MICHIGAN ACADEMY OF SCIENCE, ARTS AND LETTERS

VOLUME XXXVI (1950)

CONTAINING PAPERS SUBMITTED AT THE ANNUAL MEETING IN 1950

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The annual volumes of Papers of the Michigan Academy of Science, Arts and Letters are issued under the joint direction of the Council of the Academy and of the University of Michigan Press. The editor for the Academy is Frederick K. Sparrow; for the University, Eugene S. McCartney.

Before the inauguration of the present series in 1922 the Academy published twenty-two volumes under the title Annual Report of the Michigan Academy of Science. Copies are still available for distribution and will be sent on exchange as long as the editions last. Applications for copies should be made to the University of Michigan Press.

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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS

EUGENE S. MCCARTNEY
FREDERICK K. SPARROW

VOLUME XXXVI (1950)

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

ANN ARBOR: THE UNIVERSITY OF MICHIGAN PRESS
LONDON: GEOFFREY CUMBERLEGE, OXFORD UNIVERSITY PRESS
1952

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Volume XXXV (1949) was published on March 9, 1951

PRINTED IN THE UNITED STATES OF AMERICA
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CONTENTS

GEOGRAPHY

FUNDAMENT VEGETATION OF THE CALUMET REGION, NORTHWEST INDIANA—NORTHEAST ILLINOIS. Alfred H. Meyer 2

MORPHOLOGY AND HISTORICAL ERUPTIONS OF MOUNT FUJI. Forrest R. Pitts 5

GEOLOGY

AN UNUSUAL OCCURRENCE OF VARVED DEPOSITS IN SOUTHWESTERN MICHIGAN. Stanard G. Bergquist..... 7

ILLUSTRATIONS

PLATES

GEOLOGY

BERGQUIST:

Pl. I. Bluff in Wisconsin till above the varved sediment at Miami Park Beach, southwestern Michigan.....9

Pl. II. Section of glaciolacustrine deposit showing alternate bands of fine sand and clay in the bluff at Miami Beach Park 9

FIGURES IN THE TEXT

GEOGRAPHY

MEYER: Fig. 1. The natural vegatation pattern of "The Calumet," northwest Indiana—northeast Illinois 3

PITTS: Fig. 1. Cross section of Mount Fuji.....5

GEOLOGY

BERGQUIST: Fig. 1. The Covert ridge of the Lake Border moraine and the site of varved deposits at Miami Park Beach in southwestern Michigan.....7

FUNDAMENT VEGETATION OF THE CALUMET REGION, NORTHWEST INDIANA—NORTHEAST ILLINOIS*

ALFRED H. MEYER

CALUMET REGION is the name commonly given to the area about the head of Lake Michigan. Physiographically, it is identified with the drainage basins of the Little Calumet and the Grand Calumet rivers. Industrially and commercially, it is intimately associated with metropolitan Chicago, and the area as here demarcated coincides approximately with the area south and east of Chicago in which commuter service is common.

Owing to its having the strategic qualities of site and situation expressed and implied in this statement of identification, "The Calumet" has become the subject of widespread interest and investigation. As would be expected, much of the published literature on the Calumet area deals with the history of its settlement and its phenomenal industrial and commercial development. Such literature, however, seems significantly deficient in descriptions of the elements of the geographic landscape with which the historic events must be associated in order to form an adequate concept of the historical development of the region. Natural vegetation is one of the basic elements to which we must give consideration. It is the purpose of this paper to supply a picture of what the fundament vegetation looked like at the time when the white man started to dispossess the Pottawatomie Indian (Fig. 1). It is not proposed here to evaluate the data in relation to human occupance or events, except incidentally.

For the portrayal of the vegetation landscape, recourse must be had to the original survey records. Unfortunately, the surveyors' township plats do not adequately indicate continuity of lines and clearness or completeness of symbolism to produce accurately demarcated vegetation areas. The surveyors' field notes (e.g. "Leave timber and enter prairie") prove of some assistance here. Such data were transferred from forty-seven individual plat units to a specially prepared township base map. The kinds and sizes of trees observed by the surveyor along section lines and recorded in separate field notebooks were also regularly entered along every third north-south section line of our base map and along most of the east-west township lines. Such transects are considered generally adequate for purposes of areal integration. The sectional tree inventory is far too detailed to be reproduced legibly on a map of a scale here used but on the writer's original work sheet it served a number of highly useful functions in directing the writing of this text and the drafting of the map.

The vegetation data derived from the plat maps and notes of the original Federal land survey have been reduced by the writer to six classifications comprising

three forest types and three grassland types: broad-leaved forests, mixed broadleaved and coniferous forests, and swamps; prairies, wet prairies, and marshes. The regional distribution of these forms is indicated on a present-day political base map for purposes of orientation.

BROADLEAVED FOREST

The broadleaved forests are dominated by various kinds of oak— white, yellow, black, red, bur, pin, and white swamp oak. Very common also are lynn (linden), white ash, black ash, hickory, soft maple, sugar maple, elm, beach, birch, aspen, cottonwood, and sassafras. Other recurring species include cherry, butternut, walnut, ironwood, black gum, and sycamore.

MIXED BROADLEAVED AND CONIFEROUS FOREST

In the mixed broadleaved and coniferous stand (north of dotted line on the map), jack pine, common juniper, white pine, arbor vitae, and tamarack are the chief conifers. The hardwoods are mostly of a scrubby type of black oak, white oak, yellow oak, and pin oak. This mixed hard-soft timber consociation is not areally differentiated by the surveyor, wherefore the dotted line drawn on the map represents only a general zonal boundary based on the detailed field inventory as well as we could determine it.

This forest belt is limited almost entirely to the modern and ancient beaches, following the Lake Michigan shore in a strip whose width varies from a fraction of one mile at the Indiana-Illinois state line to about four miles in the northeast corner of the map. The sandy soils with their edaphic dryness are the primary determining factors for the existence of the conifer and scrub oak vegetation.

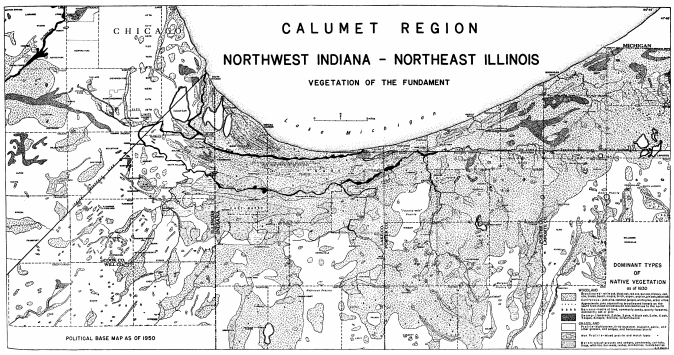


FIG. 1. This map shows the natural vegetation pattern of the Calumet before the landscape was transformed by the white man. The design is based upon unpublished data from forty-seven plats and upon numerous detailed field notes of the original Federal land survey of the area, made from 1829 to 1834. The hydrographic features are also of this period

"BARRENS"

The so-called "barrens," a form of timber, are denoted on the map simply by the letter *b*. The surveyors did not areally delimit this type of timber, nor did they define the term. The land-management office of the Department of the Interior could find no official legend or statement explaining the term. Because of the unavailability of such information, the lack of complete transcription of sectional line data as previously noted, and the varied types of environment with which the term is associated, definite delineation of the "barrens" does not seem feasible.

Webster's *International Unabridged Dictionary* (1945) defines barrens as "level tracts of land, poorly forested and commonly having light sandy soil; as, pine *barrens*."

But mapping the occurrence of this term brings out the interesting fact that the barrens need not be "level"; as a matter of fact, most commonly here they are not identified with level terrain. The descriptive terms "rough barren," "broken barrens," and "rolling barrens" have been noted in the proportions of 7, 5, and 8 times as compared to 5 times for "level barrens."

In terms of vegetation the surveyors note "oak barrens," "hickory barrens," "oak and hickory barrens," and "pine barrens." A thin stocking of trees generally seems to be implied; and frequently adjectives like "bushy," "brushy," and "scrubby" emphasize the generally low quality of merchantable timber.

SWAMPS

Tree vegetation in partly water-covered areas is not always denoted as swamps to distinguish such areas from marsh areas with their characteristic herb vegetation. A number of them, however, are so distinguished and frequently are named by their chief types of vegetation. The most commonly recognized swamp types are tamarack, alder, pine, black ash, elm, oak, maple, aspen, willow, and buttonbush. These are designated by number on the vegetation map (see particularly the northeastern part of the area). The swamps are typically associated with depressions and stagnant river meanders and poorly drained river channels.

MARSHES

As the map indicates, marsh vegetation is much more extensive than swamp vegetation. Marshes are fairly well delineated in the original Federal survey plats, except (as mentioned above) that a clear distinction is not usually made between them and some of the swamps. Vegetation types of the marshes are seldom mentioned by the surveyors, but cranberry is significantly identified with a number of the more important marshes (see Westchester and Pine townships). From other early marsh landscape descriptions we learn that slough grasses and sedges pondweeds, wild rice, cat-tails,

flags, bur-reeds, blueberries, and huckleberries were among the most common marsh types of vegetation.

The three deepest, most extensive marshes are the Cady Marsh north of Dyer, the linear marsh flanking the "Little Calumet River," and the swamp and sandy-ridge-interrupted marsh embraced by the modern sites of East Chicago, Indiana Harbor, and Whiting.

It is obvious that the geographic distribution of these marshes, together with those of the swamps and wet prairies, must be recognized and analyzed by anyone attempting to describe and explain the patterns of circulation and settlement of the aboriginal and succeeding stages of human occupance. It would be interesting to know, for example, to what degree the extensive and impassable marshes and swamps handicapped the earlier traveler and the settler.

WET PRAIRIES

"Wet prairies" are frequently noted by the early surveyors, apparently to designate areas possible to travel over during average weather conditions although much too wet to be cultivated. Since such survey notes are restricted to limited observation along section lines—and even then not consistently recorded—it is difficult to express accurately on a map in contiguous form all such areas, or even a part of them. Such areas as the writer has outlined would seem at least to express approximate spatial relations of these poorly drained areas to the real water-covered marshes and swamps. Extensive wet prairie areas are readily recognized in the Cook County townships of Hyde Park, Thornton, and Bloom, and in other sections.

PRAIRIES

Among the surveyors' records of dry prairie areas west of the townships just mentioned (embraced mostly in the contiguous parts of Lake, Stickney, Lyons, Worth, and Bremen townships) the following survey notations are indicated: "level rich prairie," high and dry," "level and elevated," "dry sandy," "high, level, and dry good soil." Reference to a modern contour map reveals that these dry prairies are elevated from one to two ten-foot contours above the wet prairies.

The dry and wet prairies are recognized as part of the great "Grand Prairie" which extends from Vincennes in Indiana northward to the Wisconsin line. Only occasional groves of trees interrupted the "savanna" or "pampa" landscapes as characterized by early local observers.

Prairies separated by such groves often came to be recognized as distinctive settlement units by the first white settlers, as, for example, the Twenty-Mile Prairie in Portage and Union townships, the Morgan Prairie in Morgan and Washington townships, the Robinson Prairie in Center and Ross townships, and Door (Dor Min) Prairie in New Durham and Scipio townships.

THE PRAIRIE COVER

Prairie grasses were not described in the original survey, but from other sources we learn some of their identities. According to one record, "The dark, rich, well drained Prairie soils were thickly covered with Indian grass, bluejoint turkeyfoot (big bluestem), prairie beard grass (little bluestem), bluejoint, and numerous patches of wild flowers."[1] It is further observed that "To relieve the eye, and add a pleasing variation to these plains of grass, little groves nestled here and there on the bosom of the prairie, that on a bright spring morning resembled islands of blue in a sea of green. . . . [They] were generally located on the side of a pond, or had springs of water in them; sometimes a pleasant stream of water ran through them."[2] It is such spots that particularly favored Indian encampments and pioneer settlements, as is indicated in the first settlements in the east, in the La Porte ("the door") vicinity. The door effect consisted of "a natural opening through the timber from one prairie to the other, where 'Door Village' now stands."[3] The Indian village of Ish-Kwan-dem (in the vicinity of modern Westville) occupied a similar position, and the name is said to connote "the door" situation.[4]

The vista of the tall grass prairies indeed must have been impressive' Barce's observations are interesting: "Nothing could be more delightful than the open prairie in the spring and summer. Stirred by the fresh morning breezes, the billowing grasses stretched as far as the eyes could see, while a profusion of wild flowers filled the air with fragrance and added hues of violet and purple to a background of green."[5]

But once the grasses and flowers had dried in late summer or autumn the same landscape often presented a terrifying scene. "The savage, that rue child of nature, speaking the language his great mother had taught him, called the prairie 'Mas-Ko-Tia,' or 'The Place of the Fire.' The name was appropriate, for there giant conflagrations, feeding on the tall dry grass of the autumn savannas, and fanned into a fiery hurricane by the western winds, at night time illuminated the whole heavens, and sweeping onward with the speed of the wild horse, left nothing behind them but the blackened and smoking plains."[6]

Prairie fires have often been held responsible for the total absence or the limited occurrence of forests in the humid prairie country, such as we have in the western Calumet area. Terrifying as these fires were to the Indian and the first settlers, it is claimed that they did improve foraging conditions for both wild and domesticated grazing animals, and also extended the acreage and quality of wild and cultivated plant foods, such as cranberries and blueberries, corn and other grains.

ACKNOWLEDGMENTS

The writer gratefully acknowledges the assistance of Mrs. Alfred H. Meyer, Mrs. Elsie Peters McBride, and Mr. Gordon Klett in recording data from the original survey sources and transferring them to the preliminary draft map from which the vegetation map was finally constructed.

VALPARAISO UNIVERSITY
VALPARAISO, INDIANA

*This paper is the third of a series of articles supported in part by research grants from the Michigan Academy of Science and the Indiana Academy of Science.

[1] Ulrich, H. P., and Others, *Soil Survey, La Porte County, Indiana* (1934), No. 26, p. 8. U. S. Dept. of Agriculture, Washington, D.C., 1944.

[2] *Ibid*., pp. 101-102.

[3] *Illustrated Historical Atlas of La Porte County, Indiana*, p. 3. Chicago: Higgins, Belden, and Co., 1874.

[4] Knotts, A. F., "Indian Trails, Mounds and Village Sites of La Porte County, Indiana" (typewritten manuscript), 1932, p. 8.

[5] Barce, Elmore, *The Land of Potawatomi*, p. 100. Privately published, Fowler, Indiana, 1919.

[6] *Ibid*., p. 95.

MORPHOLOGY AND HISTORICAL ERUPTIONS OF MOUNT FUJI

FORREST R. PITTS

MOUNT FUJI (Fujisan in Japanese) lies north of Suruga Bay, between the prefectures of Shizuoka and Yamanashi, Japan. This volcano is so situated that the meridian of 138° 44' East of Greenwich and the parallel of 35° 21' North intersect near its summit, which is 3,776.29 meters above sea level.[1] Extending forty-five kilometers from north to south and thirty from east to west, it covers a large area, 908 square kilometers. The only larger mountain in Japan is Aso, in Kumamoto prefecture, Kyūshū, which has an area of 1,400 square kilometers. Mount Fuji's volume of 1,060 cubic kilometers makes it the largest volcano in Japan; the next largest is Mount Hachigatake, with 430 cubic kilometers.[2] Mount Fuji lies immediately north of Ashitaka volcano and northwest of Hakone volcano; it is quiescent at the present time.

Authorities writing in Western languages are not in general agreement as regards either the internal structure or the number and dates of the recorded eruptions. It is the purpose of this paper to throw more light upon these matters by the use of Japanese sources.

The almost symmetrical shape of Mount Fuji has led many geologists to believe that it is a near-perfect example of a strato-volcano, in which lava flows occur in alternation with layers of fragmental ejecta. In 1935 Japanese scientists working on the problem first advocated the theory that the upper part of the cone was built upon an old caldera and that the main subsidiary craters, Komitake on the north slope and Kofuji on the east slope, represent caldera summits.[3]

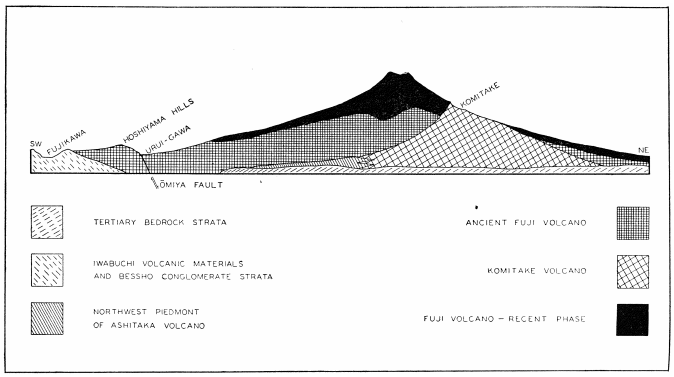


FIG. 1. Cross section of Mount Fuji (Tsuya, 1940)

The latest published prewar research of Dr. Tsuya,[4] one of Japan's foremost geologists, deals with an entirely new explanation of Mount Fuji's internal morphology. The accompanying sketch (Fig. 1) illustrates his theory, the main points of which are presented here.

The bedrock under Mount Fuji is thought to be the Misaka strata of the lower Miocene, a material of which the hills immediately to the northeast and northwest are composed. Metamorphosed tuff resembling the Misaka strata and green andesite fragments are known to have been erupted from Hoeizan and Kofuji. This type of andesite is found in the Izu area as the lower Miocene and one part of the Pliocene, as well as in the mountains west of the Fuji River on the southwest piedmont.

A core boring made in 1939 at the village of Ōbuchi on the south piedmont of Mount Fuji gave considerable information regarding the nature of the underlying materials. Below 600 meters the material found was a green andesite resembling the Misaka beds. At a depth of from 400 to 500 meters there were recovered Mount Ashitaka volcanic materials, which closely resembled the andesite of Komitake volcano. Komitake, an eroded strato-volcano halfway up the north side of Mount Fuji, is composed of successive layers of chrysolite and pyroxene-andesite, interspersed with layers of agglomerate and volcanic detritus. The lava which composes the very top of Komitake is of the same kind as the very oldest erupted from Mount Fuji. Dr. Tsuya considers Komitake to be of about the same age as Ashitaka; and he believes that it had already been subject to erosion for long ages before all but the top of it was buried by materials erupting and flowing from Mount Fuji.

Agglomerate mudflows lie above the eroded masses of Komitake and Ashitaka. These form the Hoshiyama and Habuna hills to the southwest of Fuji and outcrop at irregular intervals around the entire mountain. Extremely impermeable, they force any underground water to flow to the surface along the line of contact between them and the lava-detritus mass which lies above. The water flowing out from between the two strata is of

considerable volume, and it forms the Yogyoike spring at Inokashira, on part of the Shiraito waterfall, the spring of the shrine at Ōmiya, the well water and springs near Motomurayama, and the Fudōtaki waterfall of Sugita. The mudflows contain a confused mixture of various blocks of basalt, rock fragments, volcanic ash and mud, tree fragments, and round pebbles of the Tertiary period. They are dated later than the Komitake eruptions inasmuch as they contain, in addition to the materials cited above, blocks of andesite of the Komitake variety.

Forming the upper part of the Fuji cone and covering its sides are the lava flows which came, presumably, from the same core as did the agglomerate mudflows. Dr. Tsuya lists by name fifteen different lavas but it suffices here to state that all of them belong to the last phase of the building of Mount Fuji. The lava flows alternate irregularly with layers of volcanic detritus, and composed, therefore, a strato-volcanic cap over the mudflows. Thus Komitake and the highest parts of Mount Fuji are both mountains of the strato-volcano variety, although of different ages and different composition, have individual cores, and were separated in the process of formation by a series of mudflows.

Since the formation of the main body of Mount Fuji, there have been created two series of subsidiary, or parasitic, cones. More than half of them are distributed in a zone running from northwest to southeast through the main Fuji crater, and the rest are scattered around the mountain close to the 1,400-meter contour line.[5] The former series of cones is probably due to a line of weakness along a major dislocation in the area, for the western edge of the Fossa Magna lies only a short distance west of Mount Fuji. The latter group may have been caused by a line of weakness along the juncture between the weathered mudflow base and the overlying lava-detritus cap. Hōeizan is an explosion crater, and it ejected a completely different volcanic breccia of a yellow-gray to gray color. Hence Dr. Tsuya believes that its core was unique, and was not connected with the main core of Mount Fuji.

A problem as puzzling as Mount Fuji's internal structure has been that of the number and dates of its recorded eruptions. Various sources have estimated the number as five, seven, and, again, ten. Since the introduction of writing into the Japanese islands there have actually been recorded in native documents fifteen distinct eruptions, all in our Era. The times of these eruptions, together with the names of the Japanese chronicles (if available) recording the eruptions, are as follows:[6]

1. Sixth day of the seventh lunar month of Ten-ō 1, or August 4, 781; *Shoku Nihongi*.

2. Sixth day of the sixth lunar month of Enryaku 19, which was 800; *Nihongi-ryaku*. Legend states that this eruption formed Kofuji.

3. From the latter part of the twelfth month of 801 to the first part of the first month of 802; *Nihongi-ryaku*.

4. Third lunar month of 802; *Fujisanki* (*Records of Mount Fuji*).

5. Tenchō 6, or 826.

6. Twenty-fifth day of the fifth lunar month of Jōkan 6, or 864; *Sandai-jitsuroku* (*True Record of Three Generations*). This date is based upon a Suruga government office report. The government office report from Kai-no-kuni gave the date as the seventeenth day of the sixth lunar month. Prior to this eruption there existed northeast of Mount Fuji a crescent-shaped lake called Se-no-umi. The Aokigahara lava issued forth from a crater on the northwest side of Fuji at a point 2,300 meters above sea level. The flow divided Se-no-umi into three parts, which are now known as Lake Motosu, Lake Shōji, and Lake Nishi. Covered by a verdant forest of conifers and deciduous broad-leafed trees, the flow today occupies an area of 54.22 square kilometers.[7]

7. Jōkan 12, or 870. From 901 to 930 Mount Fuji smoked and rumbled, but did not erupt.

8. "A certain day" in the eleventh lunar month of Shōhyō 7, or in December, 937; *Nihongi-ryaku*.

9. Seventh day of the third lunar month of Chōhō 1, or March, 999; *Honchō-seiki*.

10. Sixteenth day of the twelfth lunar month of Chōgen 5, or January, 1033; *Nihongi-ryaku*.

11. Twenty-eighth day of the third lunar month of Eihō 3, or March 25, 1083; *Fusō-ryakki*.

12. Eighth lunar month of Eishō 8, or 1511.

13. Eiroku 3, or 1560.

14. Genroku 13, or 1700.

15. Twenty-second and twenty-third days of the eleventh lunar month of Hōei 4, or about December 16, 1707. This eruption produced the protrusion and crater on the south side of Mount Fuji, which is known as Hōeizan, or Mount Hōei, so named from the year period in which the eruption occurred.

Thus it is seen that seven of the fifteen recorded eruptions occurred in a ninety-year period, from 781 to 870, inclusive. All these eruptions, as well as those which followed, were part of the recent phase, shown in black in Figure 1. Four eruptions have occurred since 1500, after a four-century period of inactivity, and the last one was the most violent. Mount Fuji, therefore, cannot at present be considered totally inactive.

UNIVERSITY OF MICHIGAN

[1] Rikuchi sokuryōbu (Land Survey Bureau), "Fujisan no hyōkō ni tsuite (On the Altitude of Mount Fuji)," *Chikyū* (*The Globe*), 13, no. 3 (1930): 213-217.

[2] Yajima Naka, "Kazan no kitei menseki oyobi taiseki to sono bumpu (Volume, Area, and Distribution of Volcanoes in Japan)," *Chirigaku Hyōron* (*Geographical Review of Japan*), 17, no. 5 (1941): 417.

[3] Kambara Shinichirō, "Fujisan no chishitsu ryakuhō (A Brief Report on the Geology of Mount Fuji)," *Chigaku Zasshi* (*Journal of Geography*), 47, no. 553 (1935): 109-124.

[4] Tsuya Hiromichi, "Fujisan no chishitsugakuteki narabi ni gansekigakuteki kenkyū (Geological and Petrological Studies of Mount Fuji)," *Chigaku Zasshi* (*Journal of Geography*), 52, no. 618 (1940): 347-362.

[5] *Nihon chiri taikei* (*Outline of Japanese Geography*), Kaizōsha, Tōkyō, 6a (1930): 121.

[6] The information on historical eruptions was compiled and integrated from two sources: *Nihon chiri taikei* (see note 5), pp. 121-122, and Inobe Shigeo, *Fuji no rekishi* (*History of Mount Fuji*), pp. 66-84, Kokinshoin, Tōkyō, 1929.

[7] *Nihon chiri taikei* (see note 5), p. 110.

AN UNUSUAL OCCURRENCE OF VARVED DEPOSITS IN SOUTHWESTERN MICHIGAN

STANARD G. BERGQUIST

ALONG the margin of Lake Michigan, in the vicinity of South Haven and especially in the area where the Covert ridge of the Lake Border moraine swings close to the shore, is a line of vertical cliffs that has been cut back by the waves of the lake. The bluff here is sculptured in heavy blue to buish-gray till composed essentially of dense pebbly clay, compact in structure and of unusual hardness and toughness (Fig. 1).

A mile south of South Haven, Deerlick Creek in cutting its channel has exposed a section of blue till which can be traced out into the floor of the lake. Here the deposit is so firmly indurated and resistant that prolonged erosion by wave action has failed to remove the exposed surface. A number of small parallel grooves with intervening low ridges, furrowed out of the material by the combined activity of running water and waves along the shore, provide evidence of the resistant nature of the deposit. A short intermittent stream directly north of the outlet of Deerlick Creek flows across the bed of indurated clay in a series of small abrupt falls and enters the lake over a floor of basal till.

Northwardly along the lake shore the section of blue till becomes progressively thicker and stands in a vertical bluff whose face has been scored by rainwash and gully erosion. In places the bluff is trimmed back and sliced along joint planes to produce sharp pinnacles with extremely sheer slopes.

The basal till in this area is remarkably similar to that described by Leverett[1] as occurring in the vicinity of Richmondville in the Thumb region of Michigan. It has characteristics that closely resemble those of the Illinoian till in Ohio as outlined by Stout.[2] The drift is blue in color, dense in structure, highly calcareous, and indurated. It contains polished and, often, striated pebbles and cobbles predominantly of limestone so firmly set into the matrix of clay that it is necessary at times to use a pick to release them.

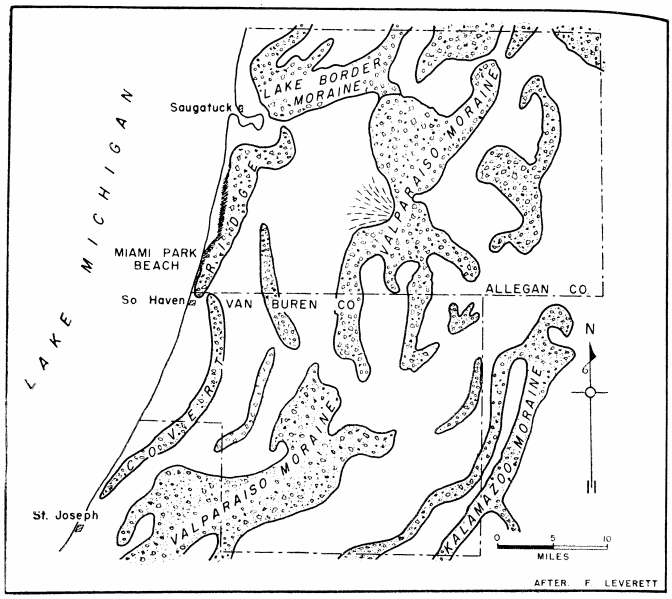


FIG. 1. The Covert ridge of the Lake Border moraine and the site of varved deposits at Miami Park Beach in southwestern Michigan

Nodules of clay-ironstone, many containing septaria filled with secondary calcite, are intermixed with the till. These were derived locally from the Coldwater shale immediately underlying the glacial drift in the area and undoubtedly mixed with the clay when the pre-Wisconsin ice advanced over the bedrock surface.

It is the opinion of the writer that geologists who have studied the effects of glacial activity in the Great Lakes region have minimized the significance of the Illinoian invasion as related to sculpture of preglacial valleys, the general shaping of the lake basins, and subsequent influence upon the present surface expression. It is generally conceded that the Labradorian ice deployed across the Great Lakes area during Illinoian glaciation. In its advance the ice naturally encountered the deep valleys of preglacial drainage ways cut into the bedrock surface. The keeling of the massive Illinoian glacier into the rock-cut valleys undoubtedly recited in the development of tongues of ice which were directed in movement through them in much the same manner as that by which various lobes were induced in the Wisconsin ice during a later invasion.

It seems only reasonable to assume that the Illinoian ice was responsible for a considerable amount of cutting in the preglacial drainage ways of the area. If that is true, then the valleys could have been deepened and widened appreciably by the Illinoian ice moving through them. Thus the preliminary shaping of the basins that later were to provide the sites for the establishment of the present Great Lakes may well have been initiated prior to the Wisconsin stage of glaciation.

Upon retreat of the Illinoian ice sheet there was spread out upon the Paleozoic rock surface in Michigan a fairly thick blanket of clayey drift. That this older drift is not of local origin is evidenced by the fact that wells drilled through the Wisconsin cover have universally

encountered the indurated blue clay in practically all sections of the Southern Peninsula. Water-well drillers commonly refer to this drift as “hard pan” because of its difficulty of penetration by the drill.

In many areas of the state, moraines and drumlins completed by the Wisconsin ice are cored in Illinoian till. In the northern section of the Southern Peninsula, and especially in the areas affected by the Valders activity of late Wisconsin glaciation, the present topographic expression definitely reflects the character of an older glacial surface. Here the later drift is relatively thin and in places barely covers the older deposits, which are commonly exposed in road cuts and stream channels.

In his studies of glacial till in New Hampshire, Goldthwaite[3] recognized the presence of two distinct layers of till distinguished from each other by color and density differences. The bottom layer resting on bedrock is composed essentially of compact blue-gray clay while the upper, less compacted layer, which includes the soil zone, varies in shades from yellow to rusty brown. He concluded that the variations in color and density between the two layers were responsive to the water content at the time of deposition and do not reflect necessarily two distinct advances of the glacier.

It is quite possible that detailed laboratory studies of texture and composition of the two drifts in Michigan may bear out similar relationships and thus represent deposits formed by the same ice but under different degrees of water saturation. If we accept this interpretation for the two distinct layers so consistently represented in the glacial deposits of the Southern Peninsula of Michigan, it is necessary to account for the disposition of the deposits that were laid down during the retreat of the Illinoian ice across the region of the Great Lakes. Certainly we are in no position to infer that the older drift was completely removed from the bedrock surface during the Sangamon interglacial interval prior to the onslaught of the Wisconsin ice.

At Miami Park Beach, four miles north of South Haven in Allegan County (Fig. 1), the low Covert ridge of the Lake Border moraine forms the approximate shore of Lake Michigan. The crest of the bluff here stands at an altitude of 670 feet or 90 feet above the level of the present lake. The upper 35 feet of the material comprises a bluish-gray, highly calcareous, pebbly clay till. Retreat of the bluff through the action of waves and rainwash has resulted in the development of abrupt cliffs, which break off into pinnacles and stacks along well-developed joint planes (Pl. I).

At the base of the surficial till is a section of glaciolacustrine varved sediments with a measured thickness of 36 feet. This deposit is composed of alternate bands of fine sand and plastic, pebble-free blue clay. Although the contacts are sharp and distinct, the varves are unusual in that they are extremely variable in thickness, ranging from merely a few inches to several feet in both the sand and the clay layers. The surface of the uppermost layer of clay in the section is slightly crenulated and »displays some minor displacements that may have been induced by pressure of the readvancing ice that later shaped the Covert ridge. The lack of uniformity in the thickness of the varves may possibly be due to near-shore deposition of the sediments in an ice-border lake of relatively short duration (Pl. II).

If the various bands of sand and clay, regardless of thickness, can be regarded as indications of seasonal deposition, then the total deposit represents some forty years of glaciofluvial activity in front of the ice mass. If, on the other hand, the thinner bands were formed during episodes of interseasonal climatic fluctuations, then the interval of lake occupancy would be considerably shorter. Again there is no way to determine the measure to which the surface of the varved deposit was sliced off by the readvance of the ice to the position of the Covert ridge.

The laminated sediments of the deposit rest directly on the compact, indurated, pebbly blue clay that forms the main body of the Illinoian drift in the area. Because of the cover of recent beach material and foredune ridges below the bluff along the shore, it is difficult to appraise the areal extent of the basal till lakeward. If the situation at the mouth of Deerlick Creek, previously described, is any criterion, then it is logical to assume that the older till extends into the floor of the lake for some distance out from the present shore.

The localization of the varved deposits in the area described would seem to indicate that the site of deposition was in a small embayment of lake waters confined in front of the ice whose border was then standing some distance from shore in the Lake Chicago basin. The sediment was carried into the embayment by meltwater draining off the ice during intervals of melting in the warmer summer seasons. The fine sand was deposited immediately to form the summer layers. The finer fractions of clay, on the other hand, were held in suspension and refused to flocculate out until the water in the lake had reached a uniform temperature and density throughout, during the winter seasons.

After the episode of glaciolacustrine deposition the climate cooled. The water-saturated varves froze into a solid mass and the ice front, advancing landward, overrode the surface to form the segment of the Covert ridge overlying the varved deposit. The material transported by the readvancing Wisconsin ice consisted of an admixture of Illinoian till pushed up from the lake floor and of Wisconsin drift contained in the ice mass. The mixing of the two drifts may account, in part, for the lighter color of the surficial deposit in the Covert ridge.

In that portion of the Glenwood lake basin that lies in front of the Covert ridge, directly east of South Haven, small streams have cut through the surficial drift to expose isolated segments of varved material composed largely of alternate layers of silt and clay. In these exposures the bands are uniformly thin and display characteristics that more nearly conform to the varvity described by Antevs.[4] Whether these widely separated

exposures can be correlated with the varved deposits in the Miami Park Beach area is uncertain. The relationships may not, however, be too remote.

Further investigation of the bluffs along the shore of Lake Michigan, together with a detailed study of the scattered exposures of varves in the Glenwood basin, may throw additional light on the extent of interstadial activity after the retreat of the Wisconsin ice previous to the final shaping of the Covert ridge. It is entirely possible that after the completion of the Valparaiso moraine a segment of the ice may have retreated bodily to a new position in the basin of Lake Chicago, and subsequently may have readvanced to form the bulk of the Covert ridge along the shore.

To sum up the events as related to the activities of the ice in the area described, there is unquestionable evidence to support the view that two distinctly different drift sheets are present. The firmly indurated till that forms the basal portion of the glacial deposits undoubtedly is associated with pre-Wisconsin activity and as such may have an origin related to the Illinoian invasion. The surface drift that forms the cover of the Covert ridge is definitely Wisconsin in origin. It represents a readvance of the ice after an episode of retreat during which the varved sediments were deposited in an ice-border lake related to the Gary substage of Wisconsin activity.

MICHIGAN STATE COLLEGE
EAST LANSING, MICHIGAN

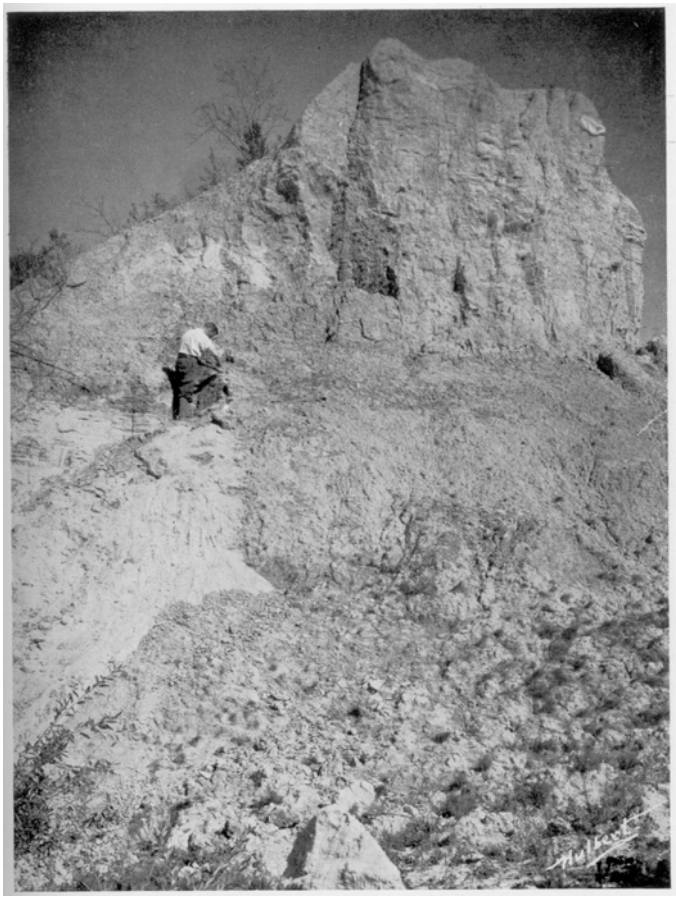
[1] Leverett, Frank, and Taylor, Frank B., "The Pleistocene of Indiana and Michigan and the History of the Great Lakes," *U. S. Geol. Surv., Mon. 53*, pp. 289-290. 1915.

[2] Stout, Wilbur, *Water in Ohio*, Geol. Surv. Ohio, Fourth Series, Bull. 44: 27. 1943.

[3] Goldthwaite, Lawrence, *Glacial Till in New Hampshire*, Part 10, Mineral Resource Survey, New Hampshire State Planning and Development Commission, 1948.

[4] Antevs, Ernst, *Retreat of the Last Ice-Sheet in Eastern Canada*, Memoir 146, No. 126 Geological Series, Canada Department of Mines, Geological Survey, 1925.

BERGQUIST PLATE I



Bluff in Wisconsin till above the deposit of varved sediment at Miami Park Beach

BERGQUIST PLATE II

Section of glaciolacustrine deposit showing alternate bands of fine sand and clay in the bluff at Miami Park Beach