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DRIFT ANALYSIS AS A GUIDE TO THE CHARACTER OF THE BEDROCK IN ONEIDA COUNTY, WISCONSIN

by
Frank Nelson Blanchard

A dissertation submitted in partial fulfillment
of the requirement for the degree of
Doctor of Philosophy in the
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1960

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INTRODUCTION

General Statement

A large part of northern United States is covered by surficial deposits related to the Pleistocene glaciation. In much of this area the bedrock geology is at best only imperfectly known, the few areas of outcrops being too widely spaced to warrant any measure of detailed geologic interpretation. Hope for economic gain has led to drilling programs in some parts of this large area, and where results were encouraging, the geology has become better known through the closer spacing of drill-holes. Most of the drift-covered region, however, has offered little to encourage intensive drilling, and other less expensive and less time-consuming methods are therefore necessary if fairly detailed geologic interpretations are to be made. Fortunately, there is a more or less definite relationship between the lithologic composition of the glacial deposits and the lithologic character of the underlying bedrock, but this relationship has been almost entirely neglected as a possible basis for geologic mapping. It is the purpose of this study to determine as much as possible about the bedrock geology of a drift-covered area by studying the lithologic composition of the glacial drift in conjunction with the few scattered outcrops.

Location and General Setting

Oneida County is located in north-central Wisconsin. Figure 1 shows the location of the county and figure 2 shows the locations of its chief towns. The county includes an area of 1,114 square miles and has a population of about 21,000. Rhinelander, the county seat, is the largest town. The elevations of bench marks in the county range from approximately 1488 to 1670 feet above sea level. The average elevation is probably close to 1600 feet and the maximum relief is no more than a few hundred feet. There are many lakes in the area, and much of the lower ground is swampy. The Wisconsin River drains the eastern and central parts of the county; the Tomahawk River drains the western part of the county and joins the Wisconsin River just south of the southern county line. The vegetation of Oneida County can be divided into three assemblages (F. D. Hole and G. B. Lee, 1955, p.43): black pine, spruce, and tamarack are typical in the northwest and in the extreme east and southeast; maple, birch, pine, hemlock, and balsam predominate in the southwest, southcentral, and southeast; and jack pine and scrub oak are prevalent over the remainder of the county. The most abundant soil types are sandy loams. The mean annual precipitation is about thirty-two inches.

Sources of Information

The geologic map of Wisconsin shows a large part of northern Wisconsin, including Oneida County, as being

underlain by undifferentiated Huronian and Laurentian rocks. The extensive cover of glacial drift is responsible for a nearly complete lack of knowledge concerning the bedrock geology of Oneida County. Furthermore, even the glacial deposits of this area have been little studied. The only published geologic information on the area is included in a Bulletin of the Wisconsin Geological and Natural History Survey, dealing with mineral land classification (Hotchkiss, 1915). Hotchkiss's report covers all of two townships and parts of five townships in Oneida County. Brief descriptions of some of the outcrops and glacial deposits, as well as a few pebble-counts of drift samples, are included with the results of dip-needle surveys.

Topographic maps have not been made for this part of Wisconsin, but planimetric quadrangle maps compiled from aerial photographs are available from the United States Geological Survey. These were found to be useful for the present study in showing roads and trails, bench mark elevations, drainage, and alignment of topographic features. The Wisconsin State Highway Department has compiled a county map from the planimetric maps, and this was found to be a satisfactory base map. Aerial photographs and photo index sheets, available from the Commodity Stabilization Service of the United States Department of Agriculture, were excellent supplements to the planimetric maps. A county soil map on the scale of one inch equals six miles is available from the Soils Department of the University of Wisconsin;

this was useful in tracing the extent of certain units of glacial drift. The United States Coast and Geodetic Survey has elevation data from a few spirit level lines along railroads in Oneida County.

Field Work and Acknowledgments

Most of the field work involved in the present study was done from June through early September in 1957. This project was generously supported by the Oliver Iron Mining Division of the United States Steel Corporation. For this the author is particularly grateful to Dr. R. W. Marsden, manager of geological investigations and to Mr. C. L. Iverson, geologist.

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Dr. D. F. Eschman, Dr. E. N. Goddard, and Dr. F. S. Turneaure all read the manuscript in preliminary form, each offering worthy suggestions and encouraging comments.

Methods of Study

General Statement.—Since the character of the bedrock underlying nearly all of Oneida County is effectively concealed by surficial glacial deposits, it is necessary to approach the problem of the bedrock geology by somewhat

indirect and unconventional methods. At first glance, glacial deposits may appear as heterogeneous mixtures of many different rock types which have been picked up, transported, and dropped in haphazard fashion. The rock types which have been transported great distances stand out as striking examples of the ability of glaciers to move material far from its original source. Boulders and pebbles of jasper conglomerate found in southern Michigan were transported from a source area in the Lake Superior region. Glacial transportation was responsible for the relocation of a boulder of norite gneiss from a source area near the city of Quebec in Canada to southern Ohio, a distance of over 700 miles (Flint, 1947, p. 118). Native copper derived from the Keweenaw peninsula of northern Michigan has been found as far south as southern Illinois. However, in the few cases where detailed studies of the lithologic composition of the drift have been made, it is strikingly apparent that the bulk of the drift in most places has been derived from relatively near-by source rocks. Since this is the basis for much of the geologic interpretation in Oneida County, a brief summary of studies of drift lithology follows.

Relationship of Drift Lithology to Bedrock Lithology.— As early as 1883 the close relationship between the lithologic composition of glacial drift and the character of the bedrock in the immediate vicinity was recognized. This fact is pointed out in the following quotation from T. C. Chamberlin (1883, p. 312-313) concerning the source of the

material composing the Cary end moraine: "In this preliminary definition of the formation [the moraine] it will suffice to remark that a notably large ingredient of its material was derived from the formations that lie subjacent and immediately adjacent to it on the side whence the drift came. This is so conspicuous a fact that the constitution of the range is observed to be continually undergoing a change as it is traced linearly in its course across the various formations traversed by it. These transitions are sometimes surprisingly abrupt and pronounced. But, in addition to this local material, there is always present a greater or less amount representing the formations that lie in succession backward along the line of drift movement for 500 miles or more."

W. O. Crosby (1896) studied the composition of an esker near Weymouth, Massachusetts. Pebble-counts led him to the conclusion that more than half of the coarser material of the esker was derived from a source five to ten miles distant.

Using a hypothetical example, R. D. Salisbury (1900, p. 427) suggested the strong probability that in most instances the material in glacial drift of a given location is derived from near-by source rocks.

J. W. Goldthwait (1920, pp. 130, 131) summarized the results of counting more than 250 drift samples collected during a state-wide survey in New Hampshire. The lithology of the drift samples showed a clear relationship to the

source rock, with a strong prevalence of local rock types. Where the drift was derived from small areas of diverse rock types, it was strongly heterogeneous; where the drift was derived from larger areas of a single rock type it was found to be more homogeneous.

Somewhat unusual results of drift analysis were obtained by W. C. Krumbein (1933) in studying the drift in eastern Illinois, Indiana, and Michigan. The lithologic composition of the Valparaiso moraine was studied from till samples ranging in size from 200 to 500 pebbles of plus two millimeters diameter. Sample spacing averaged 7 miles for a distance of 165 miles. A prominent contact between limestone and shale was recorded in the derived drift a distance of 40 miles down-glacier from the actual contact. Krumbein believes that the reason for the large distance lies in a protective covering of the bedrock by an earlier drift sheet. In a concluding remark the author states that "In general it may be said that the occurrence of pebbles of the immediately underlying bedrock in a given till is a function largely of protective coverings of the rock, and the direction of the currents of ice" (p. 404).

J. M. Trefethen and J. N. Harris (1940, p. 411) showed that over 75 percent of the material of an esker-like ridge near Orrington, Maine was derived from local bedrock.

The lithology of the Kennebec Valley esker in Maine was studied by J. M. Trefethen and H. B. Trefethen (1944). The esker extends along a southerly course for a distance

of about 50 miles; it crosses terrain underlain by at least three distinctively different bedrock types. Drift samples consisting of two hundred pebbles of one-half inch to three inches diameter were taken at intervals ranging from two to four miles along the course of the esker. Sand samples were also collected and studied. Pebble counts led to the conclusion that the greater parts of the coarser and finer fractions of the drift were transported from three to eight miles, and probably not over five percent of the drift pebbles were derived from a source more distant than 50 miles.

C. D. Holmes (1952) published the results of an excellent large-scale study including the lithology of the drift in western New York. In this area the glacier-flow was predominately across the strike of the bedrock. The lithologic composition of the glacial drift was determined from till samples which consisted of from 200 to 800 pebbles of one-fourth to one-half inch diameter. Outcrops of distinctive rock types made it possible to assign a definite source area for much of the material found in the glacial deposits. The aerial distribution of the distinctive rock types occurring in the drift was found to be governed by the degree of rock resistance, the direction of ice flow, the topography, and the distance from the source rocks. Till isopleth maps for each of the distinctive rock types showed maximum percentages of these rock types in the drift at or along the source beds. The isopleths decreased in

regular fashion toward the end moraine, but depressions along through-valleys showed that these valleys provided more effective transportation lines. At 33 locations samples of both till and sorted gravels were counted, and at 30 of these locations the composition of the drift was almost identical for the pair of samples.

The lithology of the Marseilles till sheet in northeastern Illinois has been studied by R. C. Anderson (1955). The lithology of the drift was determined by studying drift samples consisting of 100 pebbles each. The sample spacing varied from three to six miles, depending on the type of glacial deposit. The bedrock geology in this area is well enough known so that most of the drift pebbles could be identified as to probable source area. The distribution of drift pebbles with respect to the bedrock source indicates that the percentage of a given rock type in the moraine "is dependent upon the provenance of the rock type, its lithologic properties, the nature of the glacial processes, and the dilution it has undergone by the addition of other rock types" (Anderson, 1955, p. 228). Anderson concludes that "Pebble lithology is determined largely by the position of local source areas relative to the direction of ice movement" (p. 243).

A. D. Howard (1956) presented the results of studies of till-pebble lithology in parts of Montana and North Dakota. The definite relationship between drift lithology and source beds led him to conclude that till isopleth maps might be

useful in determining the type of bedrock buried beneath glacial drift.

Glacial dispersion of rock fragments derived from a relatively small area of outcrop of a unique rock type is typically in the form of a fan lying with its apex at or pointing towards the source area of the distinctive rock type. Several such boulder trains or glacial fans have been identified and mapped in detail in the New England states (Flint, 1947, p. 120). In the Fennoscandian countries a substantial number of ore deposits have been discovered and located at least partially as a result of detailed mapping of glacial fans of ore boulders. Examples have been cited by Sauramo (1924) and by Grip (1953). In Ontario, Canada, the Steeprock Lake iron deposit was discovered as a result of observations of glacial erratics of iron ore south of the source area (Dreimanis, 1956). Mapping of the glacial fan of iron ore boulders played a prominant role in discovering the location of the deposit. H. E. Hawkes (1957) briefly discussed analysis of the composition of glacial drift as a method of geochemical prospecting, with the implication that the greater percentages of a given rock type or metal contained in glacial drift will be found closer to the source.

Glacial fans several hundred miles long demonstrate that some erratics, drift boulders, and drift pebbles have traveled great distances; however, it is significant that in virtually all instances the percentage of the unique rock

type in the drift falls off rapidly on the downglacier side of the outcrop and that the highest pebble-counts (or boulder-counts) of the unique rock type are invariably to be expected at or immediately downglacier from the outcrop.

In the present study, this close relationship between bedrock lithology and drift lithology is further substantiated and is heavily drawn upon as the basis for much of the subdrift geologic interpretation of Oneida County. In the words of Hotchkiss (1915, p. 62): "The constitution of the glacial drift is one of the important criteria that must be used in this district [northern Wisconsin] to determine the character of the bedrock".

Technique of Drift-Sampling

The lithologic composition of the glacial drift was determined by examining small samples of the glacial deposits taken at regular intervals throughout the area studied. Each sample consisted of 100 pebbles collected at random from a selected location. Pebbles smaller than one-half inch diameter were rejected by screening. Where possible the samples were collected from gravel pits or fresh road cuts, but more commonly it was necessary to obtain the sample by digging a small pit at the desired location. The spacing of the samples was varied for different parts of the county (plate I). The largest interval used required samples at the corners of a three-mile grid, starting at the township corners. This spacing was used for the western

quarter of the county. Samples at the corners and centers of a three-mile grid were taken over the remaining three-quarters of the county. Samples were taken at the corners of a one-and-a-half-mile grid over an area of about 80 square miles east of Rhinelander and north of Monico; and T. 38 N., R. 11 E. was covered by samples collected at the corners of a one-mile grid. At each sample location a distinction was made between till and stratified drift. The pebbles from each sample were washed, cracked, and identified with the aid of a hand lens.

The ideal spacing of samples in drift analysis depends upon many factors, including the character and structure of the bedrock, the size of the samples, the purpose of the study, the scale of mapping, the character of the glacial deposits, and the glacial history of the area.

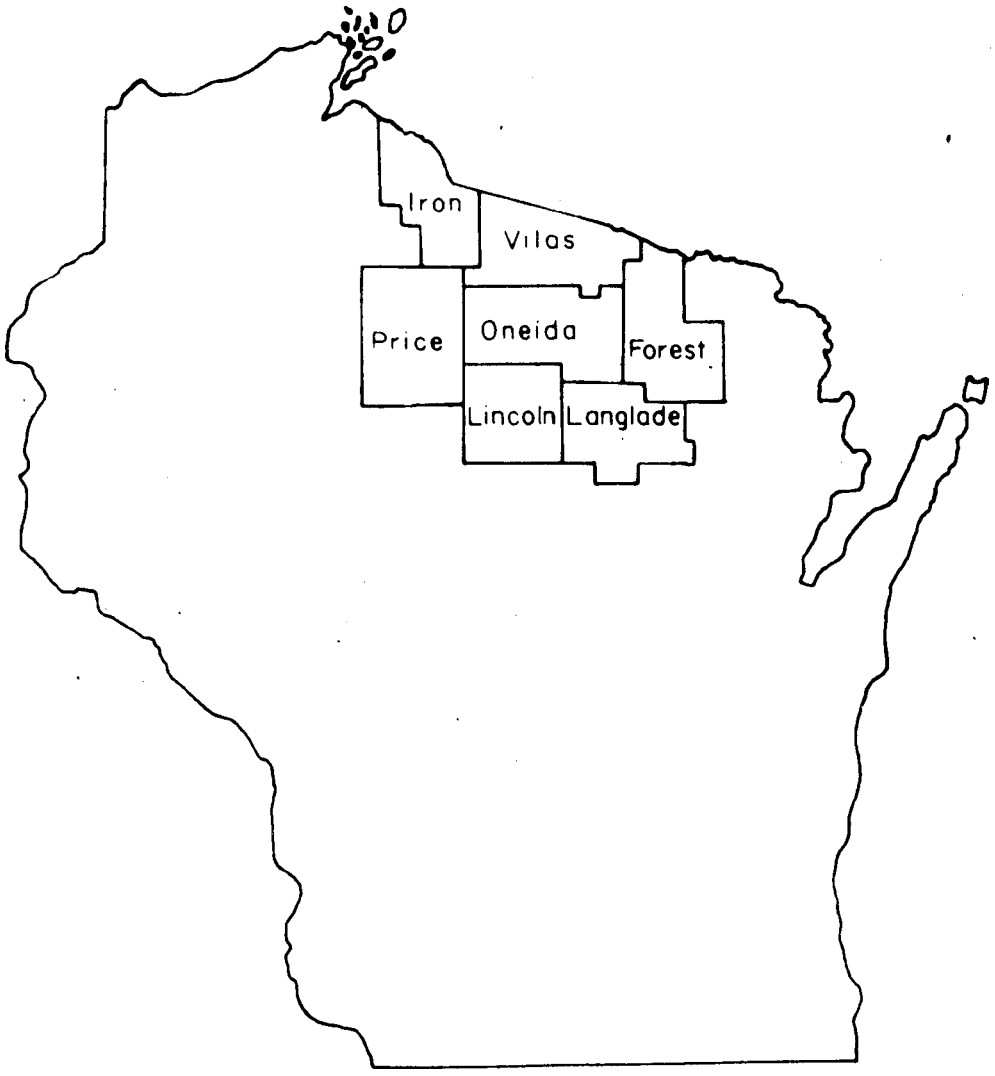


Figure 1. Map of Wisconsin showing locations of Oneida and adjacent counties.

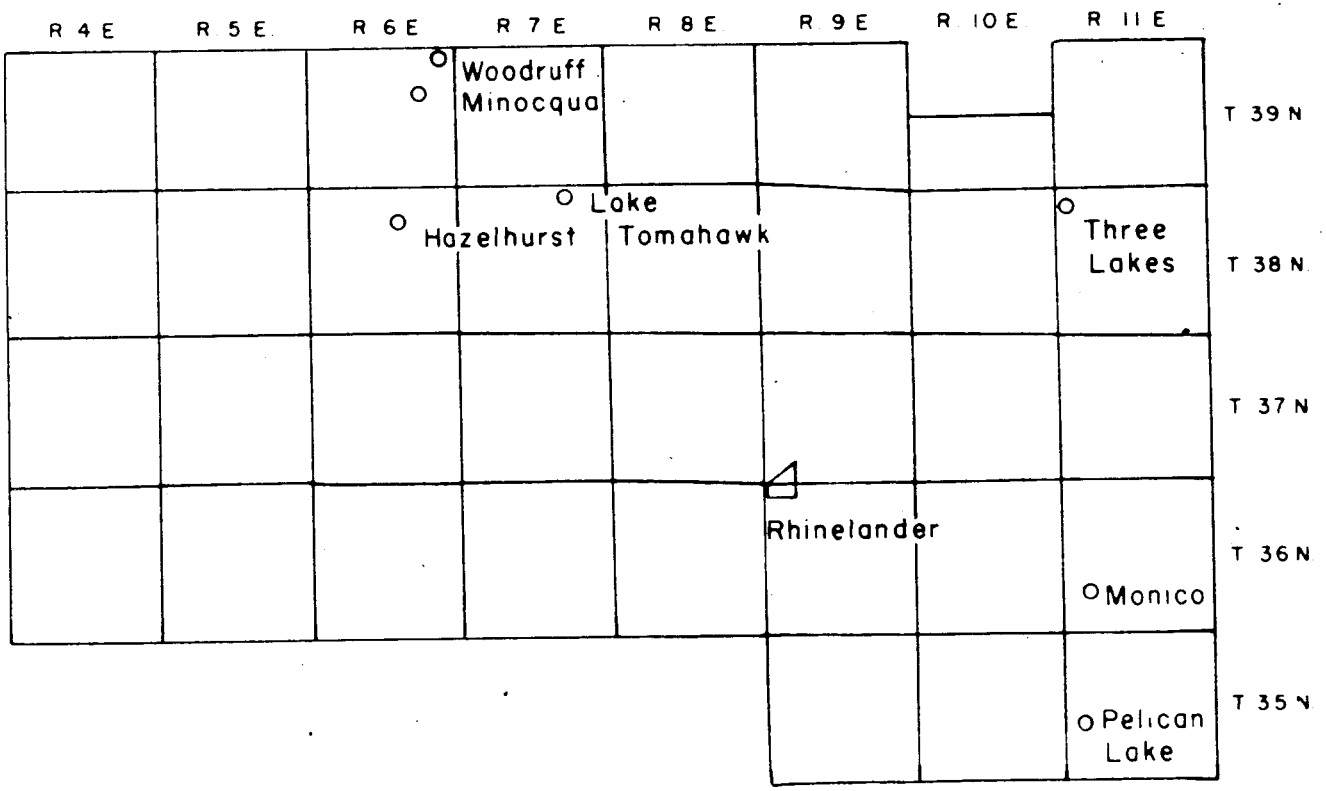


Figure 2. Map of Oneida County, Wisconsin showing locations of chief towns. Scale: one inch equals six miles.

DESCRIPTION OF OUTCROPS

Outcrops are scarce in Oneida County and most of the surface is covered by glacial drift. In the course of the field work 78 bedrock exposures were noted; their locations are shown in plate I.

The chief rock types found in outcrops are quartz diorite, microcline granite, acid gneisses, and extrusive igneous rocks. The acid gneisses are mostly gneissic phases of the quartz diorite or granite, or represent contact rocks between extrusive igneous rocks and quartz diorite or granite. The extrusive igneous rocks constitute a wide variety of variably altered and sheared, intermediate to basic rocks all of which belong to a single geologic unit. Less abundant are outcrops of diabase, amphibolite, and quartzose rocks of probable sedimentary origin.

Outcrops of extrusive igneous rocks are found primarily in the southeastern part of the county in the vicinity of Monico. Granite, quartz diorite, and acid gneisses crop out to the north of extrusive igneous rocks. Granite crops out southeast of the extrusive igneous rocks and in scattered exposures along the Wisconsin River through the central part of the country.

The extrusive igneous rocks are the oldest of the principal rock types. These have been intruded by quartz diorite followed by microcline granite. Diabase is the youngest rock type found in outcrops.

Quartz Diorite

General Statement.—Quartz diorites constitute a group of rocks which are ordinarily readily distinguishable in hand specimens or in thin sections by their characteristic appearance and composition. Hand specimens typically show a medium-grained, granitoid texture, which is locally modified by mineralogical segregations and parallelism of platy minerals to form a gneissic structure. The megascopically-visible, essential minerals are feldspar, quartz, amphibole, and biotite; garnet, pyrite, and chalcopyrite may be present in minor accessory amounts, and epidote is common as an alteration product of the ferromagnesian minerals. The black ferromagnesian minerals contrast with the clear or white feldspars and quartz, giving the rock a characteristic black and white spotted appearance. Typical hand specimens are shown in figures 7 and 8.

Occurrence.—Exposures of quartz diorite are most abundant in an easterly-trending belt through the east-central part of the county (plate I). Gneissic phases of the quartz diorite are found at outcrops 5, 5-a, 6, 9, 10, and 11 in T. 37 N., R. 11 E., at outcrop 7 in T. 37 N., R. 10 E., at outcrop 74 in T. 37 N., R. 9 E., and at outcrop 2 in T. 38 N., R. 11 E. (plate I). The strike of the foliation is invariably between northwest and west and the dip is steep to the south. A massive phase of the quartz diorite in contact with microcline granite and diabase is found at outcrop 64

(plate I) along the Wisconsin River in the town of Rhinelander (T. 36 N., R. 9 E.). The quartz diorite is the oldest of the three rock types exposed at this outcrop (figures 3 and 4).

A single exposure of quartz diorite is present in the southwestern corner of the county (outcrop 23 in T. 35 N., R. 11 E., plate I). Here the quartz diorite contains inclusions of a greenstone.

Outcrops 54 and 55 in T. 36 N., R. 10 E. (plate I) expose a rock type similar in megascopic appearance to the quartz diorite; study of thin sections, however, shows that the rock is a hornblende gabbro. This rock is fine-grained and has a slight tendency towards an ophitic texture. The appearance in hand specimen and the composition as determined from thin section suggest a close genetic relationship between this rock and the quartz diorite. Furthermore, it is located on the southern margin of the zone through which quartz diorite crops out, adjacent to the belt of extrusive igneous rocks. Because of its composition and occurrence, it is interpreted as being an early phase derived from the same magma which produced the quartz diorite.

Petrography.— Microscopic study of thin sections of specimens from seven different locations shows the following average mineralogical composition for the quartz diorites (percentages by visual estimation):

Essential Minerals

plagioclase 40 percent

amphibole	20 percent
quartz	20 percent
biotite	15 percent

Accessory Minerals

sphene
magnetite
zircon
hematite
pyrite
chalcopyrite
apatite
orthoclase

Secondary Minerals

epidote
sericite
chlorite
hematite
clinozoisite

The typical appearance of the quartz diorites in thin section is shown in figures 11 through 18. The texture is medium to fine-grained; the average size of most of the grains is between 0.1 and 2.0 millimeters. Extinction angles and refractive indices of the plagioclase indicate a composition ranging from sodic to calcic andesine. Most of the plagioclase is quite fresh, showing only a slight degree of alteration along clevage planes. Zoning is uncommon. The plagioclase twinning is mostly of the ordinary type according to the albite law, but some crystals also show pericline twinning and some crystals show the effects of combined albite-carlsbad twinning. Quartz, amphibole, and biotite, although present in all sections studied, vary considerably in quantity. Most sections containing above-average amounts of biotite contain above-average amounts of

quartz; sections below average in biotite are ordinarily below average in quartz; and in both cases amphibole varies to balance the total. In most of the sections the composition of the plagioclase is related to the relative percentages of quartz, biotite, and amphibole. In sections which are rich in biotite and quartz, the andesine is more sodic, whereas in sections which are rich in hornblende the andesine is more calcic. The amphibole is pleochroic, green hornblende and the biotite is pleochroic in shades of brown. In some sections the hornblende is poikilitic (figures 13 and 14). Zircon, surrounded by pleochroic haloes, occurs as inclusions in biotite. Hematite is present as a primary accessory mineral and as an alteration mineral, occurring as cubic pseudomorphs after pyrite.

Gneissoid varieties of quartz diorite are shown in figures 15, 16, 17, and 18. The gneissoid structure results either from parallel arrangement of the platy minerals (figures 15 and 16), or from mineralogical segregations of dark and light colored minerals (figures 17 and 18). The mineralogical composition of the gneissoid quartz diorite is essentially the same as in the massive quartz diorite.

The hornblende gabbro, exposed in T. 36 N., R. 10 E. (outcrops 54 and 55, plate I), is composed of about 50 percent plagioclase and about 45 percent hornblende. The plagioclase is commonly zoned, and it has an average composition in the bytownite range. Biotite is present, but has been partially or completely altered to chlorite.

Quartz is present in accessory amounts and it has apparently replaced hornblende and plagioclase. Accessory minerals seen are pyrite, apatite, and sphene. Alteration minerals include epidote and clinozoisite, chlorite, calcite and sericite. There seems to be a gradation in composition between this rock type and the varieties of quartz diorite. Progressing from more basic to more acidic they are hornblende gabbro, hornblende quartz diorite, and biotite quartz diorite. The composition of the plagioclase ranges from bytownite in the gabbro, through calcic andesine in the hornblende quartz diorite, to sodic andesine in the biotite quartz diorite.

Microcline Granite

General Statement.—The microcline granites in Oneida County range from slightly pinkish or brownish, to reddish, to brick-red; the red colors are due to fine-grained, dusty hematite dispersed unevenly through the rock. The texture is typically medium-grained, granitoid. Feldspars, quartz, and biotite are readily identified in hand specimens.

Occurrence.—Exposures of microcline granite are numerous in T. 35 N., R. 11 E. (plate I, outcrops 21,22,23,24,26, 27,29,34, and 35). Other occurrences in the county consist of widely scattered single exposures. These are found in T. 39 N., R. 8 E. (outcrop 74, plate I), T. 38 N., R. 8 E. (outcrop 73, plate I), T. 38 N., R. 9 E. (outcrop 4, plate I), T. 39 N., R. 9 E. (outcrop 3, plate I), T. 38 N., R. 11 E.

(outcrop 1, plate I), and T. 36 N., R. 9 E. (outcrop 64, plate I).

Only rarely in the county is it possible to observe and interpret contact relationships between different rock types. One such exposure is along the Wisconsin River in the town of Rhinelander (outcrop 64). Quartz diorite is cut by stringers and small dikes of microcline granite (figures 3, 4, and 9). Quartz veins, some of which contain minor amounts of chalcopyrite, cut both the microcline granite and quartz diorite. A diabase dike is also exposed at this location. Where the diabase is in contact with the quartz diorite and microcline granite, it exhibits a microcrystalline contact zone a fraction of an inch wide; some small stringers of the "chilled" diabase project into the quartz diorite. These relationships demonstrate that the diabase is the youngest of the three rock types exposed here and that the quartz diorite is the oldest. Almost identical relationships were found at an exposure of schistose diorite, microcline granite, and diabase in section 23, T. 33 N., R. 8 E., Lincoln County (to the south of Oneida County).

Petrography.—Thin sections of ten specimens from different locations show the following average mineral composition for the microcline granite (percentages by visual estimation):

Essential Minerals

microcline 35 percent

quartz	30 percent
plagioclase	15 percent
biotite	10 percent

Accessory Minerals

garnet
zircon
apatite
hematite
sphene
magnetite
pyrite
ilmenite
muscovite
orthoclase

Secondary Minerals

sericite
kaolinite
epidote
chlorite
calcite
hematite
leucoxene
clinozoisite

The texture is typically medium- to fine-grained, granitoid; most of the individual mineral grains range from 0.5 to 5.0 millimeters. Photomicrographs of thin sections are shown in figures 19 through 26. Cataclastic textures, various intergrowths involving quartz and feldspars, and replacement textures are abundant in most of the thin sections studied. Strained and fractured quartz (figure 25), bent, broken, and displaced plagioclase twin lamalla (figure 20), and well developed mortar structure (figures 21 and 22) give evidence of cataclastic deformation. Much of the potash feldspar is perthitic (figures 21 and 23), containing slender, oriented lenses of plagioclase (albite-oligoclase). Myrmekitic and micrographic

intergrowths of quartz and feldspar are common (figure 24). Ragged remnants of much-altered plagioclase surrounded by nearly fresh microcline indicate that microcline has replaced plagioclase.

Extinction angles and refractive indices indicate that the composition of the plagioclase ranges from sodic to intermediate andesine. Some of the plagioclase shows distinct zoning (figure 26); more commonly the plagioclase zoning is shown and emphasized by varying degrees of alteration which increase in intensity inward. The plagioclase alteration varies from almost nill, leaving the crystal nearly clear, to extreme sericitization or saussuritization which nearly obliterates the twin lamallae; in all cases the alteration is more complete than in the potash feldspar (figure 19). The potash feldspar, some of which is perthitic, is chiefly microcline, but small amounts of orthoclase are present. The biotite varies from brown to green and contains zircon inclusions surrounded by pleochroic haloes. Some of the brown biotite is very dark, the pleochroism being from light brown to nearly black. Epidote, chlorite (pennine, showing anomalous brown and purple interference colors) and sericite are the most abundant alteration minerals. Hematite, which is present as a primary accessory mineral and as a finely-dispersed, dusty, alteration mineral, typically gives the rock its brownish and reddish colors..

Extrusive Igneous Rocks

General Statement.—Extrusive igneous rocks crop out chiefly in the southeastern part of the county. The individual rock types included in this group are acid to intermediate porphyries (quartz latites and dacites), andesites, highly altered intermediate to basic igneous rocks, altered and sheared acid to intermediate igneous rocks and amphibolites. All of these rock types, except for some of the amphibolites, are very fine-grained. All, except for the more acidic rocks and the coarser-grained amphibolites, are dark greenish-grey in color and posses the characteristics of "greenstones".

Occurrence.—Most of the exposures of extrusive igneous rocks are in T. 36 N., R's. 10 and 11 E. (plate I). The outcrops are generally small and some include a variety of rock types. The area of extrusive rocks trends east, bounded on the north by quartz diorite, microcline granite, and gneissic phases of both, and on the southeast by microcline granite. Outcrops bearing the following numbers (plate I) consist partly or wholly of extrusive igneous rocks: 12, 13, 14, 15, 16, 17, 22, 23, 33, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 47, 48, 49, 50, 51, 52, 55, 57, 58, 59, 60, 62, 63, 68, and 69.

Some of the bedrock is distinctly schistose, the foliation striking approximately east and dipping vertically; other outcrops show primary flow structures striking in the same direction and dipping vertically. A magnetic

anomaly in this general area also has an easterly trend. Flow features are of several types, including textural features apparent only in thin section (described below) and megascopically visable flow structures resulting from a subparallel arrangement of platy minerals, vesicles, and inclusions. Outcrop 16 (plate I) contains elliptically-shaped inclusions which weather to a light olive green. These are elongated in a common direction and some are connected by thin streaks of the same material (figure 5). Outcrop 36 (plate I) consists of volcanic rocks distinctly showing the original flow-layering. Some of the layers contain angular inclusions which represent brecciated rock later cemented by the lava (figure 6). The inclusions show preferred orientation parallel with the flow-layering, their white weathered surfaces standing in marked contrast with the greenish or blackish background material. Original flow-layering and primary foliation strike east and dip vertically.

Some of the outcrops, especially toward the northern part of the belt, show granite or quartz diorite in contact with extrusive rocks, but in most places the contacts do not show conclusive age relationships. Outcrop 45 consists of granite interfingered with a greenstone. In general appearance it looks as if the granite bears an intrusive relationship to the greenstone, this being positive if the greenstone was originally an extrusive igneous rock. The granite is a muscovite granite, bearing little resemblance

to any of the major rock types previously described; the greenstone is a fine-grained amphibolite. In a brief description of the outcrops in this general area, Hotchkiss (1915) reported that, although contacts between greenstone and granite are common, age relationships are mostly obscure; wherever discernable, the granite is generally intrusive into the greenstone.

Diabase is in contact with a greenstone in outcrop 16 (plate I), and for reasons enumerated below (page 30) it is interpreted as being intrusive into the greenstone.

Many of the outcrops expose widely divergent rock types, which are grouped together as extrusive igneous rocks. These include sheared and altered rocks ranging in composition from quartz latite to basalt. Although sedimentary and tuffaceous features were not observed, it is entirely possible that some of the rocks placed in the group identified as extrusive igneous rocks are actually altered pyroclastic rocks or altered clastic sedimentary rocks. Field occurrences indicate that the rocks placed in this group are tentatively to be considered as pre-granite, pre-quartz diorite and pre-diabase in age. The chief varieties within the group of extrusive igneous rocks are discussed separately in the following paragraphs.

Acid Porphyries.—Rocks of this type range from quartz latite (or possibly even rhyolite) to dacite and are found in outcrops 17, 22, 36, 39, 47, 60, and 61 (plate I). In hand specimens (figure 10) they are very fine-grained,

greenish-grey, slightly to strongly porphyritic, vitreous appearing rocks, some of which show a fine flow structure consisting of sub-parallel arrangement of platy minerals or vesicles.

Thin sections show phenocrysts of quartz and feldspars, commonly both potash feldspar and plagioclase, in a quartzo-feldspathic matrix (figures 27, 28, 29, and 30). Generally the feldspar is in greater abundance than the quartz. Plagioclase phenocrysts are either sodic andesine or a more sodic variety. Biotite is commonly present either in the matrix or as phenocrysts. Several of the accessory minerals, ilmenite, magnetite, pyrite, zircon, and sphene are generally present. Common secondary minerals include sericite, chlorite, epidote-group minerals, calcite, and hematite.

The texture of these rocks is typically very fine-grained, porphyritic or microporphyritic (figures 27, 28, 29, and 30). Phenocrysts of quartz and feldspar range from 0.1 to 4 millimeters in diameter; the matrix materials are generally from .02 to 0.1 millimeter in diameter. In some of the sections the phenocrysts are corroded and deeply embayed by the matrix minerals, in others the phenocrysts are strained, fractured, granulated and veined by matrix minerals, and in still others the phenocrysts are undeformed euhedral to subhedral crystals (figures 27 and 28). In places, primary foliation is in the form of subparallel platy minerals, elongate vesicles, or phenocrysts.

Trachytitic texture, in which the matrix foliation "flows around the phenocrysts", is evident in some sections (figures 29 and 30).

Most of the quartz latites and dacites are not greatly altered. In some sections, biotite is partially altered and feldspars are somewhat clouded with sericitic alteration. A few of the plagioclase crystals have been thoroughly saussuritized. Secondary vesicle-fillings of radiating epidote were noted in some specimens.

Andesites.—Rocks of this type are nearly gradational with the quartz latite-dacite type and they may even extend to basalt in composition. The andesites are typified by specimens from outcrops 22, 25, 40, 42, and 45 (plate 1). In hand specimens the andesites are difficult to distinguish from other grey-green, fine-grained, poorly foliated greenstones. In thin section, however, they are readily identified as partially altered and sheared andesites. Photomicrographs of typical thin sections are shown in figures 31, 32, 33, and 34.

The essential minerals of the andesites are plagioclase and amphibole in approximately equal percentages. The plagioclase is typically andesine or oligoclase-andesine and the amphibole is green hornblende or pale green actinolite. The accessory minerals in any section include several of the following: biotite, quartz, sphene, magnetite, pyrite, chalcopyrite, and zircon. Secondary minerals are epidote and clinozoisite, chlorite, sericite, leucoxene,

calcite, and hematite. Actinolite and hornblende, although in essential quantities may be deuteric alteration products after pyroxene.

The texture is fine-grained, the individual minerals ranging from .02 to 1.5 millimeters in diameter. Some of the specimens are porphyritic or subporphyritic with amphibole or plagioclase phenocrysts (figures 32 and 33). Primary foliation exists in some of the andesites but a secondary foliation is more typical. Sphene is present in fine, granulated aggregates (figure 31). In some sections it is possible to observe an original acute rhombic section of sphene which has been partially granulated and stretched-out parallel with the foliation. Some of these sphene aggregates have an "S"-shaped pattern.

Vesicular or amygdaloidal textures are present in some of the andesites (figures 32 and 33). Calcite, chlorite, quartz and epidote are typical amygdules. In one section the textural relationship between amphibole and plagioclase is ophitic (figure 34), suggesting the possibility that the rock is an altered diabase in which the amphibole is pseudomorphous after pyroxene.

Alteration and secondary minerals are generally well developed, but not so much so as to preclude identification of the plagioclase nor to mask the original texture of the rock. Partial to complete saussuritization of the plagioclase has produced epidote and clinozoisite. Commonly the amphibole is partially altered to chlorite and epidote.

Some of the quartz is probably a primary mineral, but most is likely secondary.

Diabase

Occurrence.—The diabases are dark grey, medium- to fine-grained rocks having an ophitic or subophitic texture and the composition of a gabbro. Three diabase outcrops are recorded in the area. In one (outcrop 59, plate I) the diabase is not in contact with other rock types, in another it is in contact with acid igneous rocks, and in a third it is in contact with extrusive igneous rocks. The diabase in outcrop 16 (plate I) is strikingly different from the other rocks in the outcrop in the extent of alteration and metamorphism. The greenstones in this outcrop are highly altered basic igneous flows, whereas the diabase is unaltered, suggesting that the diabase is considerably later than the flows.

Diabase, microcline granite, and quartz diorite are exposed in outcrops along the Wisconsin River in the town of Rhinelander. The diabase exhibits a microcrystalline contact zone a fraction of an inch wide where it is in contact with the quartz diorite and microcline granite; small stringers of the "chilled" diabase project into quartz diorite. These relationships demonstrate that the diabase is younger than the other two rock types. The diabase is in the form of a small dike intruded into a mass of phaneritic acid and intermediate igneous rocks.

It is concluded that the diabases exposed in the three outcrops are genetically related and that they occur as dikes or other small bodies intruding the extrusive igneous rocks, the quartz diorite, and the microcline granite.

Petrography.—The mineralogical composition of the diabases as determined from thin sections of three specimens from different outcrops is as follows:

Essential Minerals

plagioclase	50 percent
pyroxene	30 percent

Accessory Minerals

magnetite	10 percent
olivine	
biotite	
hornblende	
zircon	

Secondary Minerals

epidote	10 percent
chlorite	
hematite	

Photomicrographs of the diabases are shown in figures 35, 36, and 37. In the medium-grained diabase, which has an average grain size of about 1.5 millimeters, the plagioclase laths are too large to be completely enclosed by optically continuous pyroxene (subophitic texture); but in the finer-grained diabase, which has an average grain size of about 0.5 millimeters, the plagioclase laths are completely enclosed by optically continuous pyroxene (ophitic texture, figures 35 and 36). Plagioclase phenocrysts are present but not abundant (figure 37). Extinction angles

of the plagioclase indicate a composition of labradorite, and the pyroxene has the optical properties of pigeonite. The minerals of the diabase are remarkably fresh and show only the beginning stages of alteration.

Quartz Rock

Occurrence.—The term "quartz rock" is used here to indicate a rock of uncertain origin composed almost entirely of quartz. The quartz rock is pure white or pinkish in color. The only outcrop where this rock type was found is in the extreme southeastern part of the county (outcrop 21, plate I) in T. 35 N., R. 11 E. Here the quartz rock occurs in contact with microcline granite. The contact is irregular and gradational, and the granite appears to be intrusive into the quartz rock. Granite specimens collected from close to the contact show contaminations of silica occuring as discrete inclusions. Higher percentages of quartz in these granites suggest resorption of silica and crystallization of this added silica as quartz. Both the granite and the quartz rock are cut by narrow veins of quartz ranging from a fraction of an inch to several feet in width. Offsets of intersecting veins indicate that the vein quartz was deposited in minor faults in the granite and quartz rock. No field data was found to suggest the origin of the quartz rock.

Petrography.—Thin sections of the quartz rock show that it is a strikingly pure mixture of fine- and medium-

grained quartz. The medium-grained quartz occurs in veins cutting the fine-grained matrix (figure 39). Traces of sericite are sparingly distributed through the rock.

Origin.—The possible origins for the quartz rock are recrystallization of sandstone (quartzite), intense silicification of some pre-existing rock, and deposition of quartz in fractures by silica-bearing solutions (vein quartz). The apparent intrusive relationship of the granite makes it doubtful if the rock is vein quartz. If it were recrystallized sandstone it would seem likely that some sedimentary textures or structures could be found. However, some thoroughly recrystallized sandstones retain little or no characteristics of the parent rock. The Rib Hill quartzite, exposed near Wausaw, is believed to be a quartzite. In this rock there is no indication of the former clastic texture from study of hand specimen or thin section, however, cross-bedding and ripple marks are preserved in some places in the rock. The Rib Hill quartzite bears definite resemblance to some specimens of the quartz rock in southeastern Oneida County. This, however, does not indicate a similar origin as some specimens of the quartz rock also bear resemblance to certain silicified carbonate rocks of the Lake Superior region.

Figure 3. Outcrop of microcline granite and quartz diorite (numbers 64 and 65, plate I), in T. 36 N., R. 9 E., sec. 6, Oneida County, Wisconsin. This exposure along the Wisconsin River in the town of Rhinelander shows clear-cut age relationships between the microcline granite and quartz diorite. The darker rock is quartz diorite, which is cut by small dikes of lighter-colored microcline granite.

Figure 4. Outcrop of microcline granite and quartz diorite (same outcrop as figure 3). A dike of microcline granite cutting quartz diorite contains an inclusion of quartz diorite (under hammer). A lighter-colored, coarser-grained reaction zone (?) is visible at the immediate contact between the microcline granite and the quartz diorite.



Figure 3



Figure 4

Figure 5. Outcrop of altered, intermediate to basic, extrusive igneous rocks (number 16, plate I) in T. 36 N., R. 11 E., sec. 30, Oneida County, Wisconsin. These elliptical-shaped inclusions, elongate parallel with the flow structure, are abundant at this location.

Figure 6. Outcrop of altered, intermediate to basic, extrusive igneous rocks (number 36, plate I) in T. 36 N., R. 11 E., sec 21, Oneida County, Wisconsin. The white, angular inclusions are oriented parallel with the flow structure and are restricted to certain layers of the original lava.



Figure 5



Figure 6

Figure 7 (left). Hand specimen of quartz diorite from outcrop number 5 (plate I). Black and white contrast is typical of the quartz diorite. Minerals are quartz and plagioclase (white) and hornblende and biotite (black). X1.4.

Figure 8 (right). Hand specimen of gneissoid quartz diorite from outcrop number 75 (plate I). Gneissoid foliation is emphasized by partial segregation of ferromagnesian minerals. X1.1.

Figure 9 (left). Hand specimen of microcline granite from outcrop number 66 (plate I). Microcline granite (light colored, right-hand side) is in the form of a small dike cutting quartz diorite (dark colored, left-hand side). X1.2.

Figure 10 (right). Hand specimen of quartz latite porphry from outcrop number 47 (plate I). Phenocrysts are chiefly altered feldspars. Matrix is composed dominately of very fine-grained quartz and feldspar. X1.75.

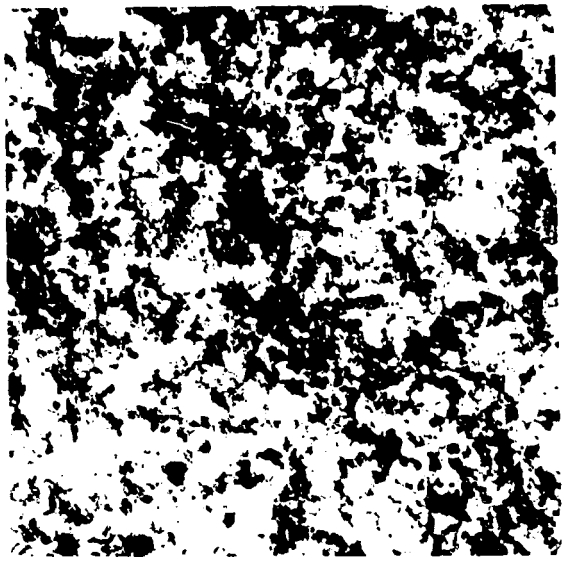


Figure 7

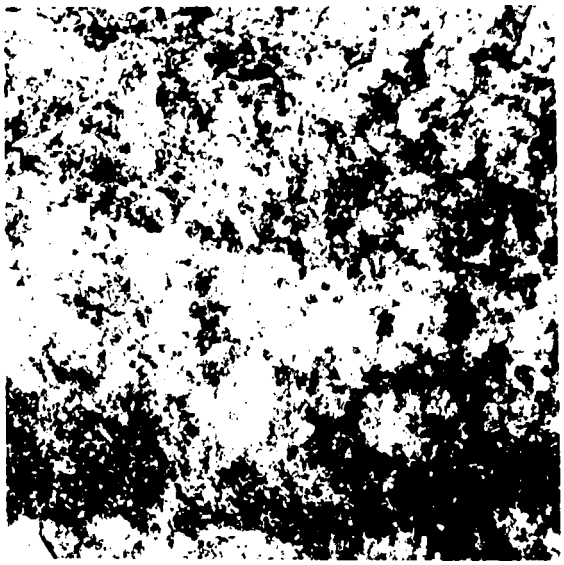


Figure 8

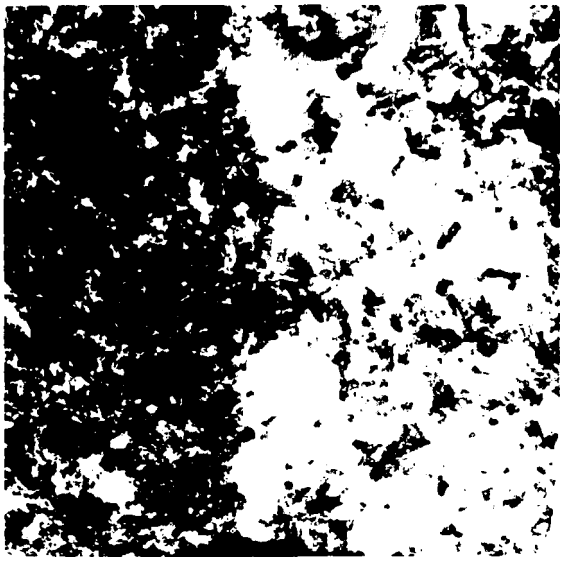


Figure 9

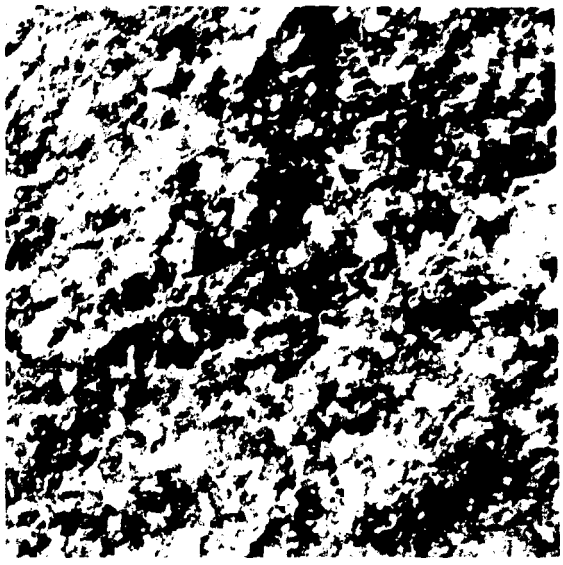


Figure 10

Figure 11 (left). Photomicrographs of quartz diorite from outcrop number 23 (plate I). Large crystal of plagioclase (upper left of center) is saussuritized. Finer-grained material is quartz and plagioclase (low relief) and hornblende and minor biotite (moderate relief). Crossed nicols, X16.

Figure 12 (right). Photomicrograph of quartz diorite from outcrop number 6 (plate I). Minerals are quartz, plagioclase, hornblende, biotite, magnetite, and sphene. Crossed nicols, X38.

Figure 13 (left). Photomicrograph of quartz diorite from outcrop number 9 (plate I). Minerals are quartz and plagioclase (low relief, clear), hornblende (moderate relief, light grey to black), and minor epidote (high relief). The hornblende is poikilitic, containing inclusions of quartz and feldspar. Nicols not crossed, X16.

Figure 14 (right). Photomicrograph of quartz diorite from outcrop number 9 (plate I). Same as figure 13, except crossed nicols, X16.

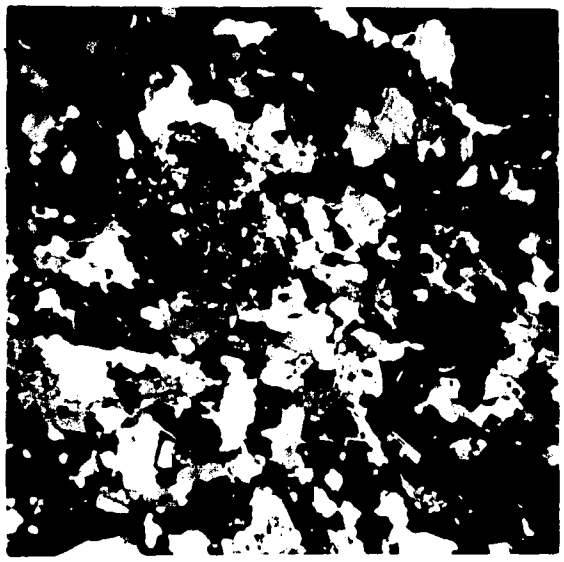


Figure 11



Figure 12

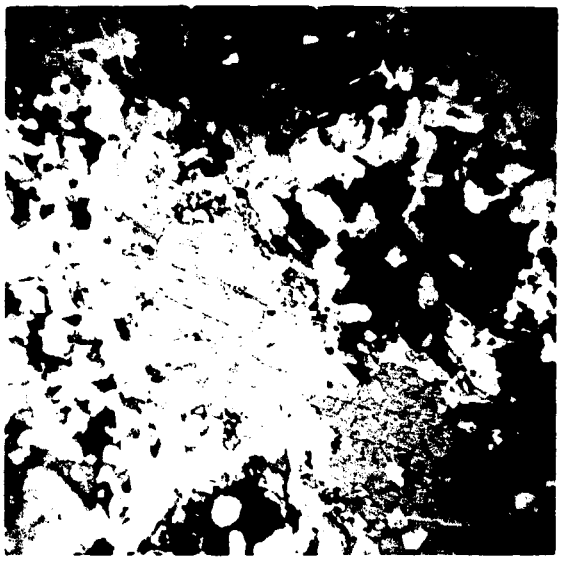


Figure 13

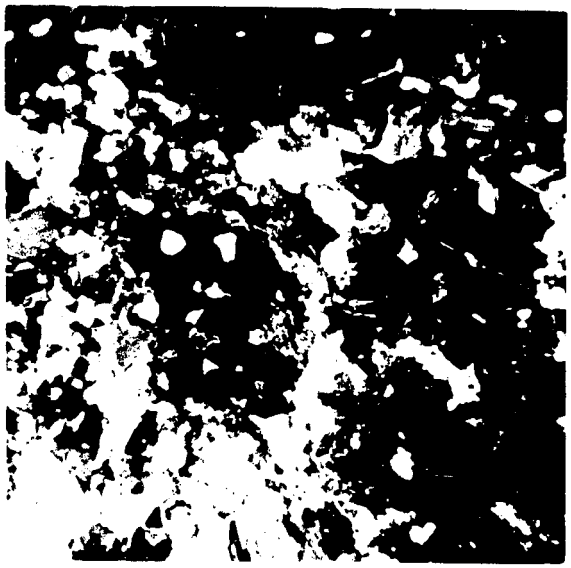


Figure 14

Figure 15 (left). Photomicrograph of gneissoid quartz diorite from outcrop number 2 (plate I). Minerals are quartz and plagioclase (low relief and clear), biotite (moderate relief), and epidote (high relief). Nicols not crossed, X16.

Figure 16 (right). Photomicrograph of gneissoid quartz diorite from outcrop number 2 (plate I). Same as figure 15, except crossed nicols, X16.

Figure 17 (left). Photomicrograph of gneissoid quartz diorite from outcrop number 6 (plate I). Minerals are quartz and plagioclase (low relief, clear), hornblende and biotite (moderate relief), epidote (high relief), and sphene (very high relief). Nicols not crossed, X38.

Figure 18 (right). Photomicrograph of gneissoid quartz diorite from outcrop number 6 (plate I). Same as figure 17, except crossed nicols, X38.



Figure 15



Figure 16



Figure 17

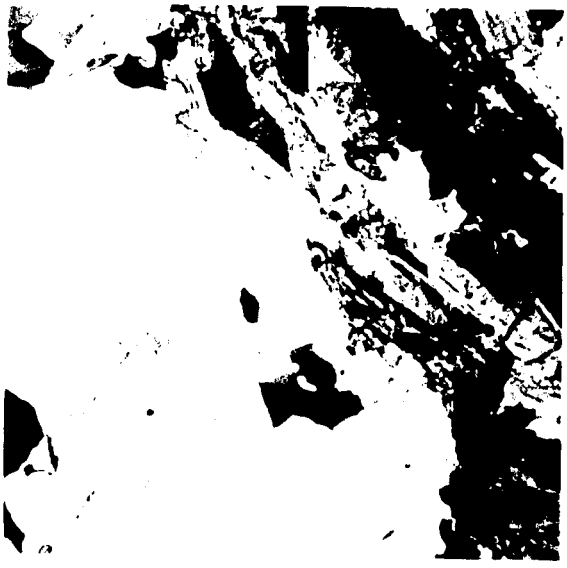


Figure 18

Figure 19 (left). Photomicrograph of microcline granite from outcrop number 4 (plate I). Minerals present are microcline, quartz, plagioclase, epidote, muscovite, chlorite, and sphene. Crossed nicols, X12.

Figure 20 (right). Photomicrograph of microcline granite from outcrop number 21 (plate I). This section shows abundant evidence of cataclastic deformation. The single large crystal of plagioclase has been fractured and displaced. The fractures have been filled by quartz and sericite. Crossed nicols, X38.

Figure 21 (left). Photomicrograph of gneissoid microcline granite from outcrop number 3 (plate I). Note the well developed mortar structure. Large crystal is perthitic microcline. Finer-grained material is quartz, plagioclase, and microcline. Crossed nicols, X12.

Figure 22 (right). Photomicrograph of gneissoid microcline granite from outcrop number 3 (plate I). Similar to figure 21, except greater magnification. The three large potash feldspar crystals (lower right, lower left, upper right) are each as large in their entirety as the area of the whole photograph. Crossed nicols, X38.

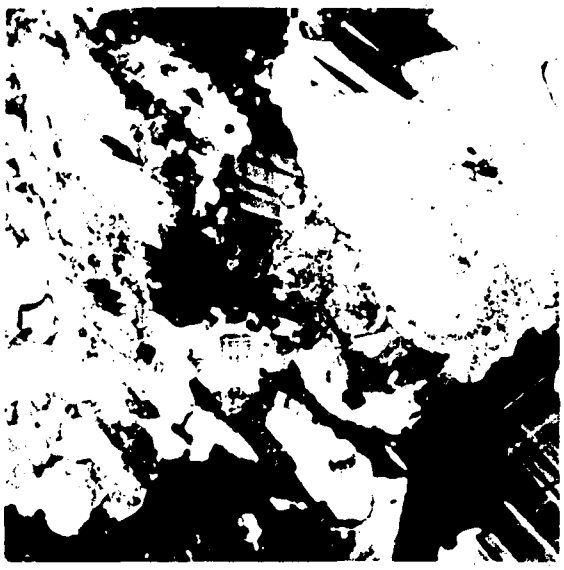


Figure 19



Figure 20

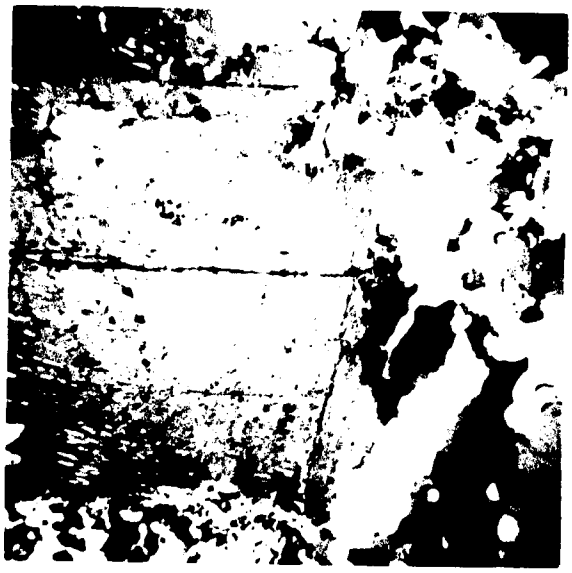


Figure 21

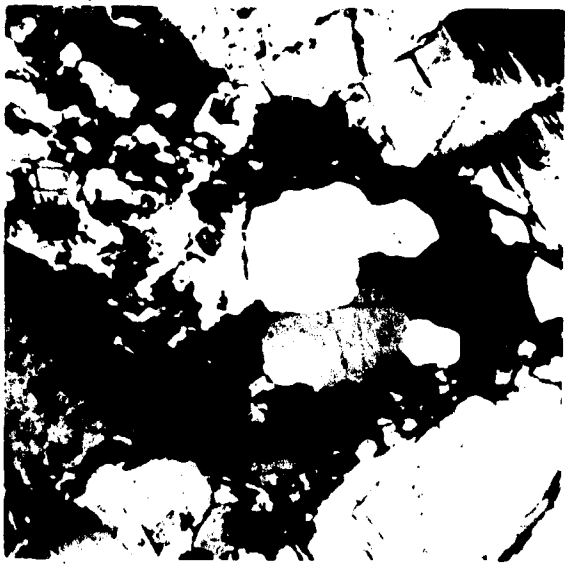


Figure 22

Figure 23 (left). Photomicrograph of microcline granite from outcrop number 35 (plate I). Microcline (right half and upper left) is strongly perthitic. Smaller perthite crystal (upper left) contains two plagioclase inclusions. Sericitized plagioclase is present in extreme upper left and lower left. Clear material is mostly quartz. Crossed nicols, X12.

Figure 24 (right). Photomicrograph of microcline granite from outcrop number 1 (plate I). Note myrmekitic intergrowth (above center), sericitized plagioclase (lower right), and strained quartz (lower left). Crossed nicols, X38.

Figure 25 (left). Photomicrograph of microcline granite from outcrop number 21 (plate I). Twinned plagioclase (above center) is fractured and veined by quartz and sericite. Large quartz crystal (left of center) shows very pronounced undulatory extinction. Plagioclase crystal (upper right) is fractured and displaced. Mosiac of small grains at bottom consists of finely crystalline quartz. Crossed nicols, X12.

Figure 26 (right). Photomicrograph of microcline granite from outcrop number 1 (plate I). Plagioclase crystal (above center) shows zoning. Large dark mass (below center) is chiefly plagioclase, showing some zoning and sericitization. Quartz is clear (upper margin). Other minerals include biotite (right and left of zoned plagioclase), twinned microcline (upper right), and garnet (dark and to right of center). Crossed nicols, X12.



Figure 23



Figure 24

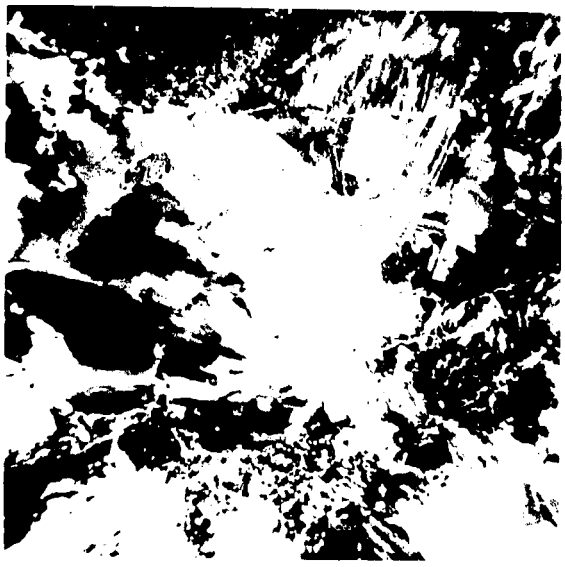


Figure 25



Figure 26

Figure 27 (left). Photomicrograph of quartz latite porphyry from outcrop number 22 (plate I). The phenocrysts are plagioclase (albite-oligoclase). The black grain (above center) is pyrite. Matrix minerals are quartz, feldspars, biotite, muscovite, pyrite, and epidote. Crossed nicols, X38.

Figure 28 (right). Photomicrograph of quartz latite porphyry from outcrop number 39 (plate I). The phenocryst is plagioclase. Matrix minerals are quartz, feldspars, biotite, chlorite, and magnetite. Crossed nicols, X48.

Figure 29 (left). Photomicrograph of quartz latite porphyry from outcrop number 36 (plate I). Flow structure is evident near phenocrysts where the matrix minerals wrap around the phenocrysts. The phenocrysts are plagioclase. Matrix minerals are quartz, feldspars, sphene, chlorite, sericite, and epidote. Nicols not crossed, X38.

Figure 30 (right). Photomicrograph of quartz latite porphyry from outcrop number 36 (plate I). Same as figure 29, except crossed nicols, X38.

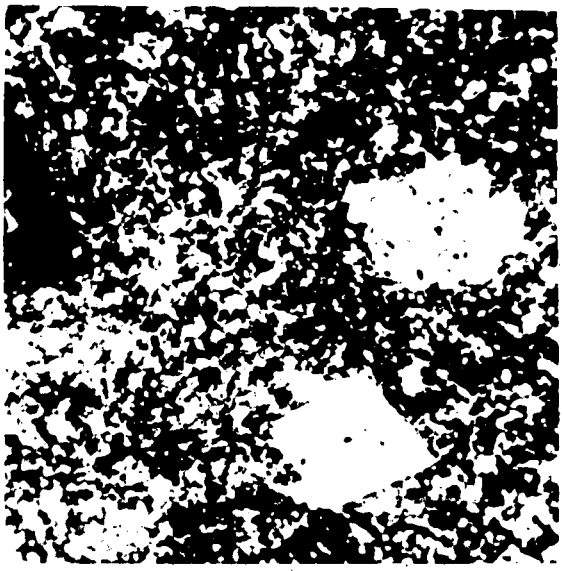


Figure 27



Figure 28

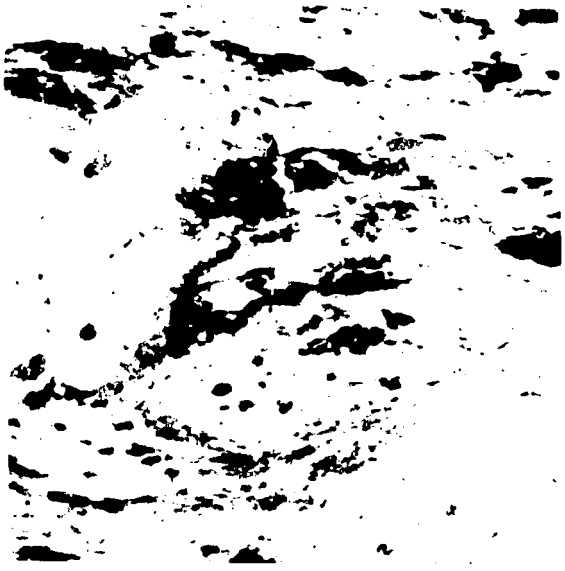


Figure 29

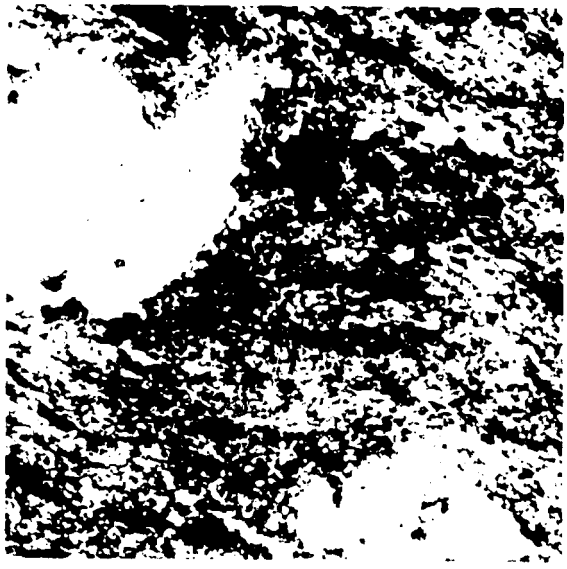


Figure 30

Figure 31 (left). Photomicrograph of andesite from outcrop number 22 (plate I). Lath-shaped plagioclase crystals (clear) enclosed by hornblende (grey). Dark material consists of granulated and sheared sphene. Small amounts of epidote (grey, high relief) are present. Nicols not crossed, X36.

Figure 32 (right). Photomicrograph of porphyritic andesite from outcrop number 40 (plate I). Large amygdule at right is calcite rimmed by chlorite. Phenocrysts at left are partially altered feldspar. Matrix consists of partially altered plagioclase laths, actinolite, and clinozoisite. Crossed nicols, X16.

Figure 33 (left). Photomicrograph of porphyritic andesite from outcrop number 40 (plate I). Same as figure 32, except nicols not crossed, X16.

Figure 34 (right). Photomicrograph of andesite from outcrop number 22 (plate I). Lath-shaped plagioclase crystals are enclosed in optically continuous hornblende (ophitic texture). Crossed nicols, X36.

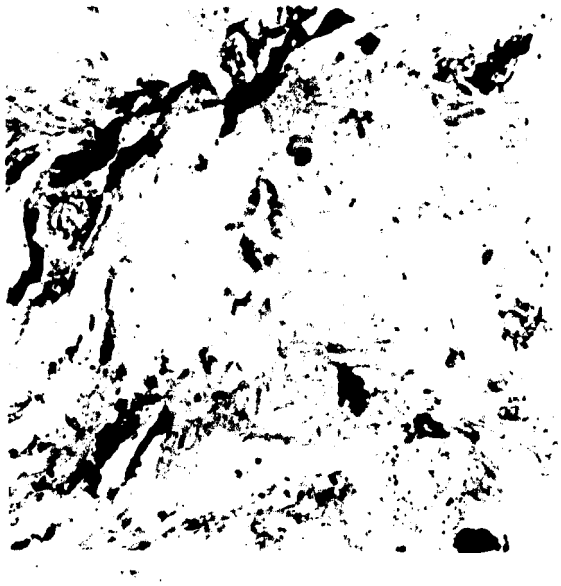


Figure 31

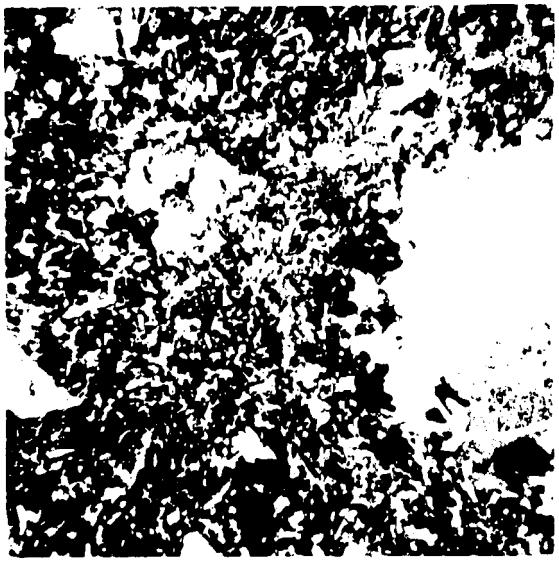


Figure 32



Figure 33



Figure 34

Figure 35 (left). Photomicrograph of diabase from outcrop number 16 (plate I). Minerals are plagioclase (clear), pigeonite (grey, moderate relief), epidote (grey, high relief), and magnetite (opaque). Nicols not crossed, X17.

Figure 36 (right). Photomicrograph of diabase from outcrop number 16 (plate I). Same as figure 35, except crossed nicols. The pyroxene (pigeonite) is optically continuous over large enough area to completely enclose the plagioclase laths. X17.

Figure 37 (left). Photomicrograph of diabase from outcrop number 16 (plate I). Same as figure 35, except greater magnification (X38). Large "blank" area is phenocryst in upper right corner of figure 35.

Figure 39 (right). Photomicrograph of quartz rock from outcrop number 21 (plate I). Very finely crystalline quartz is cut by veinlet of more coarsely crystalline quartz. These veinlets are abundant in all the sections of this rock studied. Crossed nicols, X38.

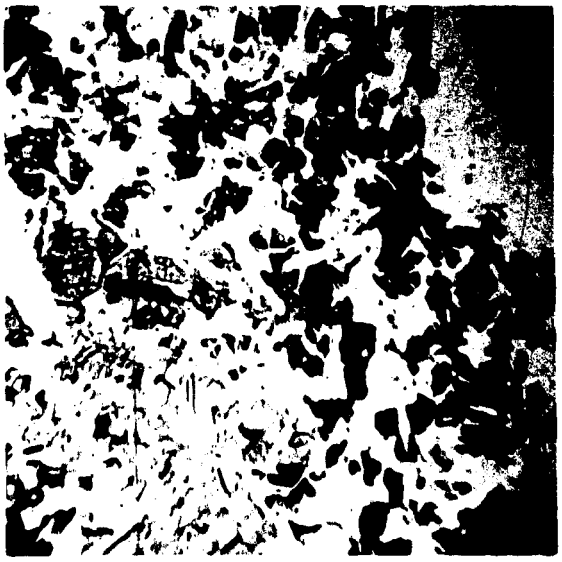


Figure 35



Figure 36



Figure 37

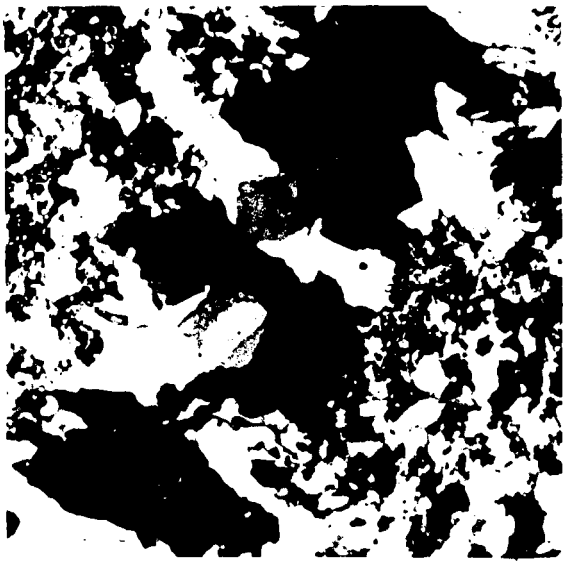


Figure 38

SURFICIAL GEOLOGY

General Statement

The surficial deposits in Oneida County consist almost entirely of glacial deposits assigned to the Cary substage of the Wisconsin glacial stage. The glacial map of Wisconsin, prepared by Thwaites (1948; F. D. Hole and G. B. Lee, 1955, p. 41), shows the end moraine of Cary age as a sinuous belt lying immediately south of Oneida County. Pre-Cary drift lies to the south of the Cary end moraine. North of Oneida County, in Iron and Vilas Counties of Wisconsin and extending into Michigan, is a less continuous end moraine related to the Valders ice advance. Between the Cary and Valders end moraines is a large area of drift interpreted as till and stratified drift resulting from deposition associated with several distinct lobes of glacial ice: the Chippewa glacier to the west of Oneida, the Wisconsin Valley lobe in western and central Oneida, and the Langlade lobe in eastern Oneida County (terminology after Weidman; 1907). The trend of the Cary end moraine, the orientation of drumlins in southeastern Oneida and adjacent counties, and the trend of glacial striae on bedrock exposures indicate that ice movement was predominantly toward the south or southwest.

Physical Nature of the Drift

As a sedimentary type, glacial deposits are commonly divided into two kinds: non-stratified drift (till) and

stratified drift. Non-stratified drift is a direct glacial deposit; stratified drift is deposited by streams associated with glaciation. These two types of glacial deposits grade into one another in many places making classification at any one location difficult if not impossible.

At each sample location an attempt was made to classify the drift as either till or stratified drift. The designation till includes all glacial deposits which lack any pronounced degree of sorting and stratification (figure 39), and stratified drift includes all glacial deposits which show definite indications of sorting or stratification (figure 40). In a few instances no classification of the kind of drift was made because of controversial evidence or because of lack of evidence. Plate II shows the nature of the drift at each sample location. Approximately 37 percent of the sample locations are in till; the fraction of the county covered by till at the surface is probably well under 50 percent.

In general, the drift at sample locations designated as till consists of non-stratified deposits of angular to subrounded particles ranging from boulders to silt or, rarely, clay. Boulder clays and clay-rich tills are uncommon in most of this area, whereas sandy or silty till with abundant larger sized material is common.

The glacial deposits at sample locations designated as stratified drift are composed of gravel and sand, showing varying degrees of sorting and perfection of stratifi-

cation (and cross-stratification). The well-sorted stratified deposits consist predominately of sandy material containing few well-rounded pebbles concentrated in thin beds or lenses; the poorly-sorted deposits are composed of coarsely bedded and crudely mixed gravel and sand. Large (ice rafted) boulders are fairly common in some of the deposits.

Weathering of the Drift

The degree and depth of weathering of drift sheets have received considerable attention in studies of glacial chronology. Consideration of the weathering of drift is also important in studies involving relationships between drift lithology and bedrock lithology. The longer a drift sheet is exposed to the processes of rock weathering, the more profound are the changes in composition of the particles making up the drift. It is certainly consistant with the principles of rock weathering to conclude that with the passage of time there will be a tendency toward relative enrichment of the more resistant components of the original drift at the expense of the less resistant components.

The drift in Oneida County is not highly weathered; actually it is noticably fresh. Oxidation of the original iron-bearing minerals in the drift has imparted reddish, brownish, and yellowish colors to much of the material, but other than this the drift presents a relatively fresh appearance. Pebbles of one-half inch diameter, the smallest

included in the drift samples, were almost all fresh enough to permit accurate identification. Some pebbles had weathering rinds visible, but ordinarily these did not penetrate through the entire pebble.

The degree of weathering of the Cary drift of Oneida County is considerably less than that of the early Wisconsin drift to the south. The early Wisconsin drift is considerably decomposed. At some locations (examined in 1958) the material of the drift consists dominantly of resistant rock types which probably survived through the complete alteration of the less resistant pebbles.

Topographic Form of the Drift

As a topographic form, glacial drift is classified as terminal and recessional moraines (end moraines), ground moraines, drumlins, outwash plains, and various smaller ice contact deposits including kames and eskers. All of these types occur in Oneida County and, with the exception of kames, are shown on plate II.

End Moraine.—The end moraine of Cary age covers much of T. 35 N., R. 9 E. (plate II). From here it extends southeastward and southwestward into Langlade and Lincoln Counties respectively (figure 46). In Lincoln and Langlade Counties the southern limit of the moraine is particularly well-defined. It stands high above adjacent ground moraine and outwash deposits, and the southern border is readily discerned as a sharp topographic break. The back side of

the moraine (the northern border) is less well-defined. On planimetric maps parts of the moraine stand out as belts pockmarked with small lakes. Deposits of the Cary end moraine in Lincoln, Langlade, and Oneida Counties consist of reddish sandy till with local patches of stratified drift.

The drift in T. 35 N., R. 9 E. (Oneida County) makes up a part of the backside of the Cary terminal moraine; the deposits are gradational into ground moraine to the northeast. In some places in the end moraine the topography is irregularly hummocky; elsewhere subparallel ridges prevail; in still other parts of the township the topography is gently undulating as is typical of ground moraine. Ground moraine and outwash lie to the north, northeast, and east of the end moraine. The part of the county in which outcrops are most numerous (plate II) lies east and northeast of the end moraine, and the contact of the end moraine probably lies just southwest of the last outcrop. Directions of ice movement (see p. 64) and the surficial distribution of the end moraine suggest that the glacial deposits in T. 35 N., R. 9 E. represent drift deposited chiefly by the Langlade lobe and that the material of the drift was derived from the northwest.

In T. 36 N., R. 7 E. there is an area of till with a minor amount of stratified drift which rises at least 70 feet above the outwash in T. 36 N., R. 6 E. The topography in this area and the high elevation suggest that here too the drift accumulated at a stationary ice front and is

likely a part of the Cary moraine.

Other smaller areas having hummocky topography and high elevation are indicated as end moraine on the glacial map. These are sporadically located with little continuity and probably represent recessional moraines of the Cary ice sheet.

Ground Moraine.—The distribution of ground moraine is shown in plate II. Most of the ground moraine consists of till, upon which sandy or silty loams, poorly drained heavy soils, and peat and muck have developed. Surface elevations on the ground moraine areas tend to be higher than on adjacent outwash deposits and lower than on adjacent end moraine. In some places the surface is well drained by streams flowing off the higher ground moraine onto outwash; in other places surface drainage is poor and lakes and swamps are abundant.

The glacial deposits in the southeastern part of the county (T's. 35, 36, and 37 N., R. 11 E.) perhaps represent ideal or typical ground moraine or till plains. The drift is thin throughout this area as evidenced by the numerous bedrock exposures. In places the topography is streamlined; swamps are elongated in the same direction; drumlins are locally abundant with their long axes trending southwest; aerial photographs show a distinct southwest lineation, due both to topography and vegetation. The drift tends to be more silty and clayey than in other parts of the county. The relief throughout the area is no more than several tens of feet and the topography is gently undulating. Large lakes

are scarce, whereas swampy ground is common.

Other areas of ground moraine occur in the central part and in the southwestern corner of the county. In many places till and stratified drift are erratically intermingled and confused and it is difficult to assign any genetic or topographic name to the deposits other than ground moraine.

Drumlins.—In the southeastern part of T. 35 N., R. 11 E. and extending into adjacent townships in Forest and Langlade Counties, there is a pronounced parallel arrangement of low, elongate hills. These show up distinctly on aerial photographs (figure 41), on drainage maps, and in the field (figure 43). The hills are straight and narrow, and of the order of a mile in length. A gravel pit on the end of one of the hills exposes both till (figure 39) and stratified drift (figure 40). The till occupies the central portion whereas the stratified drift lies on at least one flank. Glacial striae on at least three outcrops in the same township are approximately parallel with the length of the hills. Because of the form of these hills, the nature of the drift (at least partly till), the parallelism with the direction of ice movement, and the occurrence in a ground moraine area, the hills are interpreted as drumlins. Thwaites (1943) has mapped drumlins in the parts of Forest and Langlade Counties adjacent to the southeastern corner of Oneida County.

Stratified Ice-Contact Deposits.—Ice-contact deposits of stratified drift include kames and eskers. Kames, though common in Oneida County, are not shown on the glacial map.

Of the four eskers shown on the map, two were mapped in the field and the others were recognized from aerial photographs.

Near Pelican Lake, in T. 35 N., R. 11 E. (plate II), an esker extends five to six miles along a south-southwesterly trend, approximately parallel with the direction of latest ice movement in the immediate vicinity. The Pelican Lake esker averages 30 to 40 feet in height and is composed of poorly-sorted and crudely-bedded gravel. A second esker in T. 37 N., R. 4 E. (plate II) was traced for a distance of less than a mile along a southerly trend. The eskers in the eastern part of the county (T. 37 N., R. 11 E. and T. 35 N., R. 11 E. (plate II) are oriented with their long directions parallel with the local direction of ice movement. The two eskers in the western part of the county (T. 37 N., R. 4 E. and T. 36 N., R. 5 E., plate II) trend due south. This orientation is certainly suggestive that the latest direction of ice movement in the southwestern part of the county was approximately south.

Outwash.—At the surface stratified drift is more abundant than till in Oneida County. Much of the stratified drift is probably true outwash (material carried beyond the ice front) associated with melting and retreat of the Cary ice sheet. In other places masses of stratified drift are probably ice-contact deposits or coalesced ice-contact features. In some places the level surface alone suggests that the drift is outwash; in other places the surface is

irregular and it is perhaps more suggestive of a ground moraine topography.

In T. 39 N., R. 8 E. and in T. 36 N., R. 6 E. (plate II) the surface is flat and the sediment consists of well-sorted sand with relatively scarce lenses containing pebbles. In areas centering just north of the county in T. 40 N., R. 7 E. and in T. 39 N., between R. 10 and 11 E. (plate II) the surface is similarly level, but the drift consists of less well-sorted sand and silt. Except for several other small level areas the remainder of the outwash in the county is characterized by either pitted or undulating topography and less well-sorted gravels. In T. 38 N., R. 11 E. (plate II) the surface is strongly pitted with many interconnecting lakes. On the undulating outwash surface in T's 36 and 37 N., R's 5 and 6 E. (plate II) there are very few lakes; however, streams are well developed with a dendritic drainage pattern. There are few lakes on the outwash in T. 36 N., R. 10 E. (plate II), but streams having a trellis drainage pattern are well developed.

From the few known elevations in the county, from the position of stream divides, and from the general nature of the topography as noted in the field, it appears that the larger outwash areas tend to stand at a lower elevation than both ground moraine and end moraine. This is particularly noticable in the eastern part of the county where present streams tend to flow off the ground moraine onto and along the outwash deposits. The trellis drainage pattern

on the outwash in the southeastern part of the county probably developed as a result of a streamlined molding of the topography by the advancing ice sheet. As the ice melted and the ice front retreated the meltwater streams took a course par llel with the alignment of topographic features (oriented with their long dimensions trending southwest). Outwash was probably originally deposited in the form of valley trains. As the thickness of the outwash increased the valley divides were at least partially buried, permitting the valley trains to coalesce into an outwash plain. Present streams follow the same southwesterly course. As the glacial streams reached the end moraine they were blocked and forced into either a northwesterly or southeasterly path. Present streams take the northwesterly course and join the Wisconsin River south of Rhinelander.

Thickness of the Drift

As actual figures for the thickness of the drift are lacking it is necessary to present a generalized picture for the depth-to-bedrock. The abundance of outcrops in the southeastern quarter of the county indicates that the drift over most of this area is thin. Information for the remainder of the county is less definite. Widely scattered outcrops along the Wisconsin River and in other parts of the county indicate local areas of thin drift; however, much of the county outside of the southeastern quarter is covered with glacial debris probably up to several hundred feet in

thickness.

Direction of Ice Movement

The ice lobation and the directions of ice movement in Oneida County are shown in figure 46. Glacial grooves and striae are common on the outcrops in the southeastern part of the county (figures 44 and 45). These show a consistent orientation in a southwesterly direction (plate II). Towards the west, the direction progressively changes to a more westerly trend. The direction indicated by the glacial striae in the southeastern part of the county is in close agreement with the orientation of drumlins and eskers (T's. 35 and 37 N., R. 11 E.) and with the general preferred orientation of the streams. An outcrop in T. 38 N., R. 9 E. shows striae with the same general orientation; but no glacial striae were found on the widely scattered outcrops over the remainder of the county. However, a tendency towards preferred orientation of the streams over much of the remainder of the county, eskers in T. 37 N., R. 4 E. and T. 36 N., R. 5 E., and the trend of the end moraine indicate that ice moved almost due south over the central and western parts of the county. This is consistent with the ice lobation as described by Weidman (1907), as pictured from the glacial map of Wisconsin, and as indicated on the glacial map of the United States East of the Rocky Mountains (1959). The western and central parts of the county were covered by the Wisconsin Valley lobe in which

the general direction of ice movement was south. The eastern part of the county was covered by the Langlade lobe in which the ice moved along a southwesterly course. Till and stratified ice contact deposits in the vicinity of the line dividing R. 8 E. from R. 9 E. in Oneida County are probably of interlobate origin.

Figure 39. Till in T. 35 N., R. 12 E., extreme southwestern part of Forest County, Wisconsin. Location is on the southwest end of the drumlin shown in figure 43.

Figure 40. Stratified drift in T. 35 N., R. 12 E., extreme southwestern part of Forest County, Wisconsin. Location is on the southwest end of the drumlin shown in figure 43.

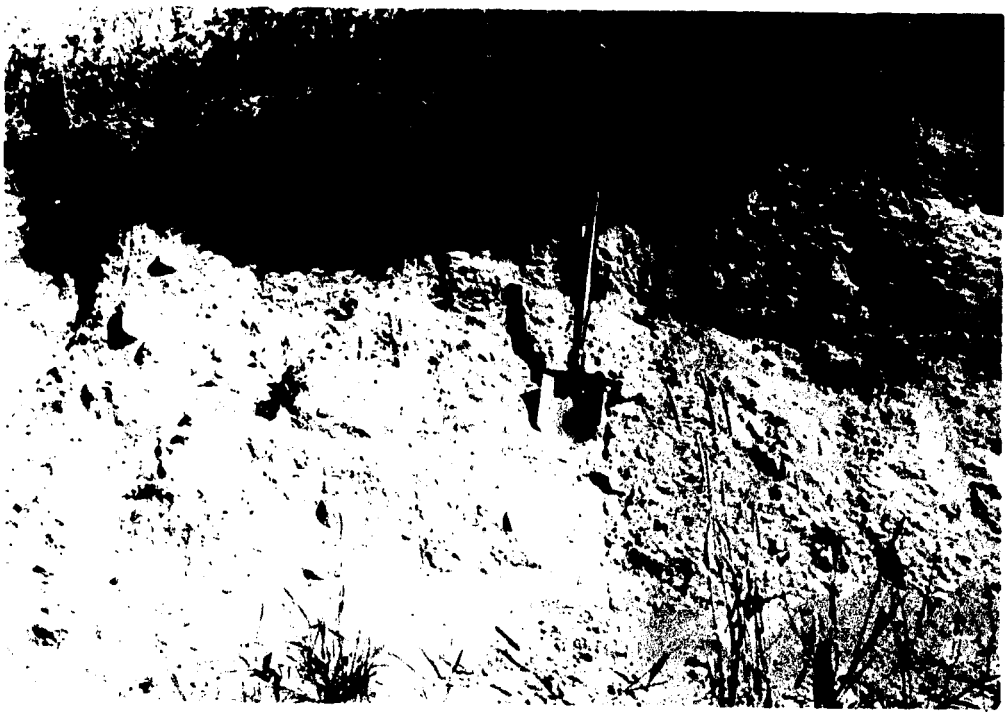


Figure 39



Figure 40

Figure 41. Aerial photograph showing streamlined topography in T. 35 N., R. 11 E., Oneida County, Wisconsin. North is indicated by the arrow; the scale is approximately 2¼ inches equals one mile; the corners of sections 13 and 24 are shown by crosses. The streamlining (streaked appearance) is caused by very low, elongate hills composed predominantly of till. This area is part of the drumlin field of the southeastern corner of Oneida County and adjacent counties. The photograph is by the U. S. Department of Agriculture.

Figure 42. Aerial photograph showing esker in T. 36 N., R. 5 E., sec. 24, Oneida County, Wisconsin. North is indicated by the arrow; the scale is approximately 2½ inches equals one mile; the southwest corner of section 24 is shown by a cross. The esker, trending approximately south, is located in the eastern half of the photograph. The photograph is by the U. S. Department of Agriculture.



Figure 41

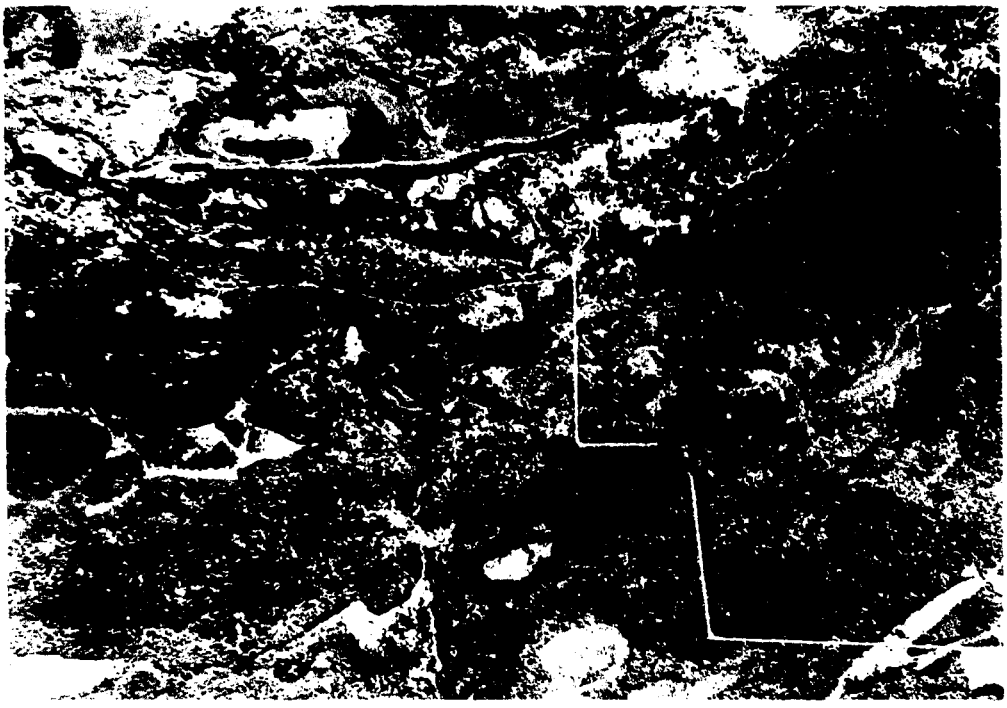


Figure 42

Figure 43. Drumlin in T. 35 N., R. 12 E., extreme southwestern part of Forest County, Wisconsin. Northeast is to the right. The gravel pit on the southwest end of the drumlin is the location of figures 39 and 40, showing the nature of the drift.

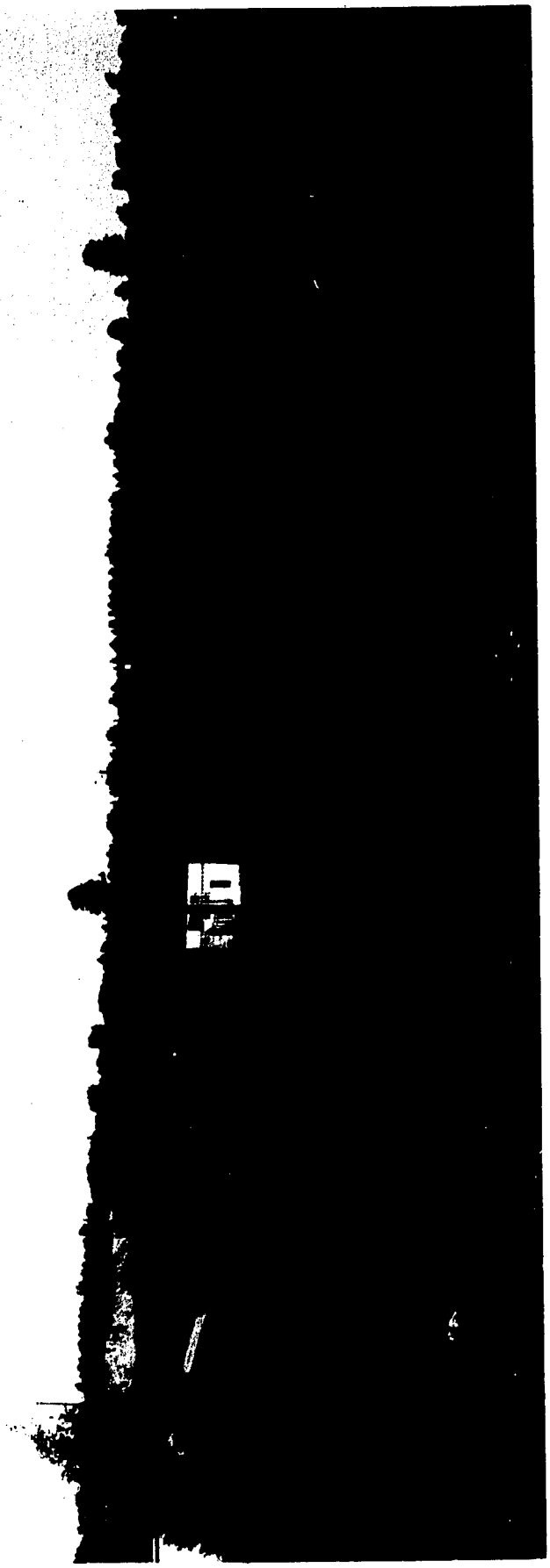


Figure 43

Figure 44. Outcrop of gneiss (number 11) in T. 36 N., R. 11 E., sec. 4, Oneida County, Wisconsin, showing well developed glacial striae. These striae trend S. 48 W. (lower right to upper left). The coarse and irregular foliation of the granite gneiss strikes N. 73 W.

Figure 45. Outcrop of greenstone (number 13) in T. 36 N., R. 11 E., sec. 29, Oneida County, Wisconsin, showing well developed glacial groove with parallel glacial striae trending S. 47 W.

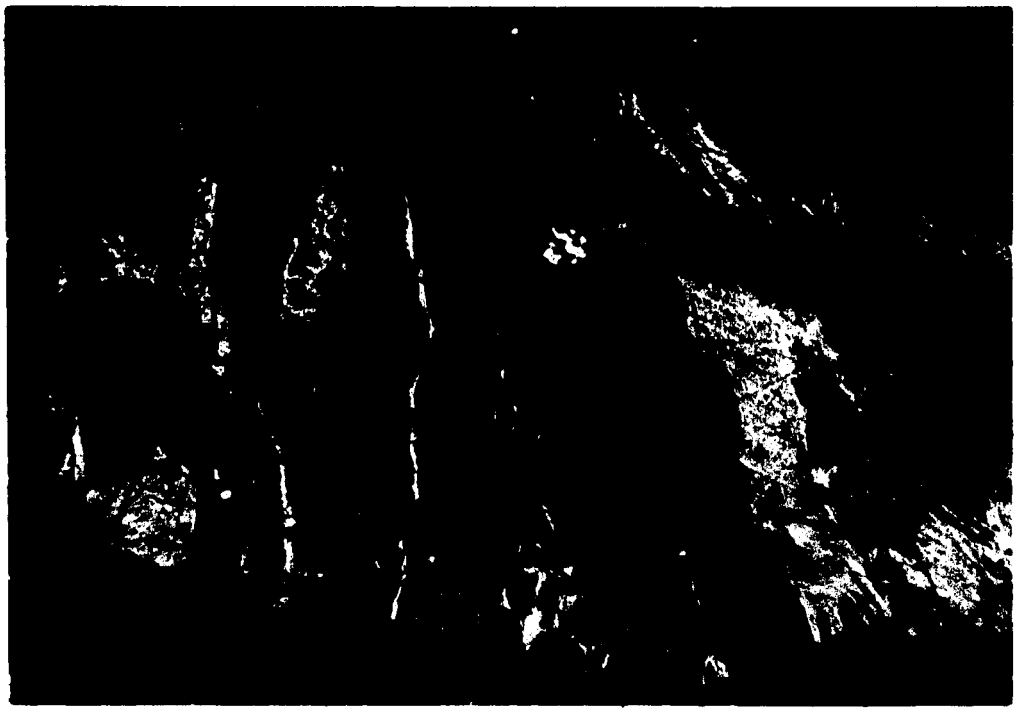


Figure 44

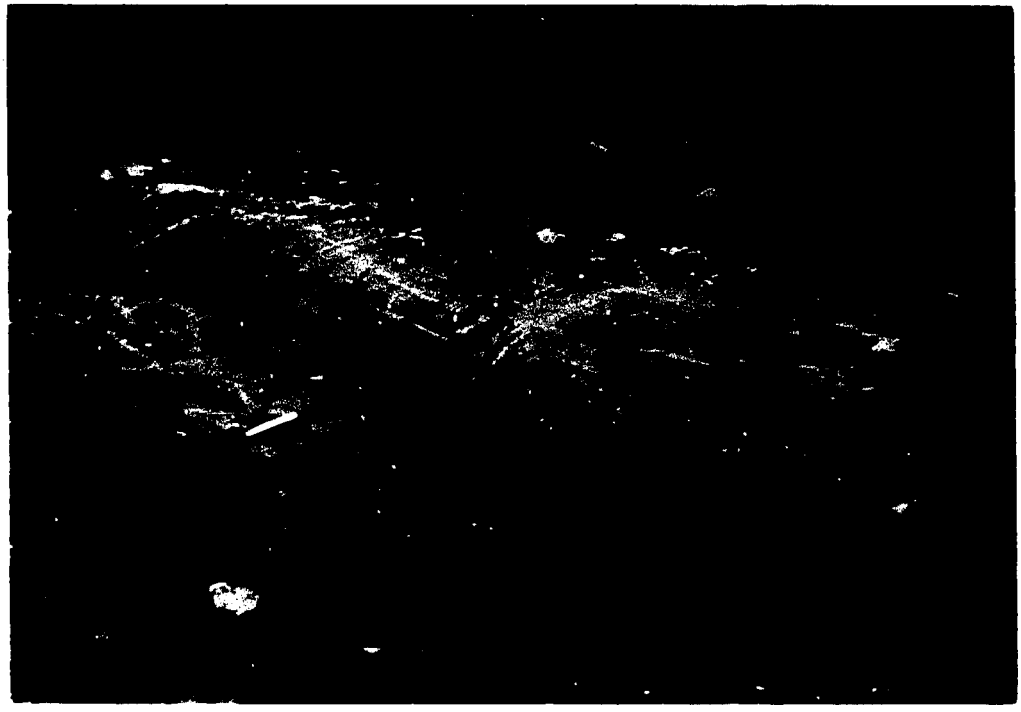


Figure 45

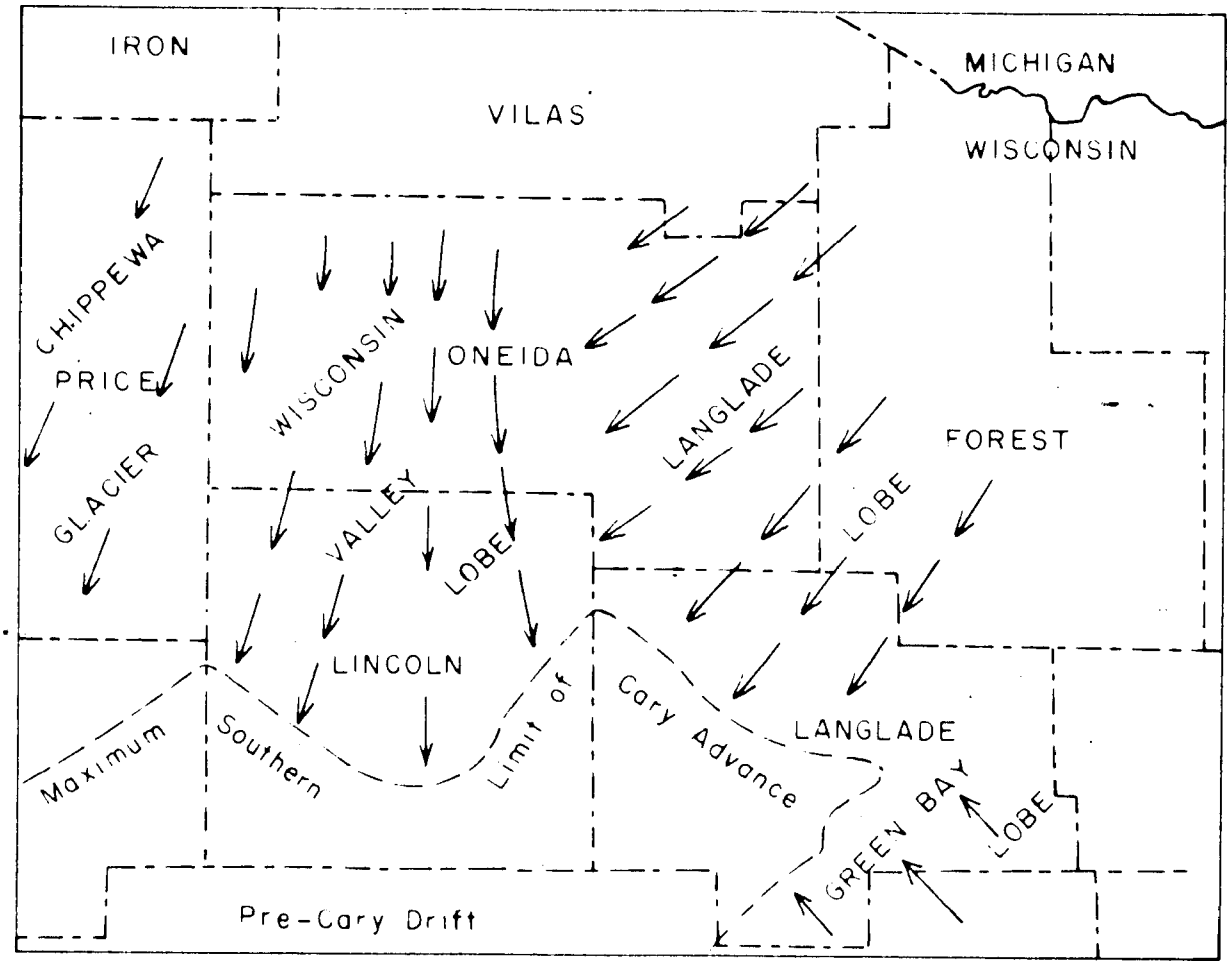


Figure 46. Map of Oneida and adjacent counties, Wisconsin, showing approximate location of maximum southern limit of the Cary ice advance, location of the ice lobes, and the general directions of ice movement. Terminology for the ice lobes is after Weidman (1907).

TREATMENT OF THE PEBBLE-COUNTS - STATISTICAL ANALYSIS

Isopleth Maps

A total of 327 samples were collected, each consisting of approximately 100 pebbles. The pebbles from each sample were washed, cracked, and identified by hand lens, and the results have been tabulated in appendix I.

In order to analyse and interpret the lithologic composition of the glacial deposits, drift isopleth maps were constructed for each of the dominant or important rock types or groups of rock types. The isopleths connect those points on the map having approximately the same percentage of a given rock type in the drift, and thus outline areas which are abnormally high or abnormally low in a given lithologic constituent of the drift.

Significant Groups of Pebble Types

The nature of some of the outcrops in the area, the nature of the drift pebbles, and general petrogenetic concepts indicate that some of the pebble types which were originally classified separately in the pebble-counts should be grouped together for purposes of studying drift composition in relation to bedrock. For example, several of the granite and quartz diorite outcrops show local, strongly-gneissic phases, and these outcrops would obviously produce pebbles of both granite and gneiss. For this reason the counts of granite and acid gneiss are

combined in constructing the isopleth maps. Other pebble types were grouped in a similar manner before constructing the drift isopleth maps.

The following groupings of pebble types were recognized: granite and gneiss; gabbro, basalt, and porphyry; slate, schist, greywacke, quartzite, non-Paleozoic chert, and iron formation. Isopleth maps showing the distribution of each of these groups will be discussed in a later section.

Reliability of the Samples

In order to evaluate the significance of differences in pebble-counts from sample to sample, it is necessary to have some idea of the reliability of the pebble-counts. A theoretical measure of the reliability can be given by establishing confidence limits (or confidence intervals), which give the range of values which will surround the true value in a specified percentage of the cases. For example, if a sample of 100 pebbles taken from a gravel pit contains 40 pebbles of granite, then, by standard statistical procedures, 90 percent confidence limits are 32 and 48 percent. The significance of this statement is that 90 percent of the time the range 32 to 48 percent will catch the exact percentage of granite pebbles in the entire gravel pit.

The graph in figure 47 shows 90 percent confidence limits for samples of size 100, for pebble-counts of one

to 50 percent of any given rock type. Points on the curve have ordinates equal to any given pebble-count from one to 50 percent, and have abscissae equal to the corresponding confidence limits. The curve indicates that 90 percent of the time a pebble-count of 20 percent granite will have a true value of 20 ± 7 percent, or between 13 and 27 percent.

The confidence limits established in the graph of figure 47 are based on the assumption that the pebbles in the sample are chosen at random --- that every pebble in the gravel pit had an equal chance of appearing in the sample. Furthermore, in the statistical procedure involved in establishing these confidence limits, it is assumed that

$$\sqrt{p(1-p)/N} = \sqrt{\bar{X}(1-\bar{X})/N}$$

where $\bar{X}$ is the proportion of a given pebble type as determined from a sample, p is the true porportion of the given pebble type in the entire population of pebbles, and N is the number of pebbles in the sample.

As a partial check on the extent to which these assumptions are justified, additional samples were taken at several different locations. Table 1 shows the pebble-counts and statistical treatment of 10 samples taken from stratified drift of a single gravel pit. The samples were collected at random locations over a vertical extent of about 30 feet and a horizontal extent of about 300 feet. Selected pebble-counts and corresponding 90 percent confidence intervals are tabulated in column A for each of the ten samples. In column B, the mean pebble-count for each pebble group is

given. This figure represents the percentage of the particular pebble type in a random sample of size 1000 and is, of course, a much better estimate of the true percentage of the particular pebble type in the gravel pit than are counts of any of the individual samples of size 100. Column C gives the percent of individual samples (of size 100) having confidence intervals which include the mean percent in column B. If the assumptions involved in establishing the theoretical 90 percent confidence intervals are valid, and if the mean percent of a particular pebble type determined from the ten samples is close to the actual percent of that pebble type in the gravel pit, then, on the average, the figures given in column C should equal approximately 90 percent. The same treatment is shown in table 2 for five samples taken from a single sample location. Table 3 shows similar data for three samples taken from a single sample location. As the average of the figures in column C of tables 1, 2, and 3 is close to 90 percent (83 percent), it is evident that in these cases the assumptions used to establish the confidence intervals are probably valid. Table 5 shows pebble-counts for four pairs of samples, each pair from a single location. Since the combined sample for each of these pairs consists of only 200 pebbles it is doubtful if these should be treated in the same manner as the samples consisting of (combined) 1000, 500, and 300 pebbles which were just discussed. However, the close agreement of the counts within each sample-pair

is worth recording. It is now established that the confidence limits which are shown in the graph of figure 47 are useful measures of the reliability of the individual samples. These confidence limits will be used in (a) justifying the isopleth intervals used on the maps showing the distribution of the various constituents of the glacial drift, and (b) in determining, for a given pebble-count, the minimum percent which can be considered as abnormally high.

Isopleth Intervals

In order for drift isopleth lines to have real significance, the interval between two isopleths must be greater than one-half the upper-minus-the-lower confidence limits for the value of the higher of the two isopleth lines. For example, a line connecting points of 35 percent granite has a 90 percent confidence interval of 27 to 43 percent. Obviously an isopleth interval of 5 percent, which would require a 40 percent isopleth, would have no real significance. An interval of 10 percent would be significant (at least 90 percent of the time) because it would require a 45 percent isopleth, which is above the range 27 to 43 percent, a range which represents the reliability of samples found to contain 35 percent of a given rock type.

Inspection of the graph of figure 47, shows that this graph can also be used to determine the minimum isopleth interval useful in constructing an isopleth map which is

to outline significant differences in the lithologic composition of the drift. In order to use the graph in this manner, the units on the horizontal axis, Y ± 2, Y ± 4, etcetra, must be changed to read 2, 4, etcetra. If the pebble type under consideration generally constitutes from 20 to 40 percent of the drift, then the minimum isopleth interval should be about 7 percent.

In general this reasoning has been followed in determining what isopleth interval to use for the various drift isopleth maps. The intervals used are given with other data in table 5.

Background Counts and Recognition of Anomalies

Recognition of abnormally high counts for various pebble groups requires establishment of background counts. Assuming that glacial drift is composed of locally derived material, the background count for each pebble type would be equal to the average count if there were no local source area for the pebbles. However, information from bedrock exposures indicates that there is a local source (within the county) for all of the pebble groups used on the isopleth maps. It follows, then, that the background count for each pebble group should be something less than the average count. For each of the pebble groups a convenient figure which is appropriately lower than the average has been selected as a background count. Combined granite and gneiss averages about 31 percent in all samples and the

background count has been selected as 25 percent.

Anomalous highs are determined from the background count and its associated upper 90 percent confidence limit. A count of 25 percent (the background for granite) has 90 percent confidence limits of 18 and 32. Adjacent samples consistantly above 32 percent should be considered as abnormally high. Thus the areas enclosed by the 35 percent isopleth for granite (plate III) are abnormally high in the percentage of granite pebbles contained in the drift.

Isopleth intervals, approximate average pebble-counts, background counts, and minimum abnormally high counts are given in table 5 for each of the pebble groups which are shown in the isopleth maps.

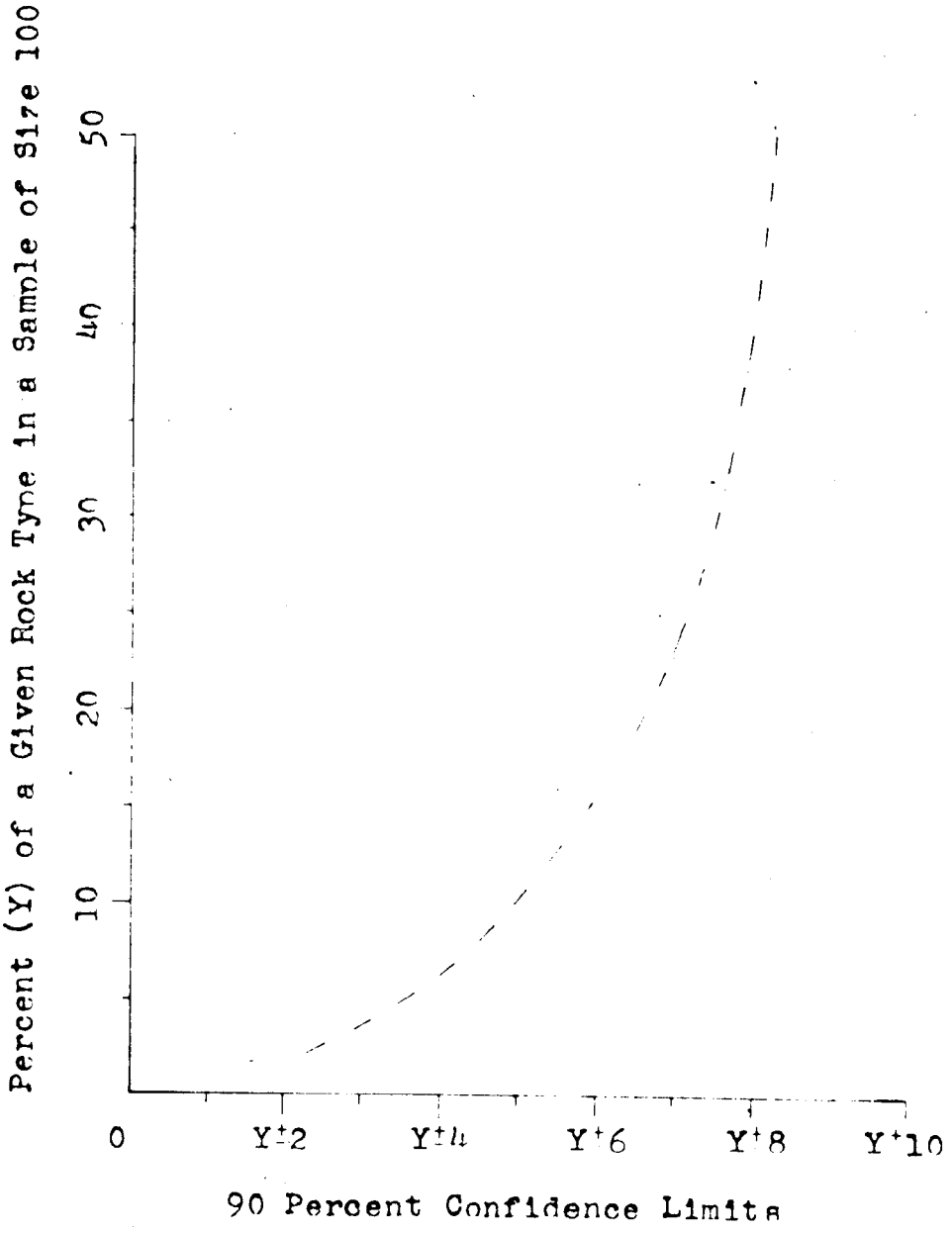


Figure 47. Graph showing confidence limits (intervals) for samples of size 100. Statistical procedures involved assume that:

$$\sqrt{p(1-p)/N} = \sqrt{\bar{X}(1-\bar{X})/N}$$

where $\bar{X}$ is the proportion of a given pebble type as determined from a sample, p is the true proportion of the given pebble type in the entire population of pebbles, and N is the number of pebbles in the sample.

Pebble Group		A Individual Samples of Size N = 100										B Combined Sample of Size N = 1000 (in percent)	C Percent of Samples Having Confidence Limits Which Include Percent of Combined Sample
		a	b	c	d	e	f	g	h	i	j		
Granite and Acid Gneiss	Pebble Count	26	22	41	35	42	37	30	32	36	35	33.4	70
	90 Percent Confidence Limits	18.8 33.2	15.1 28.9	33.0 49.0	27.2 42.8	33.9 50.1	29.1 44.9	22.5 37.5	24.4 39.6	28.2 43.8	27.2 42.8		
Porphyry Gabbro and Basalt	Pebble Count	34	42	23	27	22	27	22	28	35	33	29.3	70
	90 Percent Confidence Limits	26.3 41.7	33.9 50.1	16.1 29.9	19.7 34.3	15.1 28.9	19.7 34.3	15.1 28.9	20.6 30.4	27.2 42.8	25.3 40.7		
Sedimentary and Meta-Sedimentary Rocks	Pebble Count	29	25	22	24	19	23	32	32	22	22	14.9	100
	90 Percent Confidence Limits	21.5 36.5	17.9 32.1	15.1 28.9	16.9 31.1	12.5 25.5	16.1 29.9	24.4 39.6	24.4 39.6	15.1 28.9	15.1 28.9		

Table 1. Pebble-counts and statistical summary for ten samples taken from stratified drift at location 247 (plate I).

Pebble Group		A. Individual Samples of Size N=100										B Combined Sample of Size N=500 (in percent)	C Percent of Samples Having Confidence Limits Which Include Percent of Combined Sample
		a	b	c	d	e	f	g	h	i	j		
Granite and Acid Gneiss	Pebble Count	29	30	28	32	20						27.8	80
	90 Percent Confidence Limits	21.5 36.5	22.5 37.5	20.6 30.4	25.4 39.6	13.4 26.6							
Porphyry Gabbro and Basalt	Pebble Count	46	36	46	38	38						40.8	100
	90 Percent Confidence Limits	37.8 54.2	28.2 43.8	37.8 54.2	30.1 45.9	30.1 45.9							
Sedimentary and Meta-Sedimentary Rocks	Pebble Count	16	17	9	9	19						14.0	60
	90 Percent Confidence Limits	9.9 22.1	10.8 23.3	4.2 13.8	4.2 13.8	12.5 25.5							

Table 2. Pebble-counts and statistical summary for five samples taken from stratified drift at location 263 (plate I).

Pebble Group		A. Individual Samples of Size N=100										B Combined Sample of Size N=300 (in percent)	C Percent of Samples Having Confidence Limits Which Include Percent of Combined Sample
		a	b	c	d	e	f	g	h	i	j		
Granite and Acid Gneiss	Pebble Count	33	38	27								32.7	100
	90 Percent Confidence Limits	25.3 40.7	30.1 45.9	19.7 34.3									
Porphyry Gabbro and Basalt	Pebble Count	26	24	30								26.7	100
	90 Percent Confidence Limits	18.8 33.2	16.9 31.1	22.5 37.5									
Sedimentary and Meta-Sedimentary Rocks	Pebble Count	15	29	30								24.7	67
	90 Percent Confidence Limits	9.1 20.9	21.5 36.5	22.5 37.5									

Table 3. Pebble-counts and statistical summary for three samples taken from stratified drift at location 95 (plate I).

Pairs of Samples	Granite and Acid Gneiss	Gabbro Basalt and Porphyry	Sedimentary and Meta-sedimentary Rocks
61	21	32	30
61 a	15	36	29
156	16	34	36
LIN-3	14	39	37
158 *	18	39	36
LIN-2	13	46	34
159	43	28	18
LIN-1	35	26	29

Table 4. Pebble-counts for four pairs of samples taken from till and stratified drift. Samples 61, 156, and 159 are from locations in stratified drift; sample 158 is from a location in till. The second samples for each of these locations were collected and counted in 1958, whereas the originals were done in 1957. The asterisk indicates that 12 pebbles in the sample were originally classified with the schists, but are here included with the gabbro-basalt-porphyry group, with which they were closely affiliated.

Pebble Group	Isopleth Interval	Approximate Average Pebble Count	Background Count	Minimum Anomalous High
Granite and Gneiss	10	31	25	35
Porphyry Gabbro and Basalt	10	32	25	35
Sedimentary and Metasedimentary Rocks	8	20	18	26

Table 5. Isopleth intervals, approximate average pebble-counts, background counts, and minimum anomalous highs. Data are shown for each of the pebble-groups used in the isopleth maps.

LITHOLOGIC COMPOSITION OF THE DRIFT

Distribution of Combined Granite and Gneiss

The classification "granite" here includes pebbles of all phaneritic igneous rocks which contain readily visible quartz. Thus the quartz diorites, described under DESCRIPTIONS OF OUTCROPS, are classed as granite. Since many of the granite and quartz diorite outcrops are locally gneissic, pebbles of acid gneisses (always a minor percentage) are included on the isopleth map of the granites. The average amount of combined granite and gneiss in the drift of the map area is 31 percent. The distribution of these rock types is shown in plate III by drift isopleths drawn at an interval of 10 percent from 25 to 45 percent. As indicated in the previous section, 25 percent is considered a background count and 35 percent is considered as abnormally high or as an anomaly.

Relation to Drift Types.—Comparison of the drift isopleth map for combined granite and gneiss (plate III) with the glacial map (plate II) shows that there is no consistent relationship between the type of drift which yielded the sample (till or stratified drift, ground moraine or outwash) and the areas in which the drift is abnormally high in granite. Therefore, the areas which are abnormally high in granite reflect some cause other than purely the mechanics of redistribution of material by glacial ice and glacial meltwater.

Inferred Relation to Bedrock Lithology.—The locations

of the granite outcrops with respect to the locations of granite-high drift areas demonstrate the close relationship between the character of the bedrock and the lithology of drift. Outcrop areas of other rock types are less common, and for this reason the other drift isopleth maps are not as useful in demonstrating the local origin of the glacial deposits. These maps are, nevertheless, useful in approximating the nature of the bedrock concealed by the drift. Accordingly, the following discussion of the drift isopleth map for combined granite and gneiss emphasizes the relationship of drift lithology to bedrock lithology.

In the southeastern part of T. 38 N., R. 11 E. there is a group of small outcrops of microcline granite and mixed gneisses which extend several miles eastward into Forest County. Where the bedrock is gneissic, the strike of the foliation is approximately east or slightly north of east. In the immediate vicinity of these outcrops, the average percentage of granite in five drift samples is 27 percent. South of the outcrops, in T. 37 N., R. 11 E., lies a granite-high pebble belt outlined by the 35 percent isopleth, which encloses samples having an average granite pebble-count of 39 percent, and a maximum granite pebble-count of 47 percent. The isopleths which outline this anomalous area have an easterly trend, similar to the strike of the foliation of the gneissic granites to the north. The crest of the granite-high pebble belt lies within

four miles down-glacier of the central part of the outcrop area, suggesting that a large part of the material in the drift was transported approximately four miles from its source.

In the southern part of T. 37 N., R. 11 E. there is an area of outcrops of locally gneissic quartz diorite and microcline granite. The gneissic foliation trends north of west. The same rock types crop out in the northwestern part of T. 37 N., R. 10 E., in the east-central part of T. 37 N., R. 9 E. and in the northwest corner of T. 36 N., R. 9 E. Wherever the bedrock is gneissic, the foliation strikes approximately east to southeast, suggesting that the quartz diorite-microcline granite exposures may be more or less continuous between these scattered outcrop areas. The ice movement across this general area was approximately S. 50 W. In this direction, southwest from the outcrops, there is a granite-high pebble belt outlined by the 35 percent isopleth which trends in the same general direction as the gneissic structure of the "granite" zone to the north. Where the direction of ice movement is well known, the crest of the granite-high pebble belt lies approximately four miles down-glacier from the central part of the outcrop area. The continuity of the granite-high pebble belt strongly suggests that the separated outcrops of quartz diorite and microcline granite do in fact form a more or less continuous belt.

Along an easterly trend through the central parts of

T. 36 N., R's. 10 and 11 E. there are outcrops of mixed acidic, granitoid, igneous rocks, which in many places are in contact with greenstones and fine-grained basic to intermediate extrusive rocks. These outcrops lie within a granite-high pebble belt which is delimited by the 35 percent isopleth. The many outcrops of this area indicate that the drift is thin throughout, and as a result the bulk of the material transported from the "granite" outcrops has moved only a short distance. This short distance of travel for the material of the mixed granite outcrop area, with added granitic material from the quartz diorite-microcline granite outcrops to the north, has produced here a drift belt which is exceptionally high in granite. Many samples within this belt contain above 35 percent granite and some are above 55 percent.

In the southeastern part of the county, T. 35 N., R. 11 E., there is a group of bedrock exposures of microcline granite. The outcrops are nearly enclosed by the 35 percent drift isopleth for granite. It seems evident that in this area of very thin drift the distance of glacial transport has been slight.

Perhaps the most striking part of the map showing the distribution of combined granite and gneiss in the drift is the large area in the central part of the county enclosed by a 35 percent drift isopleth. A 45 percent isopleth within this area outlines exceptionally high pebble-counts averaging about 58 percent combined granite and gneiss.

The few outcrops of the area are granite or gneissic granite, those in the northern part being microcline granite. Because this granite-high drift bears no apparent relationship to the type of glacial deposit, because there are exposures of granite at isolated points within the area, and because of the exceptionally high pebble-counts for granite (up to 89 percent), it is believed that the drift of this area is derived from a single body of batholithic proportions composed almost entirely of granite, probably of several types.

With respect to this large granite-high area it is believed that the granite in the drift is only slightly displaced from its original position. This follows not only from the presence of granite outcrops within the area, but also from the spacing of the isopleths with respect to the direction of ice movement. On the upglacier side (the north and northeast) of the granite-drift area, the isopleth lines are closely spaced (a steep gradient, consistently about 40 percent in less than two miles); on the downglacier side the gradient is not so steep. It is very unlikely that these conditions would exist if the granite pebbles were derived from a distant source. Abrupt differences in the lithologic composition of the drift, especially of large magnitude, as are present here, should be expected where the pebbles are from a near-by source.

Two small depression isopleths occurring in the northern part of the central granite-high area suggest the presence of relatively small areas of different rock types

completely enclosed by the granite. Toward the southeast the granite-high area is roughly continuous with two of the granite-high areas previously described. Pebble counts from samples taken in Lincoln County (not shown on the map) demonstrate that the central granite-high area is cut off by the 35 percent isopleth in T. 35 N., R. 8 E. (Lincoln County).

Summary.—Granitoid, acid igneous rocks, and their gneissic equivalents, constitute about 31 percent of the material of the glacial drift in Oneida County. There is no apparent relationship between the distribution of the drift-granite and the type of deposit sampled (till or stratified drift). Areas within the county in which the drift contains consistently more than 35 percent granite are considered as anomalous, and it is believed that such areas lie but a few miles down glacier from granitic source rock.

The trends of the drift isopleths, outlining areas which are anomalously high in granite, are believed to show a distorted picture of the trends of bedrock contacts between granite and other rock types. This distortion results from irregularities of the glacial processes. Local variations in the direction or velocity of ice movement would probably be a major factor causing this distortion. These local variations are probably largely due to the effects of topography in channeling the ice. Thus the minor irregularities in the trends of the isopleths are

probably partly the result of irregularities of ice flow, but the generalized trends of the isopleths are believed to approximate the trends of the contacts of granite bedrock.

It is concluded that a large area in the east-central part of the county is underlain dominantly by "granites" and "granite gneisses" of at least two distinct types, the younger microcline granite and the older quartz diorite (and gneissic phases of both), and that either or both of these are of batholithic dimensions. The extreme southeastern part of the county is underlain by small granitic bodies which likely are continuous at depth with the larger "granite" masses. With minor exceptions (particularly in parts of T. 36 N., R's 5, 6 and 7 E.) the drift in the western and northeastern parts of the county is low in granite; these parts of the county are probably underlain mainly by other rock types.

Distribution of Combined Gabbro, Basalt, and Porphyry.

Rock Types.—The classification "gabbro" here includes fine-, medium-, and coarse-grained igneous rocks composed essentially of plagioclase and pyroxene or amphibole, with no quartz. In most places the pebbles of gabbro are fine-grained, representing the extrusive or hypabyssal enviroment. The classification "basalt" here includes all aphanitic, dark-colored, igneous rocks composed essentially of feldspars and ferromagnisian minerals with no visible quartz.

The classification "porphyry" here includes all aphanitic, porphyritic, acid and intermediate, igneous rocks; these range from rhyolite porphyry, containing quartz and feldspar phenocrysts, mostly reddish to purple in color, through andesite porphyry. Some of the pebbles of the fine-grained gabbro and basalt are partially altered to "greenstone"; others are quite fresh and show distinct ophitic texture, similar to that described for the diabase.

It is evident that the gabbro-basalt-porphyry group consists of rather heterogeneous rock types; yet study of outcrops in the area indicates that most of the pebbles falling into this diversified group represent two geologic units: (1) the older extrusive igneous rocks (including greenstones) such as are exposed in the vicinity of Monico, and (2) the younger diabases and gabbroic rocks as represented by the few exposures of diabase dikes intruding microcline granite, quartz diorite, and the older volcanic rocks.

Inferred Relation to Bedrock Lithology.—The average amount of combined gabbro, basalt and porphyry in the drift is 32 percent. The distribution of these rock types is shown in plate IV by drift isopleths drawn at an interval of 10 percent from 25 to 45 percent. Areas above 35 percent are considered anomalously high. This pebble group is nearly a complement to the granite pebble group; where granite is high, gabbro-basalt-porphyry pebble-counts are ordinarily low, and vice versa. The most noticable feature

of the drift isopleth map for gabbro-basalt-porphyry is the high zone which nearly surrounds the granite-high drift zone in the central part of the county. Gabbro-basalt-porphyry pebble-counts are exceptionally high in much of the western part of the county where the granite counts are mostly low.

Outcrops of rock types which could yield pebbles belonging to the group under consideration are restricted to three areas or locations in the county: in the vicinity of Monico, in T. 36 N., R's 9, 10, and 11 E.; in T. 38 N., R. 5 E.; and in the town of Rhinelander (northwest corner of T. 36 N., R. 9 E.).

In the vicinity of Monico there is a belt of bedrock exposures of partially altered and metamorphosed, intermediate to basic, extrusive igneous rocks bounded on the north by quartz diorite and microcline granite and on the southeast by microcline granite. The belt of outcrops, the platy flow structures, wherever discernable, and a magnetic anomaly in this general area all trend east. Adjacent to the southwest side of this belt of outcrops, and on the downglacier side, is a zone of drift outlined by 35 percent isopleth for combined gabbro-basalt-porphyry which has an easterly trend for a distance of about 10 miles before bending sharply southwest. The part of the gabbro-basalt-porphyry pebble zone which trends east is probably made up of pebbles derived chiefly from the adjacent outcrop area, and the southwest trending part of the same pebble zone

probably takes its form from that of an unexposed continuation of the bedrock. In this area of thin drift the bulk of the material in the drift was transported only a short distance from its source, perhaps one or two miles.

A slightly porphyritic basalt crops out in the northern part of T. 38 N., R. 5 E. Pebble counts for combined gabbro, basalt and porphyry are very high in the general area of this outcrop, the outcrop itself lying between the 35 and 45 percent isopleths. Although it is fairly certain that the high pebble-counts correspond with local bedrock of a similar character, the scarcity of outcrops precludes any reasonable estimation of the amount of displacement of the drift pebbles from their source.

In this same area the drift isopleths have a northeasterly trend approximately parallel with the trend of mild magnetic anomalies, reported by Hotchkiss (1915, pp. 219, 242, and 244). Hotchkiss concluded that probably most of the abnormal magnetic attractions in the northwestern part of Oneida County are due to Huronian greenstones. The high percentages of gabbro, basalt, and porphyry in the drift in this area strengthen the case for "greenstones" as a cause of the magnetic anomaly.

The diabase dike exposed in the town of Rhinelander does not appreciably influence the composition of the drift in the immediate vicinity. The diabase itself is a small body of rock occurring within a large outcrop of quartz diorite and microcline granite. From the bedrock exposures

alone, it appears that the diabase represents only a very minor part of the bedrock in a large mass of granitoid, acid igneous rocks. The paucity of gabbro-basalt-porphyry pebbles in the drift certainly supports this contention.

Summary.—Pebbles of intermediate to basic, aphanitic and fine-grained phaneritic, igneous rocks ranging from diabasic to porphyritic to equigranular in texture, and felsitic porphyries (generally a minor fraction) constitute approximately 32 percent of the coarser material of the glacial deposits in Oneida County. There is no apparent relationship between the distribution of these rock types in the drift and the type of material which yielded the sample. Areas in which these pebble types are abnormally high are believed to lie but a short distance (one to four miles in most places) downglacier from a source area. The trends of the drift isopleths, outlining areas which are anomalously high in gabbro, basalt, and porphyry, are believed to show a distorted picture of the trends of bedrock contacts between gabbro-basalt-porphyry and other rock types. Where magnetic anomalies are known to exist their trend is approximately parallel with the drift isopleths. At least some of these magnetic anomalies are probably caused by bedrock of magnetic gabbro or basalt.

From the distribution of drift pebbles of gabbro, basalt, and porphyry it is concluded that the bedrock in much of the western part of the county consists of these rock types.

The inferred area of granite in the central part of the county is probably nearly surrounded by bedrock of the gabbro-basalt-porphyry group. Other occurrences of similar bedrock are probably present in the extreme northeastern part of the county and are known to exist at least locally in the vicinity of Monico in the southeastern part of the county.

Distribution of Sedimentary and Metasedimentary Rocks

General Statement.—Pebbles of sedimentary rocks of several different ages are found in the glacial deposits of Oneida County. The pebbles can be grouped as derived from lower Paleozoic rocks, Cambrian and late Precambrian sandstones, and probable Huronian- (Animikie-; James, 1958, p.33) type rocks. Fossiliferous limestones (including a single pebble of horn coral) and fossiliferous cherts constitute only slightly more than one tenth of one percent of the coarser fraction of the drift. These pebbles were undoubtedly derived from a distant source of carbonate and cherty carbonate rocks of lower Paleozoic age. Sandstone pebbles of various descriptions constitute several percent of the drift. These were probably derived from outliers of Cambrian or late Precambrian rocks within areas of older Precambrian rocks. Because of the low percentages of sandstones and fossiliferous rocks it is not practical to represent these pebble types on the isopleth maps. Pebbles which are believed to have been derived dominantly

from rocks of Huronian age constitute approximately 20 percent of the coarser fraction of the drift. Included within this group are all sedimentary and metasedimentary rocks except fossiliferous cherts and limestones and the sandstones. The principle rock types are pelitic sedimentary and metasedimentary rocks, quartzite, greywacke, chert, and iron formation.

Rock Types.—Shales and slates are not common as pebble types in this county; however, a wide variety of schists are fairly common. The most distinctive and common pebble type classified as schist is a poorly foliated, fine-grained, greenish grey rock with distinctive limonite spots in some pebbles. These grey schists may be argillaceous sedimentary rocks which have been metamorphosed under low grade conditions. Less abundant than the grey schists are biotite schists, amphibole schists, and quartzose schists.

Pebbles included in the classification "quartzite" range from silica-cemented sandstone to a thoroughly recrystallized, vitreous quartzite. In some of the quartzose pebbles it is difficult to distinguish between vein quartz and quartzite; such pebbles were classified as vein quartz unless definite signs of clastic origin were visible. Pebbles of ferruginous (hematitic) quartzite and ferruginous greywacke-quartzite were identified in some of the samples.

The classification "greywacke" is used here to include

pebbles of greenish to dark grey, fine-grained, clastic sedimentary rock. Quartz is commonly present as angular to rounded, detrital grains in a finer-grained, dark colored matrix. Some of the greywacke pebbles are poorly cemented, but more commonly they are well-indurated greywacke quartzites. As the percentage of quartz increases at the expense of the matrix the greywacke grades into quartzite. Some of the pebbles of greywacke show signs of shearing; as this becomes more pronounced the greywacke grades into a greywacke schist and finally into greyish, fine-grained schist.

The classification "Precambrian chert" is used here to include all cherts except those which contain fossils. Most of the pebbles identified as Precambrian chert are somewhat ferruginous and are reddish or brownish; a few are white.

The classification "iron formation" here includes unaltered sedimentary iron formation, enriched iron formation, and metamorphosed iron formation. Pebbles of unaltered iron formation include carbonate iron formation (such as sideritic slates) and sedimentary iron silicate rocks. The enriched (and possibly slightly metamorphosed) iron formation includes pebbles of cherty hematite or magnetite and strongly ferruginous cherts, varying from finely banded to crudely banded to granular. Pebbles of metamorphosed iron formation consist of sugary quartz (recrystallized chert) and hematite or magnetite (martite).

A poorly developed schistose foliation is evident in some of the pebbles of metamorphosed iron formation.

Inferred Relation to Bedrock Lithology.—The distribution of the Huronian-type sedimentary and metasedimentary rocks in the drift is shown in plate V by drift isopleths drawn at an interval of 8 percent from 18 to 42 percent. In the eastern part of the county the background count is considered to be approximately 18 percent and areas enclosed by the 26 percent isopleth are considered as anomalies. The average of sedimentary and metasedimentary rocks in samples in the western part of the county is less than that in the eastern part of the county. Accordingly, a lower background count is used and 18 percent is considered as anomalously high in the western part of the county. Anomalous pebble-counts are found in three principle areas in the eastern part of the county and in one area in the west-central part.

The greater part of a square of four townships in the northeastern corner of the county lies within a 26 percent drift isopleth for sedimentary and metasedimentary rocks. If the individual components of this group were treated separately, there would be anomalies here for each pebble type; thus the existing anomaly is the resultant of abnormally high pebble-counts for all the components of the group. Because the drift in this area is predominantly outwash and because the anomaly is for pebble types which are largely of resistant rock types, it is possible that

this anomaly does not reflect the character of the bedrock in the immediate vicinity. Iron formation and associated Huronian-type sedimentary and metasedimentary rocks are known to occur over a wide area in Iron and Dickenson Counties of Michigan, some 30 miles northwest (upglacier) from this part of Oneida County. Thus the possibility that this anomaly is a part of a "glacial fan" or "pebble-train" must be considered. To resolve the problem it would be necessary to make detailed studies of the glacial history and drift composition over a large area bordering the anomaly on the north, northeast, and east sides. In this paper no more than a few comments can be made indicating the more likely of the two choices (local source rocks or distant source rocks).

Though much of the anomaly is with regard to highly resistant rock types, the grey schists are also in anomalous percentages in this area. The grey schists are definitely a non-resistant rock type and would probably be all but destroyed during lengthy transport by glacial ice or glacial meltwater. Furthermore, from study of the lithologic composition of the ground moraine in the southeastern part of the county it seems likely that the grey schists occur in close spacial relationships with other Huronian-type sedimentary rocks. Thus it is likely that the grey schists are of local origin and that the other sedimentary and metasedimentary rocks, which tend to occur with the schists, are also of local origin.

Some of the anomalous pebble-counts for sedimentary and metasedimentary rocks in the northeastern corner of the county are very high (up to 47 percent), and some of the pebble-counts for individual types within this group are high (up to 29 percent for quartzite alone). This seems rather high for any great distance of transport from the source.

The anomalous counts are from an area of glacial outwash. This fact alone suggests the possibility that the pebbles here are not dominantly of local origin, but are perhaps part of a long glacial fan spreading outward from a distant source area. If this were the case the anomaly should coincide exactly with the area of outwash. Since the two do not coincide in detail, but only in a general way, it seems likely that the pebbles constituting the anomaly are not from a distant source.

Finally, from studies of the direction of meltwater flow, there are no indications that the outwash was all derived from a common source or from a common direction. In a few gravel pits, or other suitable locations, the direction of dip of the outwash stratification and cross-stratification was determined as a guide to the direction of meltwater flow. At least three dip determinations were made at each location and there was no consistent direction of dip from one place to another. This study, however, was not made on an intensity required to statistically "prove" the point because of a lack of suitable exposures.

It should also be pointed out that the anomaly is one in which very resistant materials (siliceous sedimentary and metasedimentary rocks) take a dominant part, and it is therefore possible that the anomaly is a direct result of the physical nature of the pebbles involved. The implication is that the siliceous pebbles represent a residual accumulation remaining after complete decomposition of many of the less resistant pebbles. Evidence against this interpretation as the cause of the anomaly lies in the fact that there is no apparent difference between the drift in this part of the county and that in other parts with regard to the amount of weathering and decomposition. The drift at sample locations just outside of the anomalous area for siliceous rocks does not differ in appearance from drift inside the anomalous area. Thus all of the drift exposed at the surface in Oneida County appears to have been subjected to approximately the same amount of weathering, and it is doubtful if the anomaly of siliceous rocks is a result of the physical toughness of the rock.

From this evidence it is tentatively concluded that this anomaly in the northeastern four townships reflects the character of near-by bedrock and that Huronian-type sedimentary and metasedimentary rocks probably are present in parts of northeastern Oneida County.

A second anomalous area of sedimentary and metasedimentary rocks in the drift is in T. 37 N., R's 10 and 11 E. The anomaly is apparently located indiscriminantly with

respect to the type of glacial deposit. The pebble types responsible for the anomaly are very similar to those of the anomaly to the north. The drift composition here also probably reflects the nature of the bedrock in the vicinity.

The anomaly in the southeastern part of the county (T. 35 N., R's 9, 10, and 11 E.) consists of two highs, one centering in T. 35 N., R. 9 E. and the other in T. 35 N., R. 11 E. The easterly high in T. 35 N., R. 11 E. can be resolved into separate anomalies for several of the individual sedimentary rock types. The drift in this township is thin and bedrock is exposed in many places. The fact that some of the outcrops are of sedimentary and metasedimentary rocks suggests that the drift anomaly does reveal the general character of the underlying bedrock.

The westerly of the two highs is the result almost entirely of grey schist. Several counts above 40 percent and a high of 48 percent are indicative of bedrock of grey schist in this township and extending into Lincoln County.

Summary.—Huronian-type sedimentary and metasedimentary rocks constitute approximately 20 percent of the coarser fraction of the drift in Oneida County. The rock types included in this classification are pelitic sedimentary and metasedimentary rocks, quartzite, greywacke, chert, and iron formation. Areas in the eastern part of the county which lie above the 26 percent drift isopleth for sedimentary and metasedimentary rocks are considered to be abnormally high in these rock types; areas in the western part of the county

which lie above the 18 percent isopleth are considered to be abnormally high in sedimentary and metasedimentary rocks. Anomalous areas are located in the northeastern, southeastern, and west central parts of the county. These anomalies are believed to indicate the presence of Huronian sedimentary and metasedimentary rocks in the general vicinity of the anomalies.

CONCLUSION

The Local Origin of Drift

Observations of modern glaciers show that rock debris is transported largely in the basal parts of the ice; except for medial moraines in mountain glaciers, the upper levels in the ice are noticably deficient in rock material. The actual erosion of bedrock, whether it be by glacial plucking or by abrasion, takes place at the base of the glacier, and evidently most of the eroded material does not rise much above the level at which it was picked up. It is well known, of course, that a small amount of material has an appreciable vertical component of movement. Boulders from known source areas have been moved by glaciers to locations at considerably higher elevations (up to several thousand feet higher). This upward movement can occur either as a result of curved lines of ice flow (concave upward) or as a result of oblique upward shearing near the terminal part of a glacier where stagnant ice impedes the flow. Nevertheless, it is clear that the greater part of the debris is carried in the basal ice. This is probably a primary factor involved in limiting the distance of transport of most of the debris to relatively short distances of the order of several miles.

Material transported in near-contact with the ground is readily susceptible to deposition, and chances for deposition shortly after erosion are probably as good as for

continued transportation. Furthermore, the great abundance of rock material in the debris-laden basal ice must promote considerable mutual abrasion between rock particles in transport. Thus, if a pebble is not deposited shortly after being picked up, the chances are good that it will very shortly be worn away. The minor fraction of drift pebbles and boulders which is transported a great distance must be mechanically resistant enough to at least partially withstand the continual attrition in the basal ice, or be carried in the higher levels of the ice where the struggle for survival is less intense. Most rocks found in drift at great distances from their sources are found to be highly resistant and unfractured.

Relationship Between Drift Lithology and Bedrock Lithology

General Statement.—In view of the basic principles of glacial erosion and deposition, supported by various studies of the composition of glacial drift, it is evident that in most places the material of the drift is derived predominately from near-by source rocks. This does not necessarily mean that drift analysis will be a highly successful guide to the character of the bedrock. Rock types found in abundance in the drift are likely to be present as bedrock in the immediate vicinity, however, other rock types which occur in abundance as bedrock may be lacking in the near-by drift. In addition, rock types from more distant sources may appear in abnormally high percentages

in the drift. Finally, even if it is possible to determine which components of the drift represent "local" material, it may not be possible to assign a specific source area for the various constituents of the drift. This results from incomplete knowledge of the direction of ice movement, the distance of travel, and from complexities of bedrock structure.

The factors which are effective in determining which bedrock types will appear in the coarser fraction of the derived drift include the extent and pattern of fracturing of the bedrock, the lithology of the bedrock, the preglacial topography, and the distribution of preglacial outcrops.

Fracturing of Bedrock.—Studies of valley glaciation show the pronounced influence of fracturing upon the location of sites of active glacial erosion. Step-like longitudinal profiles of certain glaciated valleys have been attributed to the fracture pattern in the bedrock. Where fractures are abundant and close-spaced, glacial scouring has deepened the valleys; where the fracturing is less pronounced glacial erosion is inhibited. Step-like longitudinal profiles and pator-noster lakes may be the result of alternation between sites favorable and sites unfavorable to erosion. The drift which is derived from such a process of differential erosion is likely to be composed predominantly of the easily erodable material. Thus the relative proportions of easily erodable and resistant material in the drift do not necessarily represent their

relative proportions as bedrock.

Lithology of the Bedrock.—Not only may some bedrock types be missing in the drift, but other resistant rock types of distant origin may be present in anomalously large percentages. This is particularly evident in some of the older drift sheets in which weathering of the drift has been sufficient to destroy all but the more resistant pebbles.

Preglacial Topography and Outcrops.—The topography of the preglacial surface has been shown to have an influence both on the local direction of ice currents and on the selection of sites of active erosion and deposition. In some places the ice was channeled by preglacial valleys; in other places the ice flowed obliquely or normally across valleys. The asymmetrical shapes of abraded outcrops show that glacial quarrying is commonly concentrated on the downglacier side of the outcrop. Erosion is thus selective, and topography is partially responsible for this selectivity. The bedrock of protected areas will be poorly represented in the derived drift, whereas bedrock from unprotected areas may appear in disproportionately great quantities.

Protection of the bedrock in certain areas may also be afforded by earlier glaciation. Some early glacial deposits may be more resistant to later glacial erosion than weathered and fractured bedrock. Thus a till cover may prevent certain underlying bedrock types from appearing in the drift.

Direction and Distance of Transport.—Assignment of a probable source area for "locally" derived drift requires knowledge of the direction and distance of ice transport. Even though the general direction of ice movement may be determined, local variations can be extreme enough to confuse the relationship of drift to source rock. The multiple nature of the Pleistocene glaciation imposes further difficulties as the direction of ice movement across a given location generally varied from one advance to another, and ordinarily it is only the latest direction of ice movement which is readily discernable. The path followed by drift material from source to present location may be further modified through reworking and redistribution by meltwater streams which could have flowed in directions unrelated to the direction of ice movement.

The distance of transport can also tend to confuse the picture. The mean distance of transport probably varies in different parts of the ice lobe. In addition, some rock types, probably the more resistant ones, may average a greater distance of transport than others.

Bedrock Structure.—Finally, the relationship of drift composition to bedrock composition may be confused as a result of extreme complexity of the bedrock structure. Even with good outcrop distribution and determinable glacial history it may be difficult to infer the character of the bedrock from the distribution of the various rock types in the drift. With few areas of outcrops, and drift composition as the

only guide for mapping, satisfactory results may be impossible to obtain.

Inferred Bedrock Geology of Oneida County

General Statement.—Despite all the factors which tend to disrupt any simple relationship between drift composition and character of the bedrock, it has been possible in Oneida County to draw up a generalized map showing the inferred distribution of bedrock types. This area perhaps lends itself more favorably to drift analysis than would certain other areas for the following reasons. The drift is relatively fresh, showing only the beginning stages of decomposition. The directions of ice movement are fairly well established for most of the area. The glacial deposits consist mostly of stratified ice-contact deposits and till; broad outwash plains are present only over approximately six townships. The drift over the eastern part of the county is probably all associated with the Cary ice advance and is not underlain by earlier drift. Outcrops which are present in the eastern and southeastern parts of the county give sufficient bedrock control. Finally, most of the rock types found in the drift are fairly distinctive and can be readily classified.

Plate VI shows the character and distribution of the bedrock throughout the county as inferred from drift composition studied in conjunction with what outcrops were found. This map was constructed by adjusting the drift

isopleth maps to correspond with outcrops of the proper rock types. Over the eastern part of the county the drift isopleth maps were "moved upglacier" until high areas on the isopleth maps corresponded with outcrops of the proper rock types. Because of the variation in direction of ice movement from place to place, and because of difference in the distance of transport from place to place, the isopleth lines are distorted with respect to the bedrock contacts. Because of the lack of outcrop control over the western part of the county the isopleth highs were moved upglacier an arbitrary distance approximately equal to the average distance of transport of the drift in the eastern part of the county.

Bedrock Divisions.—The units of bedrock shown in plate VI include extrusive igneous rocks, sedimentary and metasedimentary rocks, quartz diorite, microcline granite, and diabase, fine-grained gabbro, and basalt.

The extrusive igneous rocks are mostly altered and metamorphosed. The specific rock types include quartz latite, dacite, andesite, schistose and altered equivalents of each of these, chloritic schists, and fine-grained amphibolites. Part of the drift pebbles assigned to the group gabbro, basalt, and porphyry were derived from bedrock of extrusive igneous rocks.

The sedimentary and metasedimentary rocks have been divided into two catagories, the siliceous rocks and the foliated rocks. The siliceous rocks consist of quartzite,

chert, and iron formation. The foliated rocks include greywacke and sheared greywacke, slates, poorly foliated grey schist and minor amounts of other types of schist.

The bedrock units, quartz diorite and microcline granite, are shown by the same pattern on the geologic map; they are, however, distinguished in the legend. Both the quartz diorite and the microcline granite are locally gneissic. Quartz diorite is more common in the marginal parts of the area indicated as quartz diorite-microcline granite than it is in the central parts. Pebbles of microcline granite are far more abundant than are pebbles of quartz diorite in the drift; thus, most of the area designated as quartz diorite-microcline granite is probably microcline granite. Drift pebbles assigned to the classification granite and acid gneiss were derived from bedrock of the quartz diorite-microcline granite unit.

Diabase, fine-grained gabbro, and basalt are shown by the same pattern as the earlier altered extrusive igneous rocks. This was done because it did not seem practical to attempt to distinguish between drift pebbles of the various fine-grained intermediate to basic igneous rocks. Part of the drift pebbles assigned to the group gabbro, basalt, and porphyry were derived from bedrock of this unit.

Age Relationships.—Age relationships between the various units of bedrock in the area were determined or inferred by contact relationships, by relative degrees of alteration

and metamorphism, by the trends of drift isopleths for different rock types, and by comparison with the general regional stratigraphy (though imperfectly known). Outcrops definitely indicate that the extrusive igneous rocks are early and are followed in age successively by quartz diorite, microcline granite and diabase. Drift pebbles of siliceous sedimentary and metasedimentary rocks tend to occur with pebbles of foliated sedimentary and metasedimentary rocks; these two groups are therefore placed together in a broad age group. It is probable that there are several stratigraphic units of each of the two sedimentary and metasedimentary categories, but no detailed stratigraphic relation can be determined from the data at hand.

Accurate correlation of the rocks in Oneida County with the regional geology would require considerably more data than exists at present. At best only several suggestions can be made. The sedimentary and metasedimentary rocks are of the types characteristic of the Huronian period. Drift isopleths of granite appear to truncate drift isopleths for sedimentary and metasedimentary rocks, suggesting that the quartz diorite-microcline granite is the later of the two groups. If so, the quartz diorite and microcline granite are most likely late Huronian or Keweenawan in age. The diabase and fine-grained gabbro are intrusive into the "granite" and these may be of Keweenawan age. The extrusive igneous rocks are older

than the granites, but of uncertain age relative to the sedimentary and metasedimentary rocks. Thus they are considered to be of either Keewatin or Huronian age.

Structural Geology.—The distribution of rock types shown in plate VI suggests that the general structure of the area consists of plunging folds intruded by plutons of several rock types. The folded rocks consist of the older extrusive igneous rocks and the Huronian sedimentary and metasedimentary rocks. The fold axes trend from east to northeast. There appears to be a fold axis in the northeastern part of the county trending west to northwest through the center of T. 38 N., R. 11 E. into T. 38 N., R. 10 E. This is either an anticline plunging west or a syncline plunging east. The adjacent fold axis on the south side extends along a westerly trend through T. 36 N., R's 10 and 11 E. In the western part of the county the structural trend is northeast.

The folded volcanic and sedimentary rocks have been intruded by quartz diorite and microcline granite. These rock types probably occur as large, irregular, discordant plutons with associated apophyses and dikes. Finally, diabase dikes intruded the extrusive igneous rocks, the Huronian sedimentary rocks, and the quartz diorite and microcline granite.

APPENDIX

Tabulation of pebble-counts and type of deposit for 327 drift samples in Oneida County, Wisconsin. The sample locations are shown in plate I.

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	1 s	2 s	3 s	4 s	5 s	6 s	7 s	8 s	9 s	10 s	11 s	12 s	13 s	14 s	15 s	16 s
Granite	11	22	16	20	14	25	14	17	14	9	15	26	22	26	27	16
Syenite	5	3	3	1		8	0	8	0	1	3	2	3	5	2	1
Gneiss			2	1						7		1		2	1	
Vein Quartz	6	3	7	8	3	6	1	5	5	2	5	6	3	6	11	3
Felsite	5	2	9	4		8	1	7			1	8			2	2
Porphyry	8	13	25	12	23	9	20	11	19	17	11	14	7	6	11	16
Gabbro, fine	9	6	6	1	4		3	8	8	6	5	16	1	11	7	10
magnetic	2	11	3	1	0	1	3		4	3		3		1	4	3
coarse	1			13	8	13	10	8	7	6	11		13	8		12
magnetic	2				1		1	3	3	5	2		4	7		4
Basalt				3		17		6	6	2	5		6	1		2
magnetic						1	2		1	2	3		2			1
Greywacke	1		1	4	9	6	12	3	7	10	8		14	13	6	11
Quartzite	12	9	4	12	10	6	5	7	5	0	8	2	6	4	10	7
Sandstone	4		2	1	1	1	7	2	1	1	2	2	1	2	1	1
Chert	10	7	4	0	3	4		5	1	1	3	3	1	2	3	3
Iron Formation	2		0	1	1	4	7	4	3	1	3	1		5	1	1
magnetic	1	1										1				
Slate	1							2	2	2						1
Shale																
Schist	17	16	5	6	14	5	6	4	4	13	12	11	16	4	14	6
Others	1	1	2									4	1			
Total	100	99	98	97	100	114	101	100	99	106	101	100	100	103	100	100

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)																
	17 s	18 t	19 t	20 t	21 s	22 s	23 s	24 s	25 s	26 s	27 s	28 t	29 t	29d t	30 t	32 s
Granite	18	19	18	22	19	21	25	13	17	27	23	14	22	21	13	21
Syenite	11	1	4	12	2	4	8	1	4	3	3	1	2	3	3	13
Gneiss		3	11	2		4	2			3	1			1	1	
Vein Quartz	6	6	1	8	6	10	11	4	2	3	5	10	2	1	6	7
Felsite	5	0	7	0	7	12	2	9	16	2	8	2	1		5	2
Porphyry	5	14	13	7	18	15	17	0	19	24	14	15	1	2	14	16
Gabbro: fine		12	10	5	8	7	3	6	10	12	5	17	1	3	12	4
magnetic		12	3		2	3	2	2	2	8	1	8	1		6	1
coarse	3	1	2	7	8	6	2	6	1	1	13		1			5
magnetic		3	5	1	3	1	2	4	4	2	4	2		1		1
Basalt	3			3	2	1		0	1			1				3
magnetic	5	1		3	2			1	2					1		
Greywacke	8	3	3	2	4	2	4	10			7	4			2	8
Quartzite	31	4	6	4	7	6	4	12	2	4	6	8			7	9
Sandstone		2	2	4	4	5	5	2	2	3	9	3			5	1
Chert	2	1	1	1	1	5	2	1	4	2		1			3	2
Iron Formation				1		1	1	2				1			2	4
magnetic	1							1								
Slate						1			1							
Shale	1															
Schist	4	9	17	8	7	6	9	0	8	6	2	17		1	13	3
Others												1				
Total	103	100	103	99	100	110	99	100	100	100	101	105	101	103	98	101

Rock Type	Sample Number and Type of Deposit (t=till, s=stratified drift)															
Granite	19		19		19											
Syenite																
Gneiss																
Vein Quartz	8															
Felsite																
Porphyry																
Gabbro fine																
magnetic																
coarse																
magnetic																
Basalt																
magnetic																
Greywacke																
Quartzite																
Sandstone																
Chert																
Iron Formation																
magnetic																
Slate																
Shale																
Schist																
Others																
Total																

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	33 t	34 t	35 s	36 t	37 t	38 s	39 s	41 s	42 s	43 t	44 t	45 t	46 s	47 s	48 s	49 s
Granite	38	32	18	26	19	29	30	17	37	37	26	19	15	24	28	23
Syenite	3	4	1		8	2	9	6	12	9	3	4	5	2	4	12
Gneiss			2	8	5		2			1	1		1			3
Vein Quartz	8	1	11	6	3	10	5	2	16	4	2	9	8	8	13	12
Felsite		3	5	2	14	6	9	5	2	5	7	2	11	3	2	6
Porphyry	14	6	16	12	7	20	14	7	11	3	10	11	10	16	23	9
Gabbro: fine	21	12	2	6	10	8	4	16	3	17	12	11	17	9	6	8
magnetic	8	3	1	2	3	2	1	1		1	1	10	1	1	5	8
coarse		1	3	7	8		4	7		3	7	1				1
magnetic		1				3	1	4		1	4	2	2			
Basalt:		1	2	2	2		4	2		2		1	11	3		1
magnetic					2		2	1		1						
Greywacke		2	8	7	2	3	2	1	4	2	6	12	6	4	2	1
Quartzite	5	7	12	3	9	9	8	4	4	6	6	7	5	6	10	4
Sandstone	5	1	3	4		3		1	3	4		1		5	3	1
Chert	2	2	5	3	1		4	7	6	2	5	2	2	5	5	10
Iron Formation	2	1	1	1		1			5	2	1	1	3	1	1	2
magnetic		1						3			2				1	
Slate				1	1			1			1		2	1		
Shale																
Schist	11	21	7	11	4	5	2	13	7	2	6	7	4	12	6	8
Others	2	1														
Total	99	100	97	101	98	101	101	98	110	102	100	100	103	101	101	104

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	50 s	51 s	52 s	53 t	54 s	55 t	56 t	57 s	58 t	59 t	60 s	61 s	61d s	62 t	63 s	64 t
Granite	13	34	33	23	24	20	30	14	20	23	26	21	15	19	18	53
Syenite	3	5	6	6	2	4	4	3	1	4	4	3	5	9	8	1
Gneiss	1		3	2	2		1		1	2				1	1	4
Vein Quartz	13	9	6	5	7	6	10	7	4	3	7	11	9	5	5	2
Felsite	3	7	2	7	4	3	3	5	15	5	4	3	6	16	13	4
Porphyry	13	6	7	5	22	11	3	40	15	9	11	8	10	14	15	2
Gabbro: fine	14	14	8	22	5	12	6	7	4	7	6	7	14	9	12	2
magnetic	5	1	5	1	1	6	3		6	3	1	10	9	2	3	1
coarse		3		6		1	7		9		1			7	4	16
magnetic		4		5		2	4		5	6		4		1	1	3
Basalt:	1		1	2	1	2	1		4			2	3	2	2	1
magnetic					1	1	1		3			1		1	1	
Greywacke	3	1	2	4	7	3	4	3	2	4	4	3	2	3	3	
Quartzite	10	5	2	6	7	9	4	7	2	8	14	7	5	3	4	1
Sandstone		1	5		1	2	2	4	3		1	1	1	1	1	
Chert	8	4	4		13	4	1	3		6	8		3	1	4	2
Iron Formation	5	2	4	1	2	1					2	1	3	2		
magnetic					1								1			
Slate				2		1	1			2					2	
Shale																
Schist	9	7	12	5	2	12	10	4	5	19	4	19	15	6	7	5
Others																
Total	101	103	100	103	101	100	95	97	99	101	93	101	101	102	104	97

Rock Type	Sample Number and Type of Deposit (t=till, s=stratified drift)															
	65 t	66 s	67 t	68	69	70	71	72	73	74	75	76	78	79	80	81
Granite	34	64	50	55	47	62	49	43	61	42	38	42	32	43	42	65
Syenite		4	8	8	3	2	3	9	2	1	6	5	6	2	3	1
Gneiss	2		2	3	1		2	3			1	1	1	8	2	5
Vein Quartz	4	4	3	1	7	5	3	2	1		5	8	1	4	9	1
Felsite	13	6	12	8	2	2	4	9	1	3	11	7	11	5	6	2
Porphyry	13	9	7	5	16	12	8	7	7	4	10	17	12	18	17	12
Gabbro: fine	7		5	3	7	5	11	9	7	15	8	6	11	6	2	7
magnetic	1		1	1	2	1	4	1	5	3	3	2	3	2	1	3
coarse	4	4	7	2	1		2	3		1	4	4	6			
magnetic	3	1	1	2	1		1	2	2	4	2	1	9		1	1
Basalt:	1									1	2	3			1	
magnetic	1							2			1	1	1	3		
Greywacke	3		3	2	3	2	4	5	2	3			1	1	2	2
Quartzite	6	2	1	6	5	4			2	7	6	4	4		2	2
Sandstone		1			1		1	1				1	1	2	2	
Chert	3	3	1	1	3	3	2	3	1	1	2	3		1	5	1
Iron Formation					1	1			1					1		
magnetic																
Slate	1			1						1						
Shale																
Schist	7	3	1	4	4	4	6	3	2	12	6		6	4	4	1
Others																
Total	103	102	102	102	104	103	100	102	94	98	105	105	105	100	99	104

Rock Type	Sample Number and Type of Deposit (t=till, s=stratified drift)															
	82 t	83 t	84s	85 t	86 s	87 s	88 s	89 t	90 s	91 s	92 s	93	94	95a s	95b s	85a t
Granite	36	42	22	18	21	28	28	21	67	17	41	36	31	29	36	26
Syenite	1	1		5	6	8	4	8	1	9	6	4	1	7	2	3
Gneiss		5	1	3		1	6			1	2	9	6	8	2	1
Vein Quartz	3	2	5	7	7	8	6	10	1	1	6	3	2	6	1	8
Felsite			4		1	12	3	1	3	3	2	6	4	4	5	2
Porphyry	8	7	25	9	12	7	11	17	6	16	16	11	14	16	8	7
Gabbro: fine	16	5	8	6	10	5	6	3	4	8	3	8	9		6	5
magnetic	3	2	3	8	1	2	1	3	2		1	11	5		1	4
coarse			3	2	1	4			2	4	4	1		4	1	5
magnetic	3	5	2	2	1				3	5	2	1	4	3	1	2
Basalt:	1			3		1	3					3		3	7	6
magnetic							1		1			1	1			1
Greywacke	6	6	5	6	8	2	6	2	1	4	1		4		5	4
Quartzite	3	11	11	2	4	10	10	7	1	5	4	1	4	7	6	8
Sandstone	3	1	3		2	1	1	6		2	2	2	6	4	1	1
Chert	1	4	3	6	5	5	2	8	1	7	6	1	1	5	2	2
Iron Formation	1		2	2	5	2	3	2	1					2	2	
magnetic		2														1
Slate												1				
Shale																
Schist	15	8	4	19	17	6	8	9	4	5	4	3	5	6	14	15
Others													1			
Total	100	101	107	98	101	102	100	98	98	88	100	102	100	100	100	101

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	96 t	97 t	98 t	99 t	100 s	101 t	102 t	103 s	104 s	105 s	106 t	107 s	108 s	109 s	110 s	111 s
Granite	32	25	35	33	28	14	37	35	28	36	11	28	30	31	36	[illegible]
Syenite	2	5	5	4		4	7	1	5	6	5	6	2	3	4	2
Gneiss	4	3	1	3	2	3	7				7	4	3	2	4	6
Vein Quartz	1	4	5	2	5	1	3	3	3	5	2	5	2	5	3	[illegible]
Felsite	3	1	2	1	5	1	2	3	5	1	2	2	3	5	8	3
Porphyry	7	4	10	19	18	4	5	12	27	17	14	8	15	15	10	8
Gabbro: fine	12	6	9	7	6	16	5	11	4	3	12	8	9	2	3	[illegible]
magnetic	4	4	2	1	3	7	1	2	4		15	2	4	2	1	4
coarse	8	4	5	4		2		8	4	3		10	2	3	3	[illegible]
magnetic	3	1	6	2		1	1		5	1	3	1	1	2	[illegible]	
Basalt:	2		2	3	1	1	1				4		1		1	[illegible]
magnetic		1		1	1		1					1				
Greywacke	2	6	3	2	4	5	7	3	1	4	1		4	3	3	2
Quartzite	7	5	2	3	9	9	6	6	3	8	1	2	2	6	5	2
Sandstone	1	4	6	4	1	2	1	3	4	3	4	2	2	1	1	1
Chert	2	6	3	6	3	4	1	6	2	7	1	4	1	9	2	3
Iron Formation	1	1			1	1	1		2	1	1					1
magnetic	1	3														
Slate		3						1			1					
Shale														1		
Schist	5	13	8	11	10	27	12	6	5	11	18	17	20	10	6	15
Others	3				1											
Total	100	99	104	106	98	102	98	100	102	106	100	100	105	108	102	99

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	112 t	113 t	114 t	115	116 t	117 s	118 t	119	120	121 t	122 t	123 s	124	125	126	127 t
Granite	26	31	24	35	19	35	42	22	36	43	30	31	33	18	28	35
Syenite		5	1	4		4	6	2	1	8	7	1	7	5	6	6
Gneiss	1	2	9	1		3		2	1	1		6		2	3	
Vein Quartz	6	3	5	1	3	6	3	7	4	3	5	2	5	7	5	5
Felsite	5	1	2	4	4	2	3	5	2	1	2	4	1		1	1
Porphyry	15	15	11	21	19	13	5	5	10	7	12	7	11	17	11	16
Gabbro: fine	8	7	9	7	10	5	10	4	6	9	6	11	6	3	10	6
magnetic	6	3	9		8	2	3	3	7	7	1	3	3	2	3	1
coarse		1	4	7		3		5	1		2	1	7	10	8	4
magnetic		2	1		1	3	4	4	3	3	2	2	2	2		2
Basalt:		2	1		2	1	2	5	1	1		5	1	1		1
magnetic				1				2		1						
Greywacke	7	3	5	1	8	4	7	7	2	6	7	3	4	2	5	6
Quartzite	11	7	3	2	8	5	4	8	5	6	8	3	5	5	2	4
Sandstone	1	2	2	4		6	3	3	1	4	5	1	4			1
Chert	5	1	1	4	1	7	2	2	6		4	8	4	5	3	4
Iron Formation		2					1	3		2	1	1		3		
magnetic				1					1							1
Slate				8		1							2			
Shale													1			1
Schist	9	10	14	8	9	4	6	8	13	14	11	17	9	13	11	6
Others		3			3		2			3			1		1	
Total	100	95	101	109	95	104	103	102	100	99	103	98	105	94	104	100

Rock Type	Sample Number and Type of Deposit (t=till, s=stratified drift)															
	128 t	129 t	130 s	131	132 s	133 s	134 s	135 s	136 s	137 s	138	139 s	140 s	141 s	142 s	143 s
Granite	35	41	30	49	42	29	31	61	35	63	49	34	32	30	36	54
Syenite	8	2	5	2	6	5	8		2	2	7	2	6	3	4	2
Gneiss		2	4	9	5	3		2	3		3	6		6	3	4
Vein Quartz	7	5	4		6	10	6	4	4	3	5	6	8	3	7	6
Felsite	3	2	1	2		7	3	3		5	4	5	3	2	3	3
Porphyry	9	8	13	5	10	7	16	8	17	7	13	12	14	12	9	9
Gabbro: fine	11	1	24	2	3	8	10	2	3	4	11	7	7	4	12	9
magnetic	3		1	1	1	6	4	4	10	1	2	3	4	2	4	2
coarse	7	2	5	1	5	4	3				3		4		5	
magnetic		2			2	4	2	3	3		3		2	3	5	
Basalt:			1		1	2		2	2				1	3		2
magnetic							1						1			
Greywacke	1		1	3	1	3	4	5	6	2	3		3	3	3	3
Quartzite	4	4		3	1	6	3	3	5	3	2	1	3	2	2	3
Sandstone	3	1	1		3		2		2		1	3	2		2	2
Chert	1	1	4	1	2	2	2		1	3	6	2	5		2	
Iron Formation						1			3						1	
magnetic													1	2		
Slate																
Shale		1														
Schist	8	28	7	26	4	9	10	4	8	11	5	24	7	26	8	
Others					1	2							1	1	5	5
Total	100	100	103	104	93	108	105	100	102	102	106	103	98	96	105	102

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)																
	144 s	145	146 t	147 t	148 s	149 t	150 s	151 t	152 t	153 t	154 s	155 s	156 t	157 t	158 t	159 s
Granite	38	43	22	39	57	36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	36	25	15	[illegible]
Syenite	3	7	3	2	3	7	7	6	[illegible]	1	3	5	6		3	3
Gneiss		2	3	2	2	2	2	3	3		4			5	3	1
Vein Quartz	7	8	3	5	8	9	6	6	3	1	2	5	2	2		2
Felsite	2			1	1	4		1	3		3		2	4	3	6
Porphyry	17	13	10	12	7	11	11	15	[illegible]		3	[illegible]	17	[illegible]	9	[illegible]
Gabbro: fine	8	5	13	5	5	9	7	5	5	3	8		9	8	[illegible]	5
magnetic		2	3	4	5		2	1	1	1			1		[illegible]	5
coarse		4	13	1	2	2	5	2	1		12	2	4	6		
magnetic			2		2	1		3	1	2			3		2	1
Basalt:		2	2	2	2	2	3					1	1	4	9	
magnetic						1			1					1	1	1
Greywacke	2	1	2	7	3	2	6	1					4	2	5	3
Quartzite	5	3	1	4	2		4	4	4		3	3	1	1		3
Sandstone	2	1		2		3	1	2	1			3	4		1	1
Chert	6	4	1	6		5	3	2	4		4	8	3	1		1
Iron Formation	2							1	5		1					2
magnetic								1	1							
Slate								1								
Shale				1					2							
Schist	5	9	23	11	5	5	14	17	24	4	33	11	25	33	43	9
Others	2			2		2			3							
Total	99	104	101	106	104	101	102	101	103	101	100	102	102	100	100	104

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	160 t	161 t	162 s	163 t	164 t	165 s	166 t	167 s	168 s	169 s	170 s	171 t	172 s	173 s	174 s	175 s
Granite	23	30	40	24	20	35	39	23	33	25	36	36	34	54	48	36
Syenite	2	1		3		4	1	6	10	6		4	1	3	4	1
Gneiss	2	1	3	2	2					2		4	2			2
Vein Quartz	3	5	6	6	3	7	4	5	6	10	4	6	3	4		4
Felsite	3	5	5	6	8	1	3	3	3	2	3		5	4	2	5
Porphyry	7	6	7	9	12	13	6		7	14	5	15	6	4	4	4
Gabbro: fine	5	8	9	8	11	2	7	3	6	9	13	3	4	4	2	10
magnetic	1	1	2	7	6	1	5	2	4	3	6	2	4	4	2	
coarse		9		3	4		1	9			8	2	6	3	3	4
magnetic			4	1	3		3	4	1	1	4	2	4	2	2	2
Basalt:	13	4	1		1	1	2	1		2	2	1	1	3		
magnetic				5				1		1	1	2	2			
Greywacke	3	1	1	1	2	5	5	5	8	1	1	3	2	3		3
Quartzite	2	3	5	4	7	4	2	7	5	7	3	10	3	5	5	3
Sandstone	3	2	3		1	5	1	2	11	2			2	3		
Chert	3	5	4	4	4	10	3	7	11	9	3	1	1	2		2
Iron Formation	1	1	1	2	1	2	2	1	2		1			1		
magnetic								2							1	
Slate								1								
Shale	1				1	1					1					
Schist	31	14	11	14	13	9	13	18	7	5	12	11	10	7	4	15
Others		3		2			3						1			
Total	103	99	102	101	99	100	100	101	98	99	103	100	101	103	96	100

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	176 t	177 s	178 t	179 s	180 s	181 s	[illegible]	[illegible]	[illegible]	185	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Granite	48	31	73	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Syenite	2	4		5	2	5	2	3	4	9		6	3	5	4	2
Gneiss	9	1			3	4	2					3	4	3	2	3
Vein Quartz		2	2	7	9	6	5	4	3	11	4	12	7	5	5	2
Felsite	5	1	1	4		3	3	1	2		3	3	1		3	11
Porphyry	5	11	1	3	15	11	15	10	2	8	10	10	5	3	11	8
Gabbro: fine	12	16	1	12	10	12	6	12	8	10	14	11	6	10	14	5
magnetic	1	2	3	8	5	3	5	5	7	5	16	8	5	5	8	8
coarse	1	5		3	2	4		1		5	1	1	1	5	5	
magnetic	1		5	1	7	2	1	2	2	5	3	4	4	4	2	1
Basalt:		1		1	6	1	4	4	1	1	5	1	1	5	4	10
magnetic				2	1					1					2	4
Greywacke	2		1	2	4	3	2	4	11	1	1	2	4	3		3
Quartzite	1	2		5	7	1	5	3	1	1	4		4	4		4
Sandstone		1		3	3	1	2	2	2	6	2	4	4	4	6	5
Chert	1	4	1	1	1	3	5		2	1	2	2	1	3	1	
Iron Formation					1	1	1							1	1	1
magnetic																
Slate																
Shale													1			
Schist	12	15	1	7	1	3	6	4	1	9	3	6	1	6	3	3
Others		1				2			2			1	4			
Total	100	97	90	99	102	101	102	103	112	103	101	100	98	103	104	103

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	194 s	195 s	196 s	197 t	198 t	199 t	200 s	201 s	202 s	203 s	204 s	205 s	206 s	207 s	208 s	209 t
Granite	28	25	36	47	40	28	20	39	33	36	33	22	31	16	35	35
Syenite	2	1	2	5	1	3	3	2	1	3	4		4	2	1	4
Gneiss				1	3	1	1		1	2	3	1			4	3
Vein Quartz	6	10	7	1	4	7	7	2	4	4	14	2	4	4	8	3
Felsite	6	7	2	3	6	1	6	15	21	5	5	8	1	1	2	4
Porphyry	22	39	7	12	9	11	20	18	19	12	16	17	13	7	11	15
Gabbro: fine	4	5	11	9	3	11	11	6	3	13	10	14	12	26	11	7
magnetic	6	2	10	2	11	4	2	2	2	9	8	22	4	13	8	3
coarse	1	1	4	1	1	6			2	2	1	1	2	4	1	
magnetic	1	1	3	2	3	8		1	5	1	4	1	7	4		2
Basalt:	6	1	3		1	1	4	2	4		1	7	2	4	3	4
magnetic	4			1	1	1						1	1	2		
Greywacke	2	2		1	7	4	3		2	2	1	1			3	
Quartzite	5	6	6	1	5	2	8	8	6		2	1	1	1	4	6
Sandstone	1	2	3	2	2	7	4	4	2	3	2	1	5	5	4	3
Chert	1		3	1			3	1	4	1	4	2		3		4
Iron Formation		1	1		1	1										
magnetic			1										1	1		
Slate														1		
Shale																
Schist	6	1	5	5	7	9	6		4	7	5	5	10	9	5	7
Others					1		1				1	4				
Total	101	104	104	99	106	105	100	100	103	100	114	103	102	103	100	100

Rock Type	Sample Number and Type of Deposit (t=till, s=stratified drift)															
	210 s	211 s	212 s	213 s	214 s	215 s	216 s	217 s	218 s	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Granite	31	38	31	23	51	20	46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Syenite	5	1	1	5	4	8	2	4	1	3	5	3	6	3	3	2
Gneiss			1			2	1	1			2	2	1	1		1
Vein Quartz	7	10		8	4	3	5	4	16	5	5	3	7	4	8	4
Felsite	1	3	1	3	3	6	2	2	3	3	1	3	6	3	3	2
Porphyry	9	9	3	5	9	4		13	8	14	15	9	14	14	16	6
Gabbro: fine	12	10	25	20	15	15	28	5	12	16	6	17	23	8	6	13
magnetic	8	4	5	12	1	8	8	3	3	14	11	20	2	7	8	3
coarse	2	4	6	2		2	4	2	1	2	2	1		3		
magnetic	2	1	4	2	1	2	1	1	2	6	2	3	1	4	3	3
Basalt:	4	5	5	8	1	8	8	1	2	5	6	3	4	5	3	1
magnetic	2	1				1	2	2		2		1		3	3	3
Greywacke	2		1			1	2	2	1	1	1	4		4	3	3
Quartzite	1	2	1	2	1	10		1	4	3	4	2	3	2	2	5
Sandstone	7	9	1	4	4	5	3	6	3	6	2	3	4	4	3	3
Chert	4	1	1	1	2	2	1	2	2	1	2	1	1	1	1	1
Iron Formation		2	1	1							1	1			1	
magnetic	1														1	
Slate	1															
Shale																
Schist	1	1	15	6	1	6	3		3	3	6	8	4	4	4	9
Others										1		1			1	
Total	100	101	103	102	100	101	106	105	102	103	102	104	100	102	102	93

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	226 t	227 s	228 t	229 t	230 t	231 s	232 s	233 s	234 s	235 s	236 s	237 t	238 t	239 s	240 s	241 s
Granite	33	32	40	20	36	32	30	41	24	28	33	16	16	32	36	29
Syenite	2	4	4	2	1		1	4	1	1	4	2	1	2	2	
Gneiss			6	1		1				2	2	2	2		1	
Vein Quartz	2	4		2	6	5	1	6	6	3	7	5	3	5	3	12
Felsite	2	1	3	5	1	15		7	4		5	2	4	3	4	9
Porphyry	5	9	16	8	7	16		8	5	3	11	7	17	10	23	25
Gabbro: fine	22	22	5	17	17	8	8	14	20	16	9	19	17	16	11	1
magnetic	6	6	6	18	8	3	10		9	10	4	16	11	5	7	1
coarse	6	3	1	7	1		17	1	4	6	3	5	4	6	4	
magnetic	4		9	4		1	13	4	2	5	2	4	3	1	2	
Basalt:	3	2	2	4	1	7	2	1	4	8	2	7	4	6	1	2
magnetic			1	5	1		2			2		2		1		1
Greywacke	2		3	1		4	2			1	1	1	1	1		1
Quartzite	3		3	1	3	5	1	3	2	4	4	2	1	1	1	5
Sandstone	2	4	2		3	6	3	4	4	3	8	4	7	6	1	4
Chert		3			1	1	2	5	2	2	3	2		1	1	4
Iron Formation					1			1	1	1	1	1		1		
magnetic							1									
Slate																
Shale					9									2		
Schist	7	5	3	7	4	2	8		7	4	4	6	7	2	5	4
Others					1					1						
Total	98	94	104	102	101	106	101	97	95	100	97	105	98	100	101	98

Rock Type	Sample Number and Type of Deposit (t=till, s=stratified drift)															
	242 s	243 s	244 t	245 s	246 s	249 s	250 s	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	260 s
Granite	29	29	49	36	59	22	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Syenite		2	1	2	3	2	1	2		1	1	2		2	1	4
Gneiss	1		6	1		4	1		1	2	1	1	1	2		1
Vein Quartz	1	6	4	4	3	5	3	3	4	5	4	5	2	2		7
Felsite	8	3	3	2	4	3	3	5	4	5	3	2	3	3		3
Porphyry	19	14	2	9	11	2	3	10	13	12	8	11	5	15		17
Gabbro: fine	14	8	6	18	6	13	14	8	13	2	9	5	13	10	6	16
magnetic	5	2	7	2	1	6	5	3	4	1	3	2	3	3		2
coarse	2	4		2		5	7	2	2		2	2	2	3	6	3
magnetic	2	4	2	1	1	6	10		2		3		3	3	3	3
Basalt:	4	1	3	4	1	2	2	5	3	2	3	1	5	4	3	5
magnetic	1		2							1		1	1			
Greywacke	3		4	2	1	2	2	1	2	4	4	3	4	4	1	5
Quartzite	3	5	3	1	3	5	5	7	6	6	8	11	4	3	6	3
Sandstone	6	9	2	9	2			3	3	3	3	3		3	3	2
Chert	1	2	2	2		3	3	6	4	1	2	8	7	4	4	4
Iron Formation					1	2	2	1		1	1		4	3	1	2
magnetic							1						1			
Slate		1														
Shale							1									
Schist	3	5	8	5	4	19	12	6	12	7	8	9	11	9	4	3
Others	1		1		1			1	2	4	4	3	1	2	5	
Total	103	95	105	100	103	99	100	96	99	99	100	98	99	101	99	104

Rock Type	Sample Number and Type of Deposit (t=till, s=stratified drift)															
	261 a	263 a	263 b	263 c	263 d	263 e	264 a	265 s	266 a	267 a	268 a	269 t	270 s	272	273 a	274 a
Granite	27	29	28	28	34	20	23	25	25	33	28	18	13	22	16	17
Syenite	8	2	3	6	4	6	3	2	2	2	1	2	2	2	2	2
Gneiss			2		1								1		2	
Vein Quartz	6	2	2	3	3	5	1	2	4		9	3	3	2	3	1
Felsite	2	5	7	4	5	1	2	6	3	5	2	2	5	14	13	13
Porphyry	18	15	9	17	8	7	4	16	13	11	2	5	8	20	19	22
Gabbro: fine	18	20	14	12	15	20	31	24	23	10	19	28	25	3	16	11
magnetic		5	4	10	5	5	8	9	7	10	8	15	10	2	1	5
coarse	2	1				2	6	3	3	7	4	5	1	10	5	3
magnetic		2	5	2	3	1	4	2	1	1	2	3	3	3		2
Basalt:	3	3	4	5	7	3	3	4	6	4	5	9	7	2		1
magnetic							1			2	1					1
Greywacke		2	4	3	1	2	2				2		2	4	2	3
Quartzite	2	4	3		2	5		1	3	4	2	1		5	8	8
Sandstone	7	1	4	4	6	12	6	7	3	6	7	5	6	5	6	9
Chert	2	1	1	3	1	2	2	1	3	1	5	3	5		5	1
Iron Formation		2							2				1	1	3	
magnetic																
Slate											1		1			
Shale											1					2
Schist	7	7	7	3	5	10	6	3	9	7	7	3	8	4		
Others			3				1									
Total	102	101	102	100	100	101	103	105	107	103	106	102	101	100	101	101

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	275 t	276 s	277 s	278 t	279 t	280 t	281 s	282 s	283 t	300	301	302	303	304	305	306
Granite	12	19	22	24	27	10	17	32	18	28	25	28	27	27	23	21
Syenite	2		1	3	3	2	3	2	1	2				1	3	1
Gneiss	5		1	1	1	2	1		1	1	3	3		2	1	
Vein Quartz	4	5	6	1	2		2	1	3	8	7	6	4	1	5	3
Felsite	8	16	5	11	11	13	14	15	13	6	4	4	6	2	9	6
Porphyry	10	20	26	15	23	15	20	16	29	18	11	3	11	12	17	17
Gabbro: fine	10	7	3	13		19	4	8	4	2	3	2	4	6	6	7
magnetic	7	5	3	6	1	5	7	2	3	2	4		4	4	5	3
coarse	13		4	4	12	4	5	3	4	5	3	5	1	3	5	5
magnetic	10		5	2	4	3	2		1	6	6	4	3	3	1	8
Basalt:		1	2	3		1	1		2		8	13	3	7	4	7
magnetic		1			1	1					3	3		3	2	5
Greywacke	2		2	2	3	2	3	5	4	5	6	4	2	4	6	2
Quartzite	10	14	12	4	8	10	7	10	4	7	4	12	15	12	6	10
Sandstone	1	3	1	5	1	5	5	4	9	4	2		3	8	4	1
Chert	1	5	3	3	1	1		2		1		1	3	2	1	
Iron Formation	1	2	2			1	1			2	4	2	2		3	1
magnetic			1	1			1			1	1					
Slate																
Shale	2				1		4		2							
Schist	4	1	1	1	1	1	3		2	4	8	9	14	2	3	6
Others											1			3		
Total	102	99	100	99	100	100	100		100	100	102	102	99	99	102	104	103

Rock Type	Sample Number and Type of Deposit (t=till, s=stratified drift)															
	307 s	308 t	309 s	310 s	311 s	312 s	313 t	314 s	315 s	316 s	317 s	318 s	319 s	320 s	321 s	322 s
Granite	33	27	40	25	33	28	25	28	36	37	35	36	28	29	28	38
Syenite		1	1	2	2	1		5	4	5	7		5	7	3	8
Gneiss	2				4	1	2	9	2	2	3	2			2	4
Vein Quartz	4	2	6	5	4	3	4	7	3	5	4	3	2	3	3	4
Felsite	7	4	5	6	7	4	9	3	4	6	3	16	7	3	2	2
Porphyry	8	7	17	13	22	15	5	6	7	4	7	10	14	25	23	18
Gabbro: fine	7	12	5	7	3	11	2	2	4	9	4	3	3	7	5	3
magnetic	6	4	3	8	1	5	25		2	1	2	3		2	1	
coarse	2	3	4	3	1	4	3	3	3	6	7	12		3	3	1
magnetic	2	6	3	7		1	5	3	3	3	3	3		5	1	
Basalt:	8		11	3	5	8	6	3	4	4	7		7	3	5	7
magnetic	2	1	1	6	1	6	4		2	2		1	2		3	
Greywacke	4	5	1	2	8	2	3	6	6		5	5	3	3	5	10
Quartzite	6	5	3	6	4	7	4	5	9	6	12	4	14	7	11	10
Sandstone		2		7	2	1	3	1		2		13	3	4		1
Chert		2	1	2	3	1	2	2	5	1	4	3	2	16	4	4
Iron Formation	2	3		1	1	2	2	1	2	2	2		2		2	1
magnetic																
Slate		1				1										
Shale												9				
Schist	7	3	1	4	2	2	7	10	12	19	14	2	2		6	
Others		1				2										
Total	101	89	103	107	103	101	103	104	101	100	99	101	102	103	103	101

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
	324 s	325 s	326 s	327 s	328 s	329 s	330 s	331 s	332 s	333 s	334 s	335 s	336 s	337 s	338 s	339 s
Granite	22	18	26	25	23	21	31	21	22	32	18	21	23	19	26	28
Syenite	6	2	2	2	12		2	4	4	6		1	6	9		2
Gneiss		2	5		1	6	2		4	4	2	2	2	2	3	
Vein Quartz	3	3	3	8	5	4	3	3		1	1	5	2		5	8
Felsite	9	4	13	1	2	11	2	1	6	3	14	8	2	11	12	6
Porphyry	7	6	20	4	7	10	6	3	12	10	13	21	9	7	20	25
Gabbro: fine	5	3	3			1	3	3	3		5	3	5	9	1	
magnetic	1	1	1	1	1			4	2			1	3	4		3
coarse	6	9	4	5	3	5	6	5	3	1	15	7	5	1	3	3
magnetic	5		3	3		5	3	2	1	1	3	3	4		3	
Basalt:	9	6		3	4		4	4	7	5			7	1		7
magnetic	1	1		2				2		1			2		1	4
Greywacke	4	10	4	6	8	6	8	13	7	11	8	7	7	9	8	6
Quartzite	5	9	7	19	8	6	8	11	8	5	8	8	10	10	10	11
Sandstone		5	3		7	7	1	5	3	1	2	2	2	5	5	2
Chert		2	6	6	6	3		2	5	4	2	2	3	12	3	5
Iron Formation	1	2		1	6	2	1	7	2	2	2	3	1			3
magnetic	2							2							5	
Slate						2		1	1	1				1		2
Shale											2	2		1	2	
Schist	15	20	2	16	14	3	20	10	8	13	5	5	9		1	7
Others												1	1		1	1
Total	101	103	102	102	107	97	100	103	98	101	100	102	102	101	99	101

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)						
	340 s	341 s	342 s	343 s	344 s	345 s	346 s
Granite	41	22	29	21	27	34	19
Syenite		6	4	2	4	2	7
Gneiss	9		1	4	1	3	2
Vein Quartz	3	2	10	2	5		5
Feisite	12	4	5	6	7	9	5
Porphyry	10	19	13	13	16	11	15
Gabbro: fine		1		3	2	6	2
magnetic			1	1		3	2
coarse	2	2	2	5	9	1	4
magnetic	2			1	4		1
Basalt:		1		1			4
magnetic		1			1		
Greywacke	4	4	1	7	6	6	3
Quartzite	6	22	13	11	7	8	12
Sandstone	3	1	7	3	4	5	3
Chert	1	8	8	2	2	5	3
Iron Formation		1	1	2	1	1	4
magnetic	5		2				
Slate				1			
Shale	1		1	2	2		
Schist	3	7		8	4	4	10
Others				1			
Total	102	101	98	96	102	98	101

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
Granite																
Syenite																
Gneiss																
Vein Quartz																
Felsite																
Porphyry																
Gabbro: fine																
magnetic																
coarse																
magnetic																
Basalt:																
magnetic																
Greywacke																
Quartzite																
Sandstone																
Chert																
Iron Formation																
magnetic																
Slate																
Shale																
Schist																
Others																
Total																

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)															
Granite																
Syenite																
Gneiss																
Vein Quartz																
Felsite																
Porphyry																
Gabbro fine																
magnetic																
coarse																
magnetic																
Basalt																
magnetic																
Greywacke																
Quartzite																
Sandstone																
Chert																
Iron Formation																
magnetic																
Slate																
Shale																
Schist																
Others																
Total																

Rock Type	Sample Number and Type of Deposit (t = till, s = stratified drift)																	
	[illegible]																	
Granite																		
Syenite																		
Gneiss																		
Vein Quartz																		
Felsite																		
Porphyry																		
Gabbro fine																		
magnetic																		
coarse																		
magnetic																		
Basalt																		
magnetic																		
Greywacke																		
Quartzite																		
Sandstone																		
Chert																		
Iron Formation																		
magnetic																		
Slate																		
Shale																		
Schist																		
Others																		
Total																		

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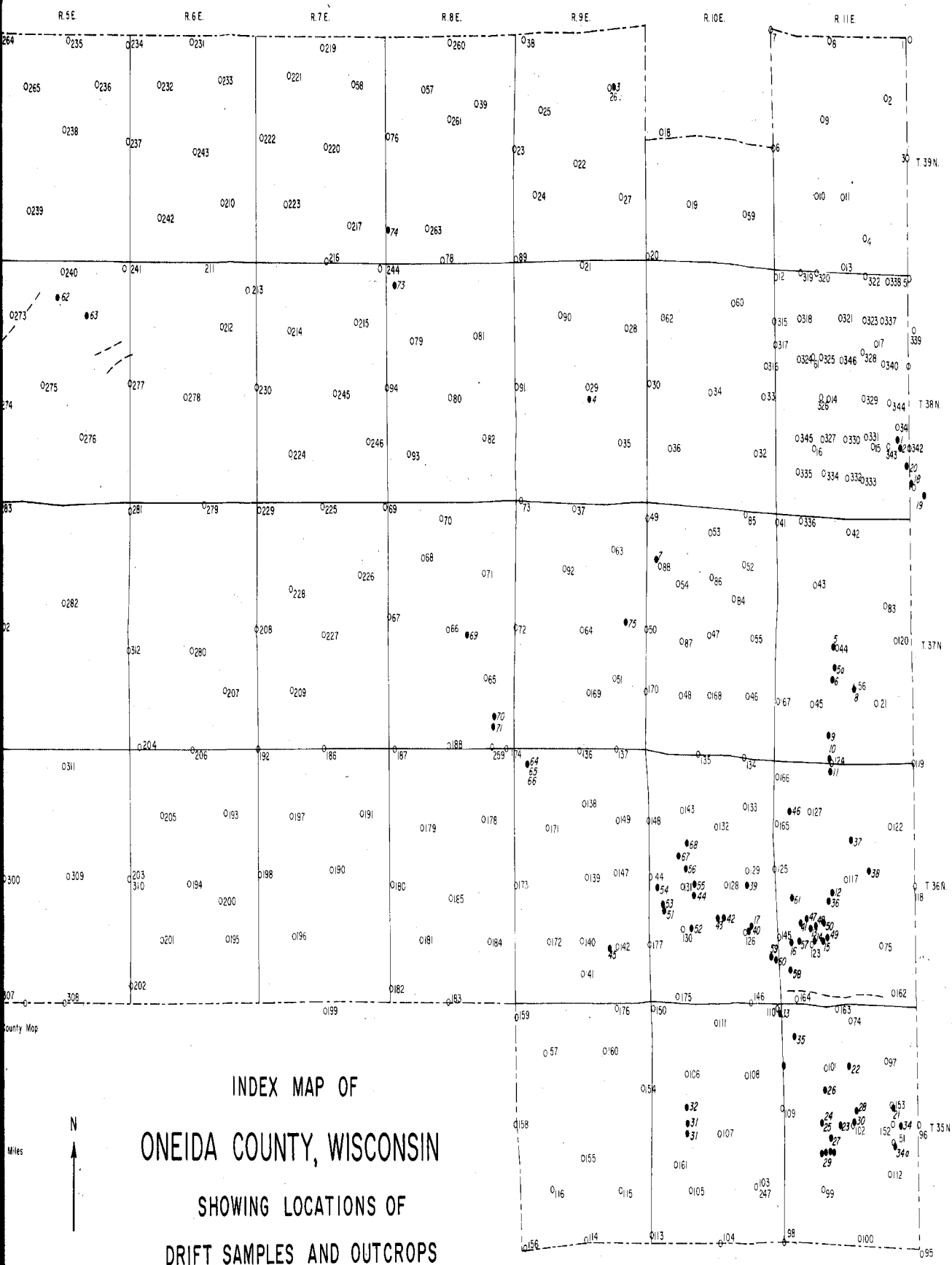
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LEGEND

21
Sample location and number

13
Outcrop location and number

General trend of high magnetic anomaly (after Hotchkiss, 1915)

County Map

N

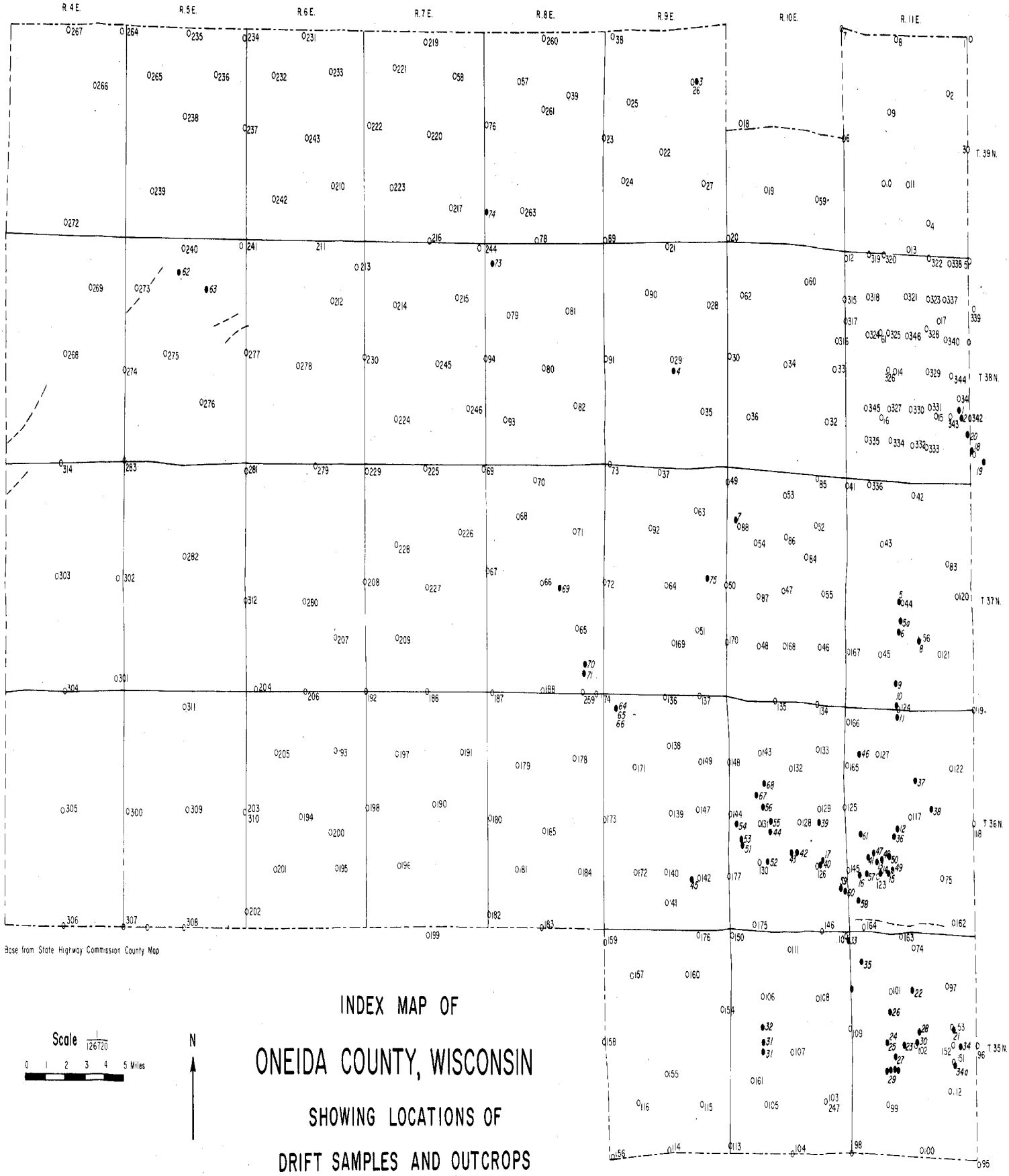
Miles

INDEX MAP OF

ONEIDA COUNTY, WISCONSIN

SHOWING LOCATIONS OF

DRIFT SAMPLES AND OUTCROPS



Base from State Highway Commission County Map

Scale 1/126720

0 1 2 3 4 5 Miles

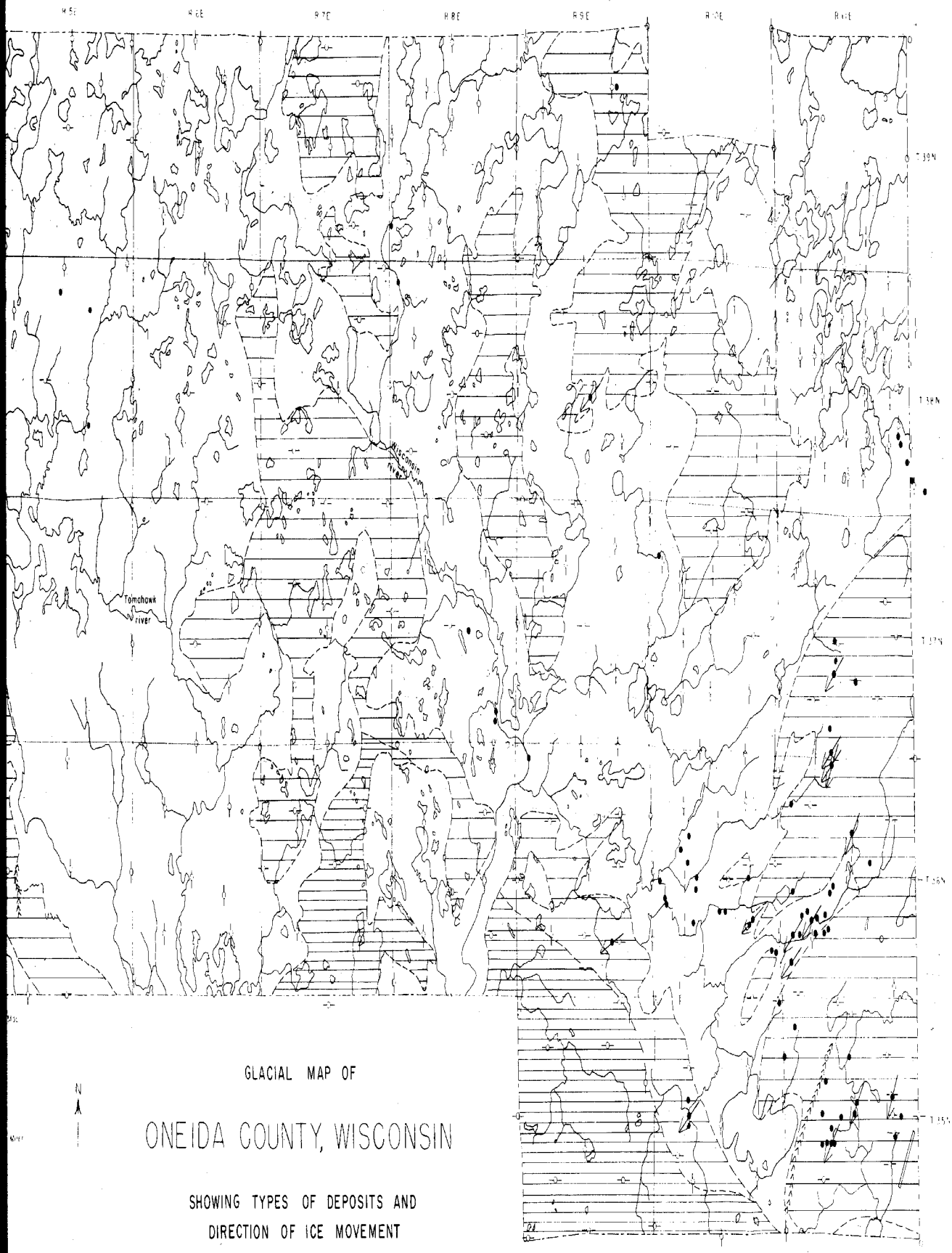
N

INDEX MAP OF

ONEIDA COUNTY, WISCONSIN

SHOWING LOCATIONS OF

DRIFT SAMPLES AND OUTCROPS



GLACIAL MAP OF

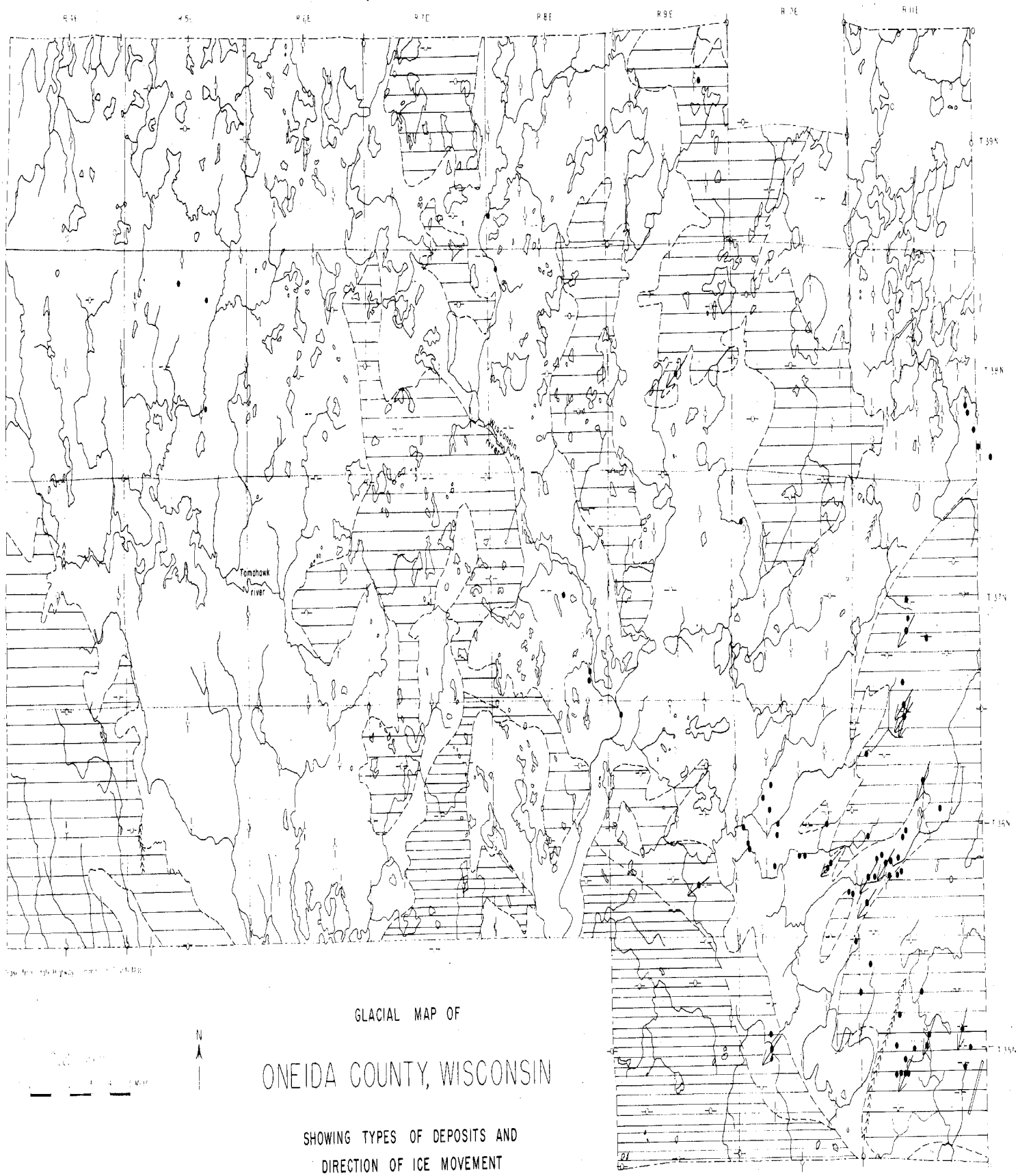
ONEIDA COUNTY, WISCONSIN

SHOWING TYPES OF DEPOSITS AND DIRECTION OF ICE MOVEMENT

N

LEGEND

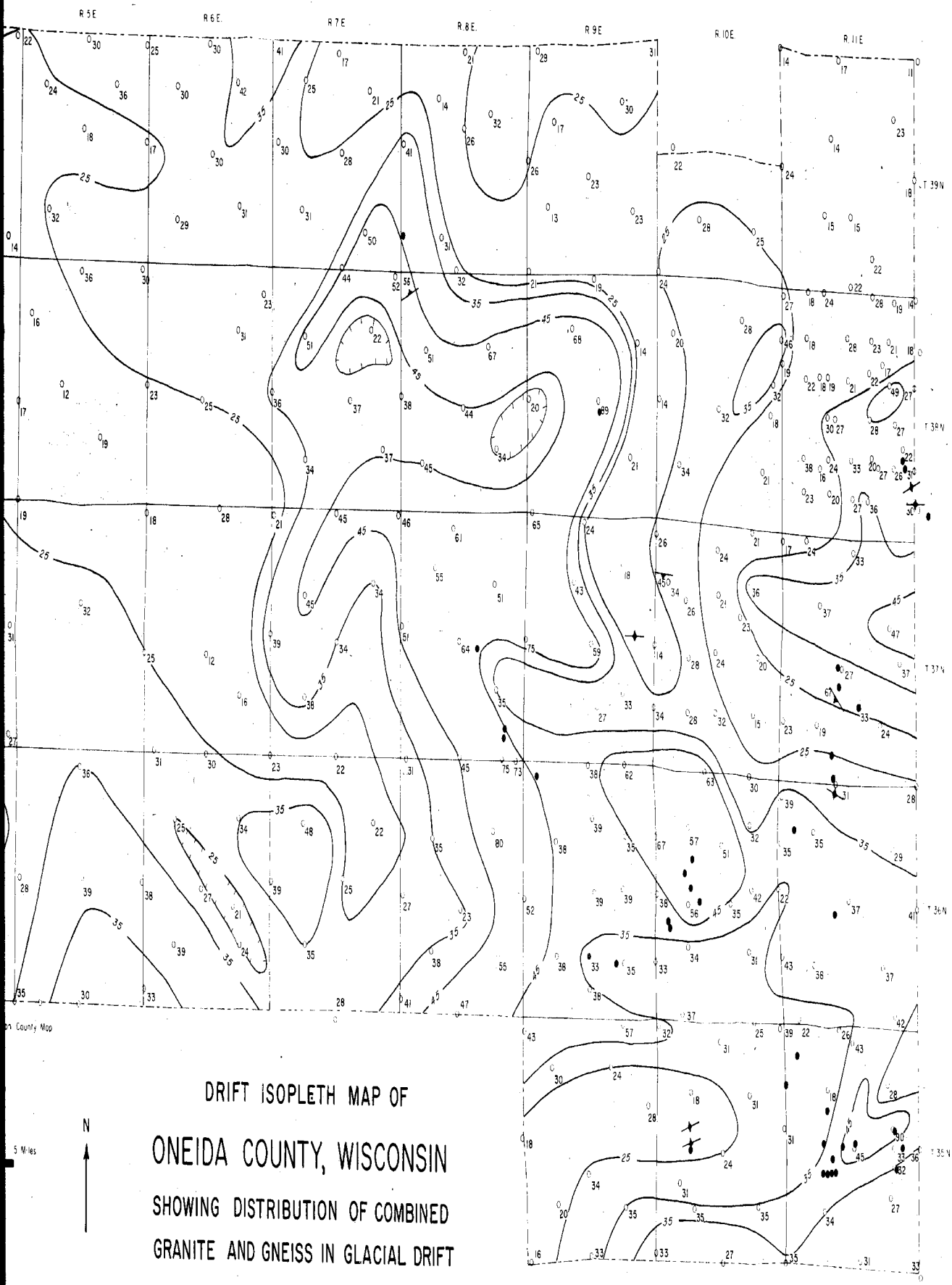
- Ground moraine
- End moraine
- Outwash (including all areas in which stratified drift predominates)
- Contact between moraines and outwash (approximate location)
- Sample location in till
- Sample location in outwash or stratified ice-contact deposit
- Sample location in undetermined drift type
- Esker (shown only where mapped in detail)
- Drumlins
- Glacial striae showing direction of ice movement
- Outcrop
- Stream
- Lake



GLACIAL MAP OF

ONEIDA COUNTY, WISCONSIN

SHOWING TYPES OF DEPOSITS AND
DIRECTION OF ICE MOVEMENT



LEGEND

25

Sample location and percent of combined granite and gneiss

Outcrop of granitoid acidic igneous rock or acidic gneiss

45 35 25

Drift isopleths for combined granite and gneiss (isopleth interval is 10 percent)

67

Strike and dip of foliation of acidic gneiss

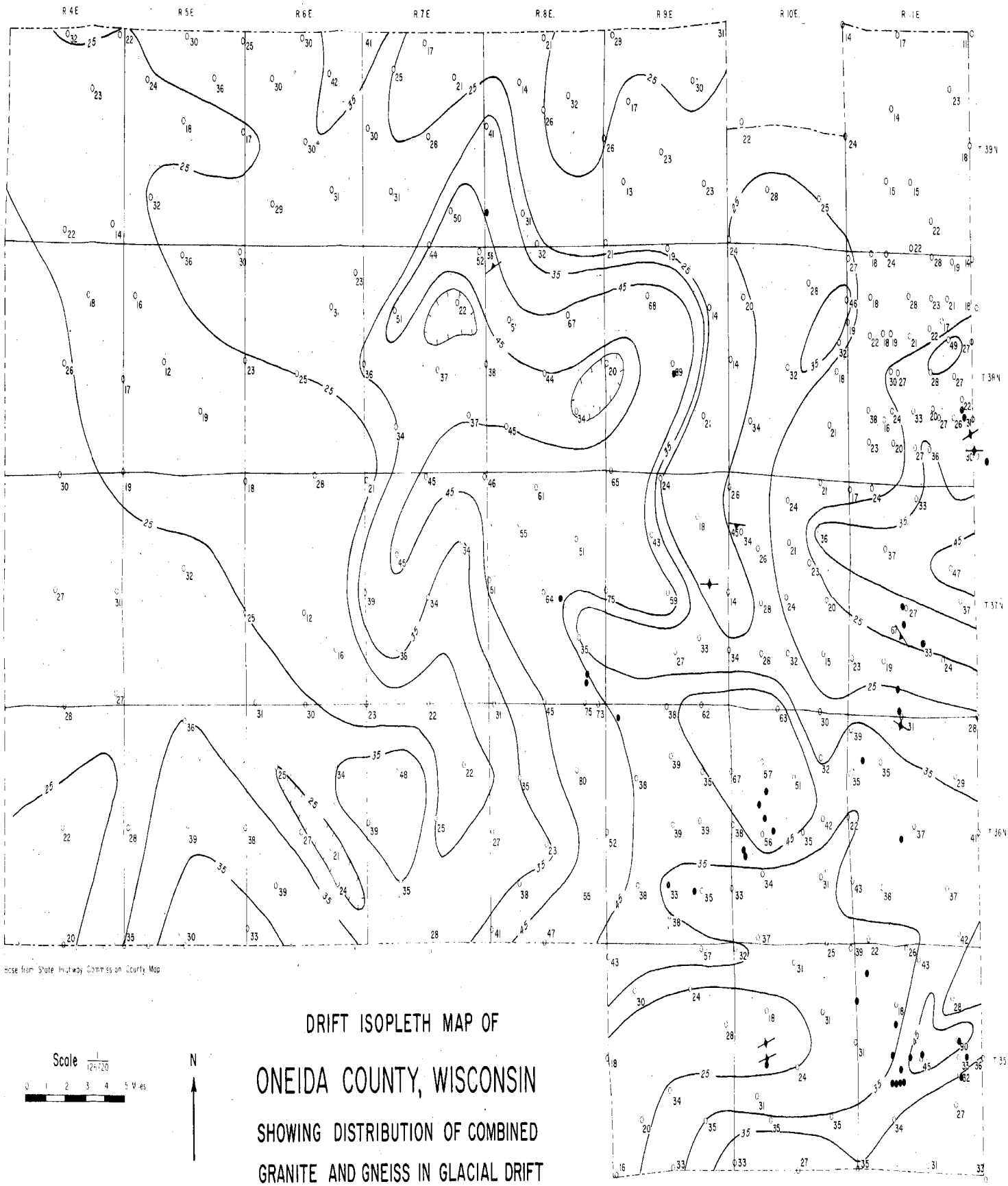
Strike of vertical foliation of acidic gneiss

n County Map

5 Miles

N

DRIFT ISOPLETH MAP OF ONEIDA COUNTY, WISCONSIN SHOWING DISTRIBUTION OF COMBINED GRANITE AND GNEISS IN GLACIAL DRIFT



Base from State Highway Commission County Map

DRIFT ISOPLETH MAP OF

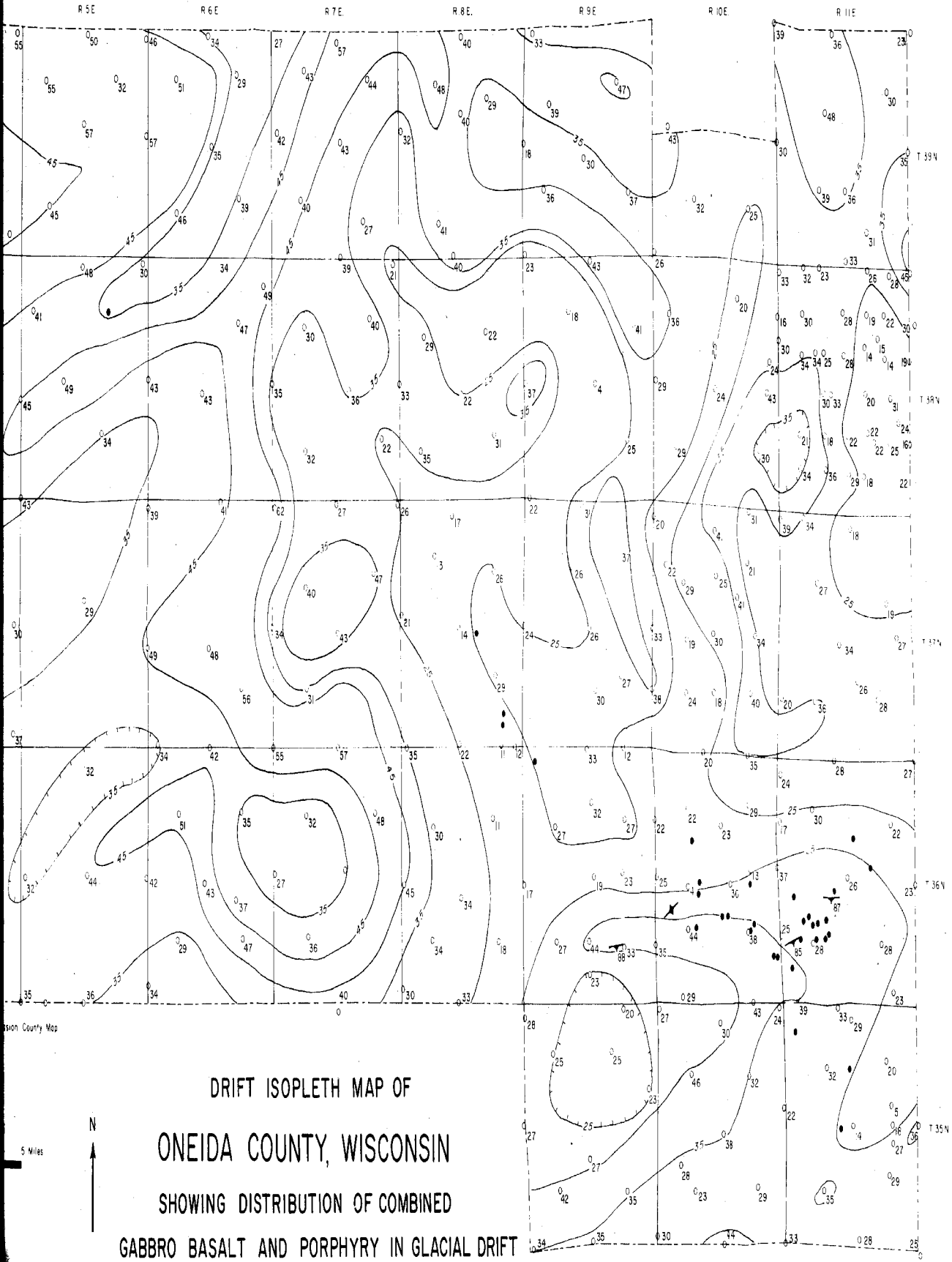
ONEIDA COUNTY, WISCONSIN

SHOWING DISTRIBUTION OF COMBINED GRANITE AND GNEISS IN GLACIAL DRIFT

Scale $\frac{1}{125{,}720}$

0 1 2 3 4 5 Miles

N



LEGEND

25

Sample location and percent of combined gabbro, basalt, and porphyry

Outcrop of gabbro, basalt, porphyry, or greenstone

Drift isopleths for combined gabbro, basalt, and porphyry (isopleth interval is 10 percent)

85

Strike and dip of foliation of basalt, porphyry, or greenstone

Strike of vertical foliation of basalt, porphyry, or greenstone

sion County Map

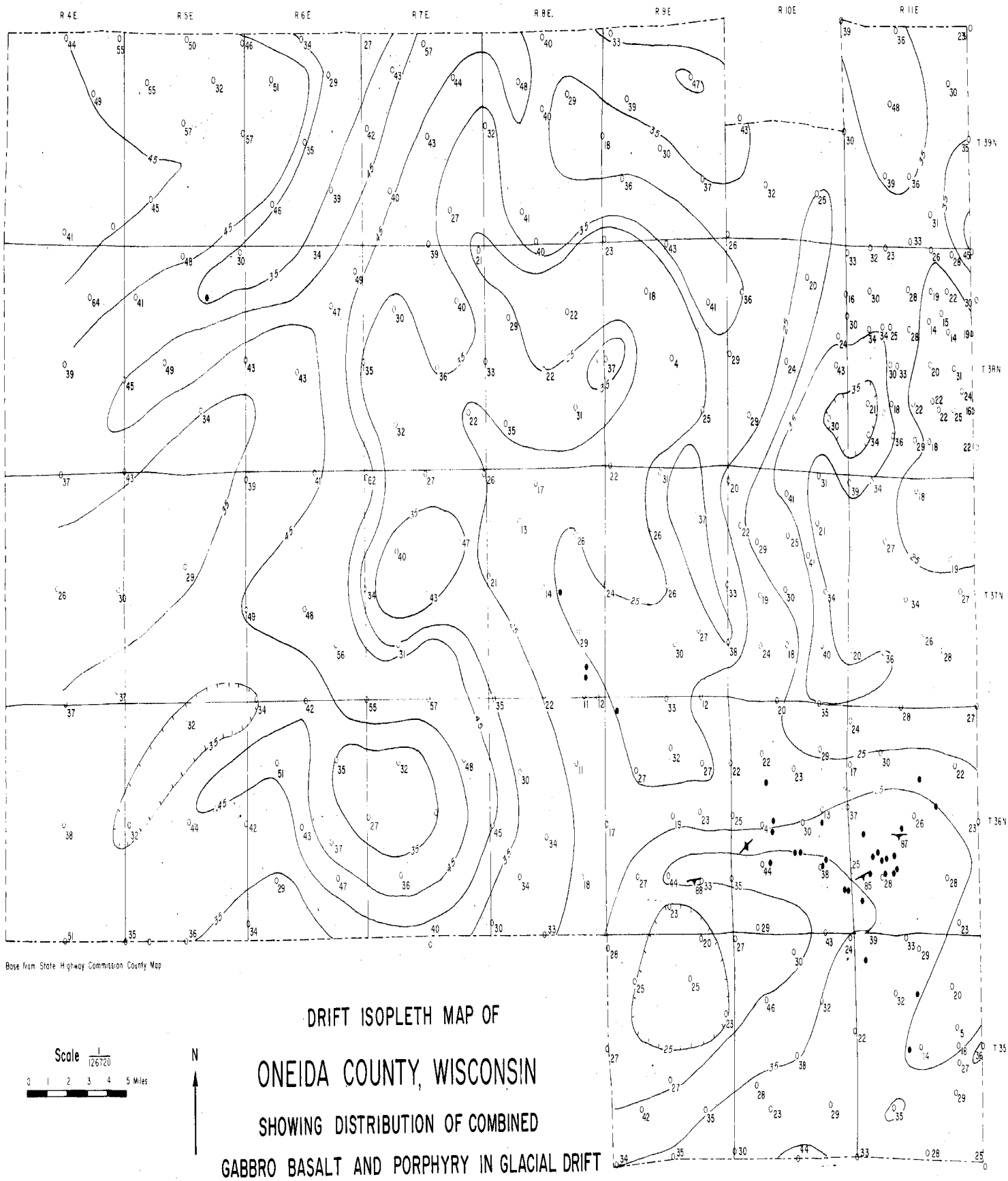
5 Miles

N

DRIFT ISOPLETH MAP OF

ONEIDA COUNTY, WISCONSIN

SHOWING DISTRIBUTION OF COMBINED GABBRO BASALT AND PORPHYRY IN GLACIAL DRIFT



Base from State Highway Commission County Map

Scale 1/126720

0 1 2 3 4 5 Miles

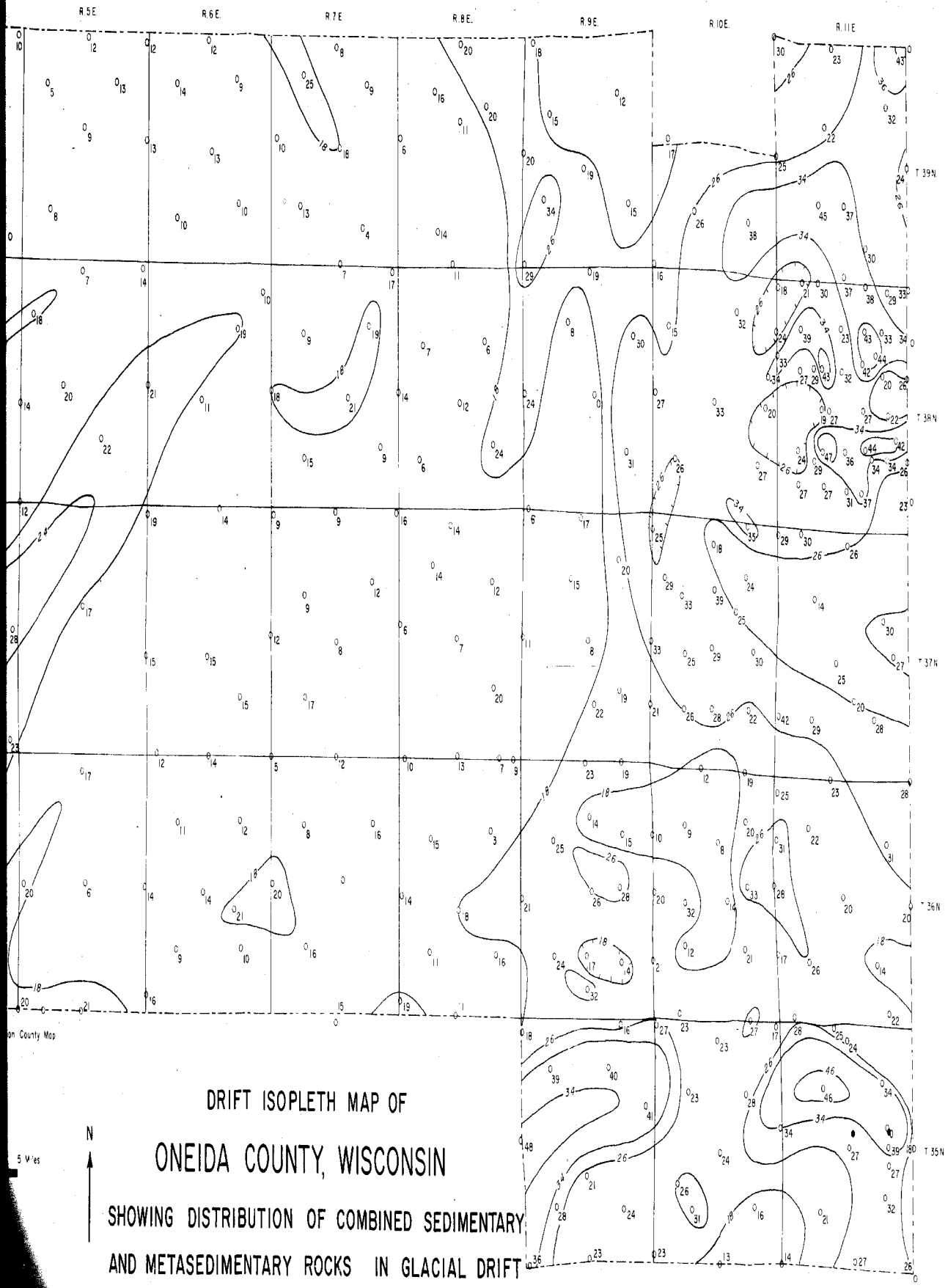
N

DRIFT ISOPLETH MAP OF

ONEIDA COUNTY, WISCONSIN

SHOWING DISTRIBUTION OF COMBINED

GABBRO BASALT AND PORPHYRY IN GLACIAL DRIFT



LEGEND

9

Sample location and percent of combined sedimentary and metasedimentary rocks

Outcrop of metasedimentary rock

Drift isopleths for combined sedimentary and metasedimentary rocks (isopleth interval is 8 percent)

on County Map

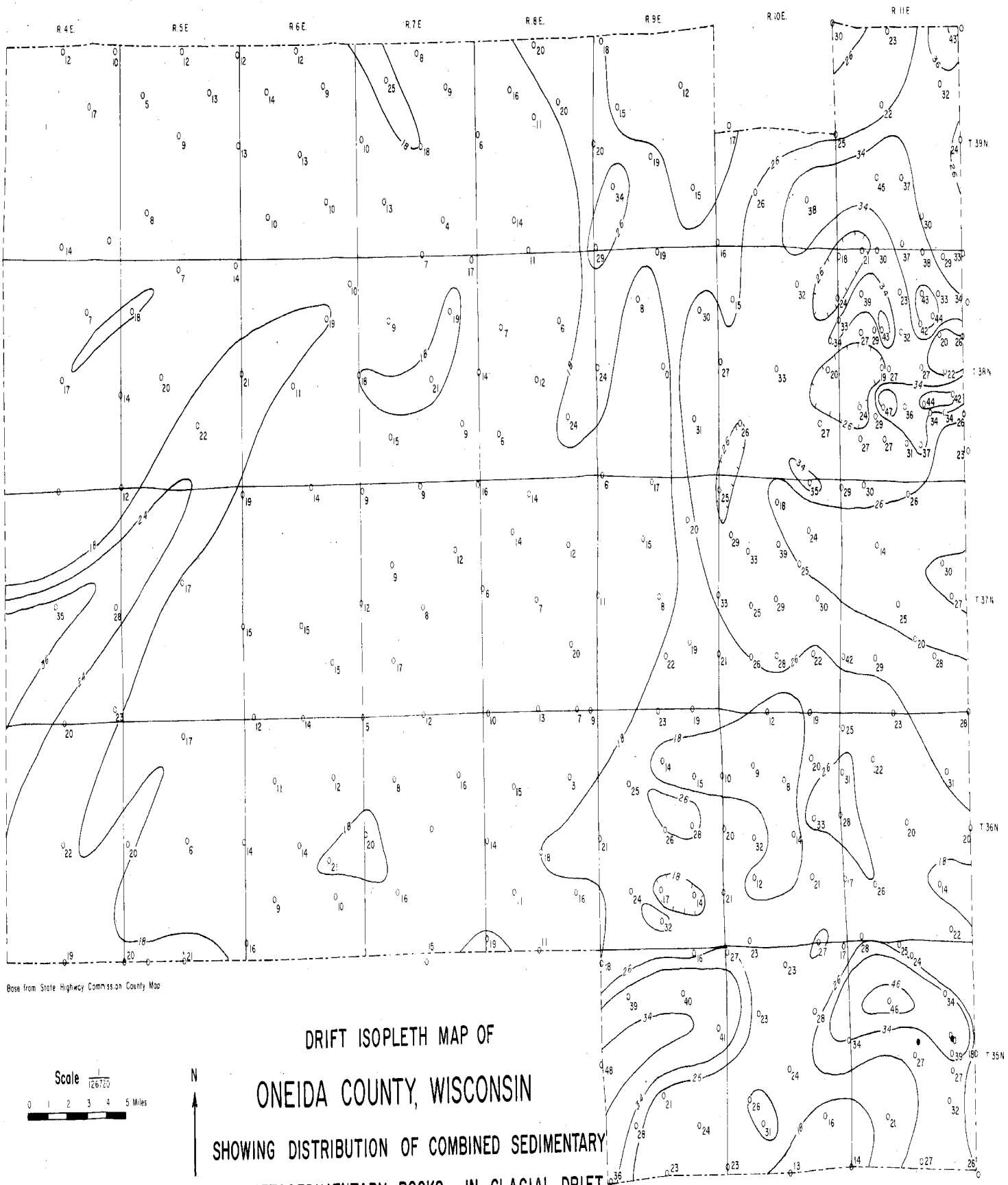
5 Miles

N

DRIFT ISOPLETH MAP OF

ONEIDA COUNTY, WISCONSIN

SHOWING DISTRIBUTION OF COMBINED SEDIMENTARY AND METASEDIMENTARY ROCKS IN GLACIAL DRIFT



Base from State Highway Commission County Map

Scale 1/126720

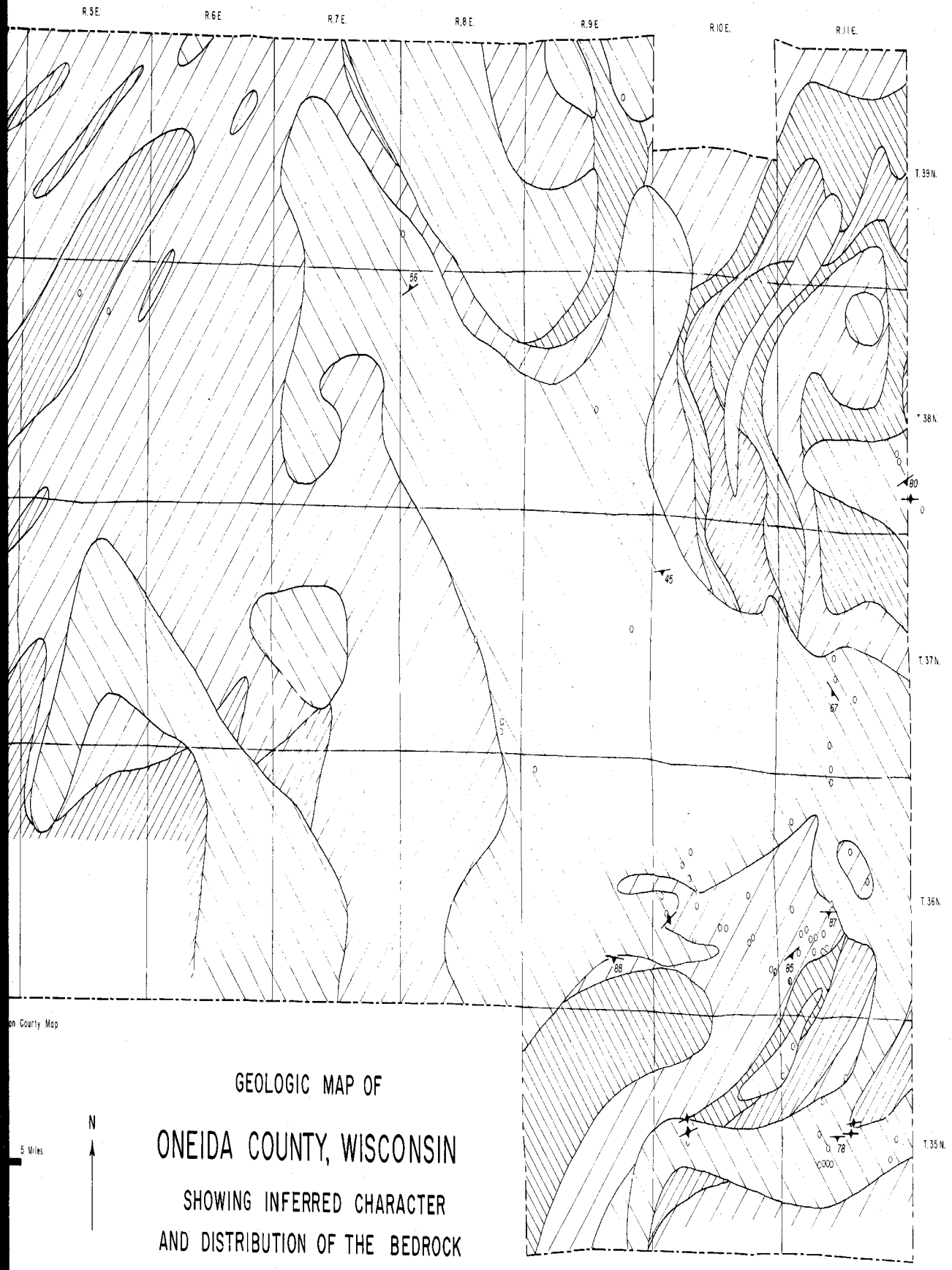
0 1 2 3 4 5 Miles

N

DRIFT ISOPLETH MAP OF

ONEIDA COUNTY, WISCONSIN

SHOWING DISTRIBUTION OF COMBINED SEDIMENTARY AND METASEDIMENTARY ROCKS IN GLACIAL DRIFT



on County Map

5 Miles

N

GEOLOGIC MAP OF

ONEIDA COUNTY, WISCONSIN

SHOWING INFERRED CHARACTER AND DISTRIBUTION OF THE BEDROCK

LEGEND

PRECAMBRIAN

Keweenawan

Diabase, fine-grained gabbro, and basalt (also includes some early extrusive igneous rocks)

Huronian (?) Keweenawan

Microcline granite and gneissoid microcline granite

Quartz diorite and gneissoid quartz diorite

Huronian

Siliceous sedimentary and metasedimentary rocks

Foliated metamorphic rocks (also includes greywacke)

Keweenawan (?) Huronian

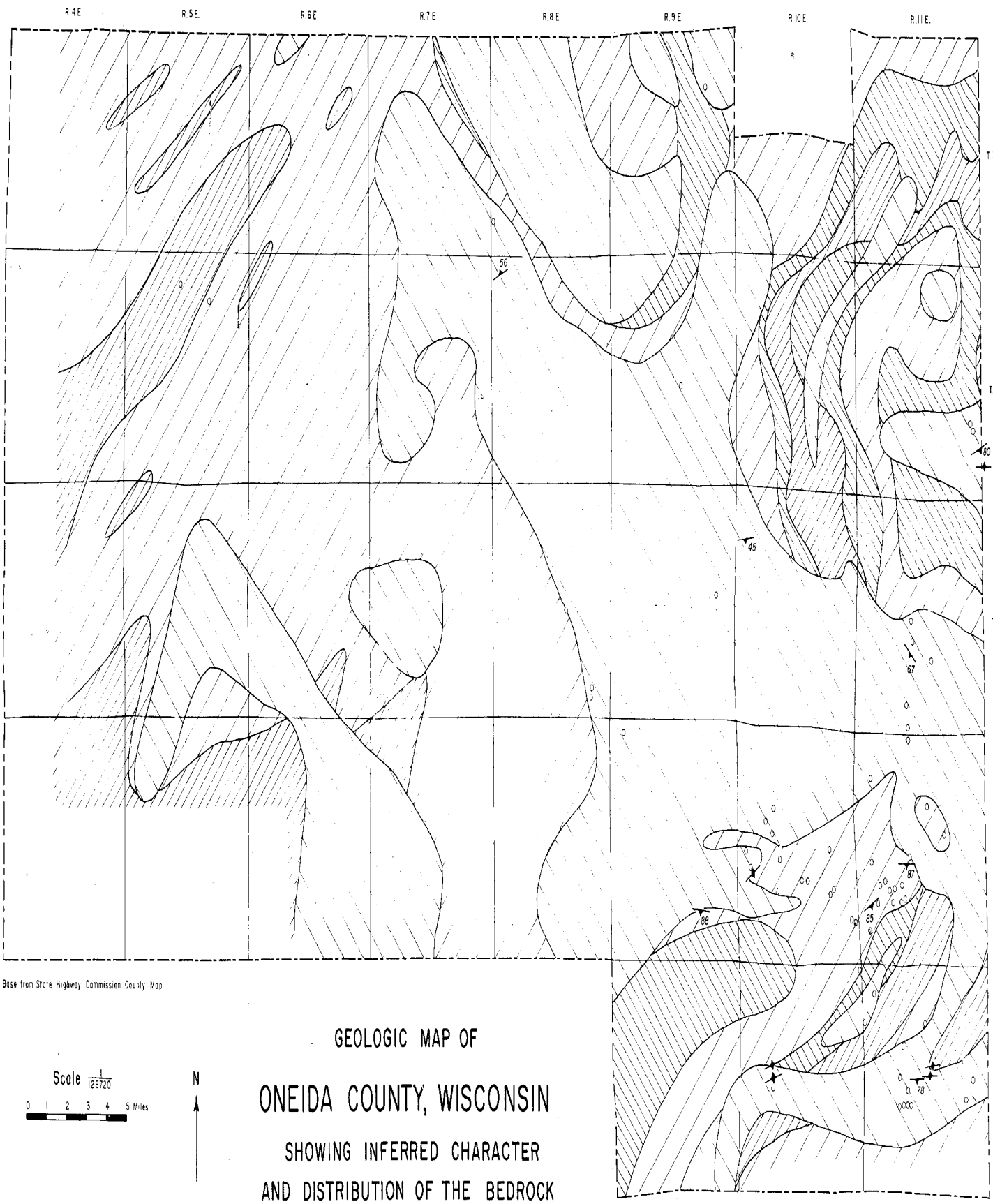
Extrusive igneous rocks (includes variably altered quartz latite, dacite, andesite and basalt, and amphibolite, greenstone, and greenschist

25 — Strike and dip of foliation

Strike of vertical foliation

Outcrop

Note: Microcline granite and quartz diorite are undifferentiated on map.



Base from State Highway Commission County Map

Scale $\frac{1}{126720}$

0 1 2 3 4 5 Miles

N

GEOLOGIC MAP OF

ONEIDA COUNTY, WISCONSIN

SHOWING INFERRED CHARACTER AND DISTRIBUTION OF THE BEDROCK