dinner bells (Pl. I, Fig. 32) have come from the Bayou Goula site and the Angola farm. Sheet-brass C-shaped bracelets occurred only at the Angola farm, although brass-wire bracelets of similar shape are listed for all four sites. Triangular sheet-brass projectile points were common in the Fort St. Joseph collections, but have not been recorded for any of the lower valley sites discussed in this paper.

Iron Objects

Jew's-harps (Pl. I, Fig. 33) were found at the Angola farm in Louisiana and at Fort St. Joseph in Michigan. These musical instruments, however, are also representative of the late historic period, at least in the upper Great Lakes region.[12] Iron clasp knives[13] and butcher knives were collected at all four sites. According to Iberville, the Bayogoula and Mugulasha Indians had knives as early as 1699;[14] probably they were pretty well distributed throughout the lower Mississippi Valley by that date. Iron-wire C-shaped bracelets and scissors were unearthed at both the Angola farm and Fort St. Joseph. Iron axes with loop hafts have been listed from the Angola farm, the Fatherland plantation, and Fort St. Joseph. Documentary evidence of the existence of iron axes in the lower valley has been found by Swanton in the writings of Iberville and of Du Pratz, who stated that these axes were made by the French and had a blade three inches long.[15] Iron hoes with loop hafts were present at both the Fatherland plantation and Fort St. Joseph.

Such articles as caltrops, fishhooks, triangular projectile points, awls, saws, tomahawk pipes, and needles have been reported only from Fort St. Joseph. Iron needles, however, were known in the lower Mississippi Valley in the early historic period, for some were given to Bayogoula and Mugulasha by Iberville in 1699.[16] The only example of an iron halberd came from a burial at the Angola farm. All the sites contained iron nails, but flat oval strike-a-lights occurred only at the Angola farm and Fort St. Joseph. A rather unusual iron kettle with three legs was found at the Fatherland plantation.

Flintlock Guns

Although the archeological evidence indicates that the historic Indians of the lower valley had flintlock guns, it is interesting to note that both De Montigny Dumont[17] and Le Page du Pratz[18] specifically mentioned them as articles of trade. Nearly identical flintlock guns have come from the Angola farm, Fort St. Joseph, and the vicinity of the Fatherland plantation. The barrels are octagonal in section at the breech, and the brass butt plates have a narrow ornate spur, which was fastened to the top of the stock. Brass trigger guards have a shaped and engraved fleur-de-lis or similar design at the distal ends; it and the section of the guard which covered the trigger are engraved with enclosed rectangles. Brass ramrod leaders, which are hexagonal, have a long, narrow tang; the brass side plates consist of a central shield with openwork at either side. The batteries or frizzens are plain and undecorated. Lead balls of slightly variable size are common at all sites. Gun flints, which are planoconvex or trapezoidal in cross section, have been recorded for all sites. Some objects, however, occur only in collections from Fort St. Joseph. These are iron butt plates with saddlebacks; solid side plates of brass, some of which were engraved; and brass side plates shaped like conventionalized dragons. A different type of butt plate excavated with a burial from the Angola farm was made of iron and has a short spur to fit over the upper butt end of the stock. Iron trigger guards were found only at this site. The gunlocks themselves, although damaged and encrusted, are similar in both the northern and southern areas.

Religious Objects

Collections from Fort St. Joseph included brass or bronze medals stamped with pictures of saints, prayers, and religious phrases; brass finger rings engraved with religious devices; brass crucifixes, brass crosses, and lead crosses.[19] No similar artifacts have been found at Bayou Goula, the Fatherland plantation, or the Angola farm, although the possession of medals and rosaries by early historic Indians in the lower Mississippi Valley was mentioned by Paul du Poisson in 1727.[20]

Coins and Fabric Seals

By virtue of the dates stamped upon them coins and fabric seals are particularly important in determining the chronological position of historic sites. In 1721 Charlevoix mentioned that the Tunica chief dressed like a Frenchman and hoarded money, and that he was "reckoned very rich.[21] This statement suggests that the use of coins was rather common. A French colonial coin dated 1722 was excavated from a pit in the Bayou Goula site, and another French coin with the date 1677 forms part of a collection from Fort St. Joseph.

Lead fabric seals were probably attached to the cloth and blankets which were introduced into the lower Mississippi Valley during the early historic period by the French. Both Du Pratz and Dumont mentioned the use of blue and red Limbourg for clothing by the Indians of the lower valley.[22] A lead fabric seal (Pl. I, Fig. 35) from the Bayou Goula site was too badly eroded to enable me to determine a date or an inscription, but its association with other trade objects and the documentary evidence for the existence of cloth in the area suggest that the seal belongs to the early historic period. Similarly shaped lead seals from the Fort St. Joseph collections are dated from 1734 to 1746.[23]

Miscellaneous Trade Objects

Powdered vermilion has come from all four sites. Its presence among Indians of the lower Mississippi Valley in the early historic period is confirmed by Dumont.[24] Only in the Fort St. Joseph collections, however, are there shell runtees, although ornaments of catlinite are found at the Angola farm, the Fatherland plantation, and Fort St. Joseph.

SUMMARY AND CONCLUSIONS

Despite the distance between the Fort. St. Joseph site in Michigan and the sites in the Lower Mississippi Valley the same types of trade objects occur in both areas. The reasons for this phenomenon are two: (1) Both sites belong to the early historic period; and (2) both areas were under French domination during this period.

Probably a number of these trade objects indicate only the historic period in general. There are, however, other artifacts which seem to be characteristic of the early historic period. Some of them are the various bead types, with the exception of seed beads, which persist throughout the historic period, coins, fabric seals, types of glass bottles, types of earthenware, types of knives, and certain styles of flintlock guns. Of course, it is possible for any or all of these objects to occur in a late historic site, but they would probably be associated with other trade objects known to be diagnostic of the late period. In addition, there are certain early historic trade objects which may be indicative of the area as well as of the period. For instance, the shell runtees, iron-tooled Micmac pipes, metal triangular projectile points, and other things were found only in the Fort St. Joseph collection and, therefore, are representative of the early historic period at that place. On the other hand, such objects as iron halberds and French elbow pipes are perhaps diagnostic of the same period in the lower valley.

There is the additional probability that early historic sites in areas dominated by the British or the Spanish will have an entirely different complex of trade objects indicative of periods and areas. For this reason the dating of historic sites by means of trade articles should be undertaken cautiously and with a knowledge of the area the dominant European nationality, the archeology of the historic sites, the documentation of the sites, and the chronology of the trade objects.

LOUISIANA STATE ARCHAEOLOGICAL SURVEY
BATON ROUGE, LOUISIANA

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[1] Quimby, George I., Jr., “European Trade Articles as Chronological Indicators for the Archaeology of the Historic Period in Michigan,” *Pap. Mich. Acad. Sci., Arts, and Letters,* 24, Part IV (1938): 25-31. 1939.

[2] Quimby, *op. cit*., pp. 25-26.

[3] Ford, James A., *Analysis of Indian Village Site Collections from Louisiana and Mississippi*, pp. 129-140. Anthropological Study No. 2, Department of Conservation, Louisiana Geological Survey, New Orleans, 1936.

[4] Ford, *op. cit*, p. 140, and Quimby, G. L, Jr., “The Natchezan Culture Type,” *American Antiquity*, 7 (1942) : 255-275.

[5] Swanton, John R., *Indian Tribes of the Lower Mississippi Valley and Adjacent Coast of the Gulf of Mexico,* pp. 274-279. Bureau of American Ethnology. Bulletin 43, Washington, 1911.

[6] Ford, *op. cit*., pp. 59-65.

[7] Swanton, *op. cit*, pp. 55-56.

[8] Swanton, *op. cit*, p. 275.

[9] Swanton, *op. cit*., p. 55.

[10] *Ibid*., p. 276.

[11] *Ibid*., p. 127.

[12] Quimby, p. 30 of article cited in note 1.

[13] *Ibid*., p. 27, and Plate II.

[14] Swanton, *op. cit*., p. 275.

[15] *Ibid*., pp. 66, 127, 275

[16] *Ibid*., p. 275.

[17] *Ibid*., p. 90.

[18] *Ibid*., p. 69.

[19] Quimby, Plates I-II of article cited in note 1.

[20] Swanton, *op. cit*., p. 313.

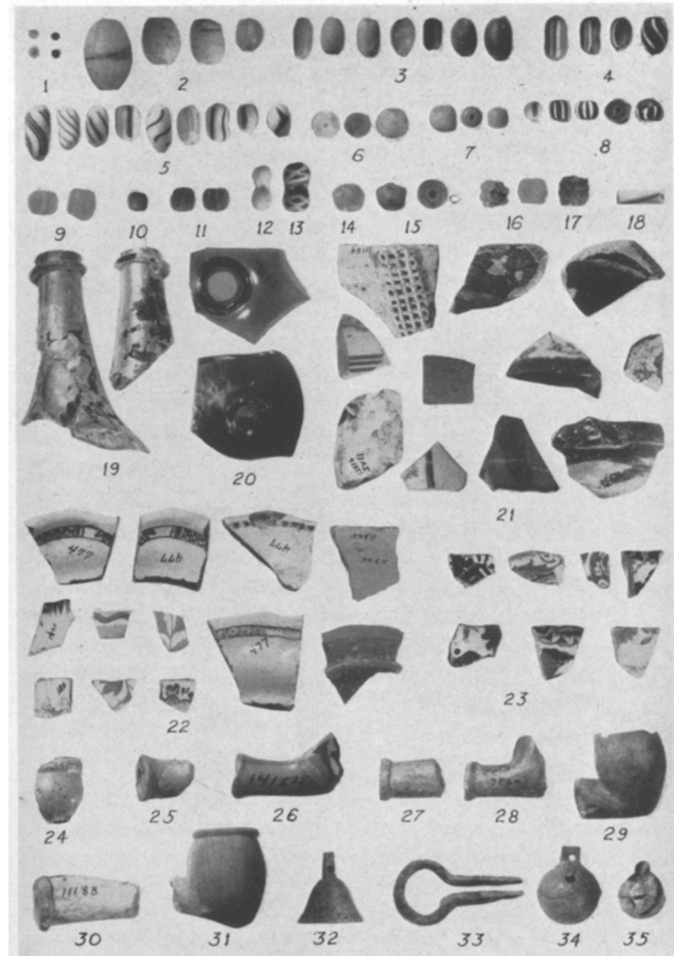
[21] *Ibid*., pp. 312-313.

[22] *Ibid*., pp. 52-53.

[23] Quimby, p. 27 and Plate I of article cited in note 1.

[24] Swanton, *op. cit*., pp. 54, 90.

QUIMBY PLATE I



Indian trade objects of the early historic period

Figs. 1-18, glass beads; Figs. 19-20 glass bottles; Figs. 21-23, earthenware; Figs. 24, 26, 28 trade pipes; Figs. 25, 27, 29-31, aboriginal pipes; Fig. 32, small dinner bell; Fig 33, jew’s-harp, Fig. 34, small hawk bell; Fig. 35, lead fabric seal

LITHIC PATINA AS AN AGE CRITERION

ELMAN SERVICE

IN THE literature of archeology in both Europe and America certain surface alterations on stone artifacts have been interpreted as evidence of great antiquity. These alterations have usually been described as "patina."[1] There are archeologists today who have dissented with this view and who feel that the blanket assertion that the presence of patina means great age is naive and ill-founded. Little agreement, however, is manifest among these archeologists as to what its presence really does mean. No one, apparently, has taken the trouble to publish a bibliography on the subject, and the writings of those few who do have a positive opinion about the nature of patina are more conjectural than scientific. That a very confused state of affairs exists in this respect is clearly indicated by the fact that the authors who have the most to say about patina often do not even refer to the same *kind* of phenomenon in their use of the term.

A rather noteworthy fact is apparent in looking over archeological literature. Those who consider the presence of patina a reliable criterion of age make, as a rule, very little comment about it except for noting its presence. It is among those authors who disagree with this concept that are found the few positive statements concerning the nature of surface change.

An Englishman, H. Dixon Hewitt (6), has contributed the most notable work on the subject among the European students. He experimented carefully and demonstrated that there are many *kinds* of chemical action on stone which can change the surface color or structure. Oxides of iron and manganese may be present in a soil to color the surface of a stone; and alkaline solutions — the chief of which are potash, soda, and ammonia — may also be active, as may alkaline chlorides. Investigation showed that at least four factors affect the amount of surface change a given chemical is able to induce: the length of time a rock is exposed to the chemical activity, the temperature, the concentration of the chemical agent, the initial condition of the stone. It is possible, of course, that in nature there are still other influences to consider. It seems obvious, inasmuch as the time element is one variable among four or more others that chemical change on the surface cannot have any absolute value in determining age. Mechanical change of surface due to certain kinds of abrasive action quite naturally depends on so many different specific circumstances as to be of even less value as evidence of antiquity.

Additional types of surface change have been described by other English authors who, like Hewitt, do not accept the mere presence of patina as evidence of great antiquity. W. J. Sollas (11) mentions that pure silica carried in solution may be deposited as a sort of thin film on the surface of a stone. This results in a brilliant polish. He also notes a similar kind of change in flint, which he defines as a granular mixture of quartz and opal. Underground water may dissolve away some of the opal and leave a very thin film of pure quartz granules. If the flint is of the black variety, the well-known "blue patina" appears.

M. C. Burkitt (5) describes flint as silica containing in loose combination a variable quantity of water. In some circumstances moisture may be given off, leaving a thin skin of colorless silica on the surface. The blue patina is due to this film lying over the black flint. Iron salts may become absorbed into the film and color the flint surface an ochreous yellow or orange. However (to quote Burkitt), "It must be borne in mind that the formation of patina is very capricious and results from conditions as yet imperfectly understood. No great antiquity can be postulated for a specimen simply because it is deeply patinated." Edgar Willett (14), like Burkitt, considers patina to be a glossiness resulting from the deposition of a film of pure silica on the surface of flint, whereas Leslie Armstrong (2) thinks it is a thin mineral film laid down in the evaporation of moisture which carried mineral substances in solution.

French archeologists have become greatly interested in patination in the last few years. On the pages of *L'Anthropologie* are recorded many controversies as to whether a consideration of patina has value. The staunchest upholder of the "pro" side of the question, the Abbé Breuil (3), makes no claim, however, that patina has any value as a criterion of age. He believes it should be studied carefully because degrees of patination on two typologically dissimilar groups of artifacts may indicate that the two groups had been stratigraphically separated.

Other French writers, working with European paleoliths, have refused to concede that patina has any value at all. René Verneau (12, 13), for example, has been very forceful in his denunciation of patination studies.

In America archeologists have often considered these surface alterations on stone artifacts to be evidence of great antiquity. N. H. Winchell (15) argued in 1913:

> The patination of flint is accepted in Europe as an indication of great age. When found on similar artifacts in America it has the same significance. Not only do European specimens show the well-known patination indicative of Paleolithic date, but African and Asiatic stone implements, when they possess this evidence, also are classed uniformly with European Paleoliths.

George Grant MacCurdy (8) seems to make the same assumptions. For instance, he describes in detail the patina of paleolithic industries as though it had some absolute value in dating particular groups of artifacts.

Many writers, even though perhaps more cautious than Winchell, nevertheless consider the presence of patina indicative of great age. Edgar Howard (7) has said that the term "patina" should be used with discretion, but he regards the patina found on the Folsom points as evidence of at least moderate antiquity. Charles Avery Amsden (1) says that inasmuch as patina is known to occur slowly it is therefore of some value, although in a qualified sense.

Other American writers have exhibited a certain distrust of this use of the concept. N. C. Nelson (9) writes that while patina is undoubtedly a valuable criterion of age, it is difficult to deal with effectively because the processes involved are not constant and so make comparative studies next to impossible. Malcolm J. Rogers (10) believes that variation in amount of patination may not be entirely due to age differences.

Many authors in the American field refer to the term in passing but say nothing definite about it. Even Kirk Bryan (4), a geologist, fails to discuss the significance of the patina he describes in one of his archeological reports.

It is readily apparent that American archeologists, compared with certain Europeans, know very little about the nature of patina. For that reason we are bound to turn to Europe for the most definitive investigation of this subject. The experiments of Hewitt (6) on chemical alteration demonstrate very well that patina should not be considered a criterion of antiquity. Inasmuch as his work is by far the most comprehensive examination of the chemistry of the subject, we are obliged to accept his conclusions in preference to the conjectures of other men. In justice to the English and French archeologists in general, however, it should be stated that Hewitt's findings do not tend to contradict their opinions. The chief criticism must be leveled against Americans, who seem to have assumed, without foundation, that patina has proved fruitful as an age determinant in Europe.

Yet the fact that patina has little value in ascertaining age does not mean that it has no use at all, as some archeologists appear to have concluded. As mentioned before, the Abbé Breuil (3) suggests a valuable application for patination studies. He is supported in this by Burkitt (5), who considers that differences in patination correlating with typological dissimilarity may be good supporting evidence that two separate industries are represented; differences in patina may indicate stratigraphical differences.

Another possibility is suggested by Sollas (11). Should it be difficult to discern whether a given stone is a bona fide artifact, patina may in some instances provide a clue. If all the chipped surfaces were formed at the same time, as is true of a genuine implement, they should all be more or less equally patinated. If the surfaces were chipped at several widely separated intervals, as may sometimes happen when the chipping was done through natural agencies, the surfaces may be unequally patinated. Patina in this situation cannot, of course, be considered of absolute value, but it may be useful in specific circumstances if intelligently employed.

There is a third way in which consideration of surface change has proved fruitful. A glossy finish occurring on the working edge of a tool may indicate that the tool was in use at one time. That abrasive action often results in just such a finish can easily be shown with a polishing wheel. Sometimes an implement that has been hafted and then used may exhibit this gloss on the part of the stone where the handle was attached.

It cannot be too strongly emphasized that there is a special danger involved in the use of the term "patina." It is a single word which designates many different kinds of surface change. A considerable number of writers have been guilty of employing "patina" as though it were a well-understood and precise concept. The reader is often unable to decide whether the term refers to a mechanically induced gloss, a "desert varnish," a corroded surface, a stain of some sort, or ordinary weathering. This word has such a wide indefinite usage at present that it is especially necessary to determine just what kind of surface change is being called "patina" in any particular instance.

A real and immediate need exists for comprehensive experimental work on the subject of surface alteration of flint. After more is known of the nature of such change, there is no apparent reason why patination studies should not be employed for a variety of purposes. It is even possible that patina may in the future prove worth while, in combination with other criteria, as an indication of age. Until then, however, its presence should be interpreted only in the three ways previously mentioned.

UNIVERSITY OF MICHIGAN

[1] According to *Webster's New International Dictionary* (1934), patina is: "A film, usually green, formed on copper and bronze by long exposure to a moist atmosphere, or by treatment with acids, etc. It is a basic carbonate of copper protecting the metal from further oxidation. . . . By extension, a film similarly formed on other metals, or the surface appearance assumed by various materials, as wood, marble, etc., after long exposure." The term "patina" has been long used in classical archeology in strict accordance with this dictionary definition. Nowhere, however, to the best of my knowledge, have archeologists in the Near Eastern field used it as a criterion of age.

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