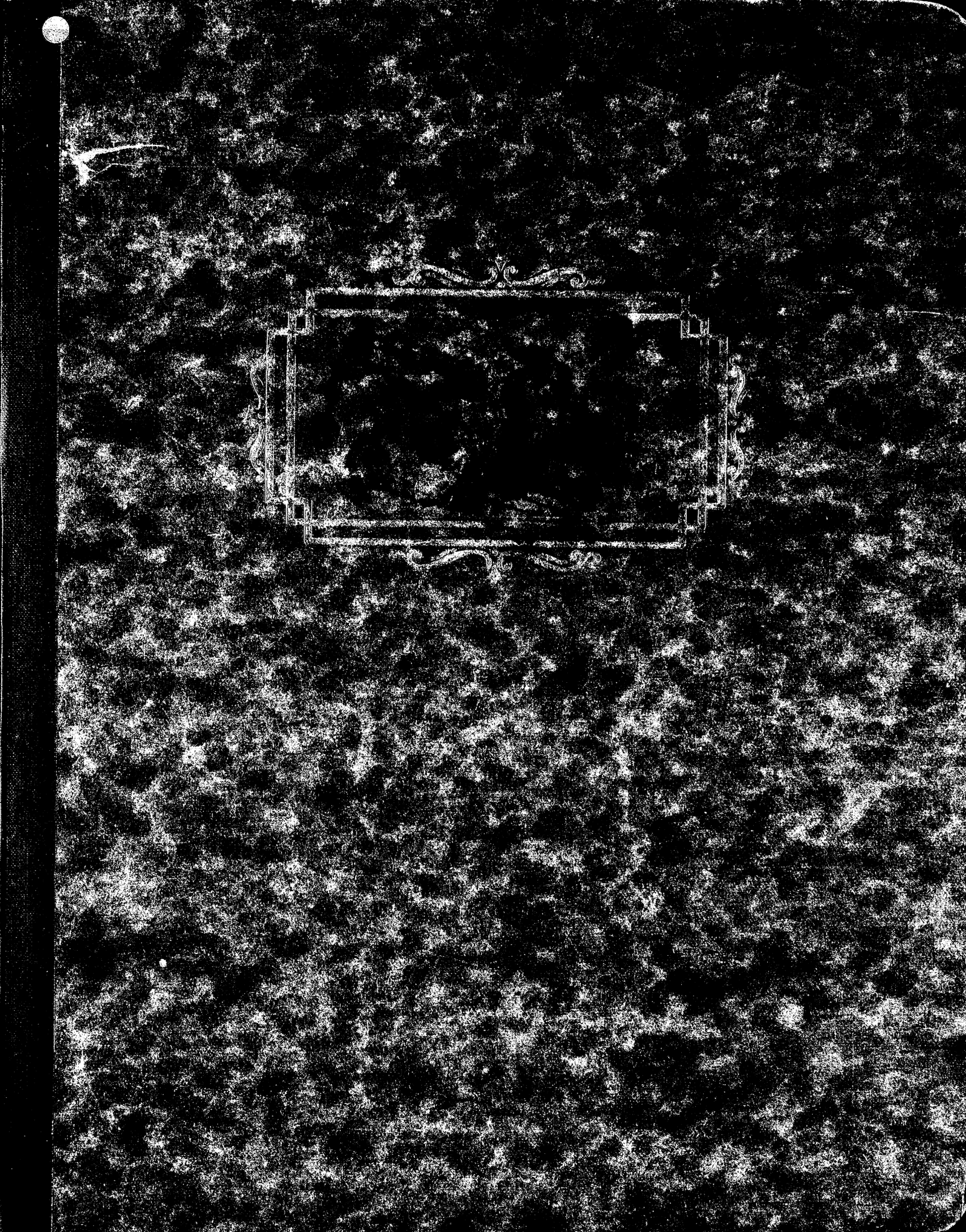
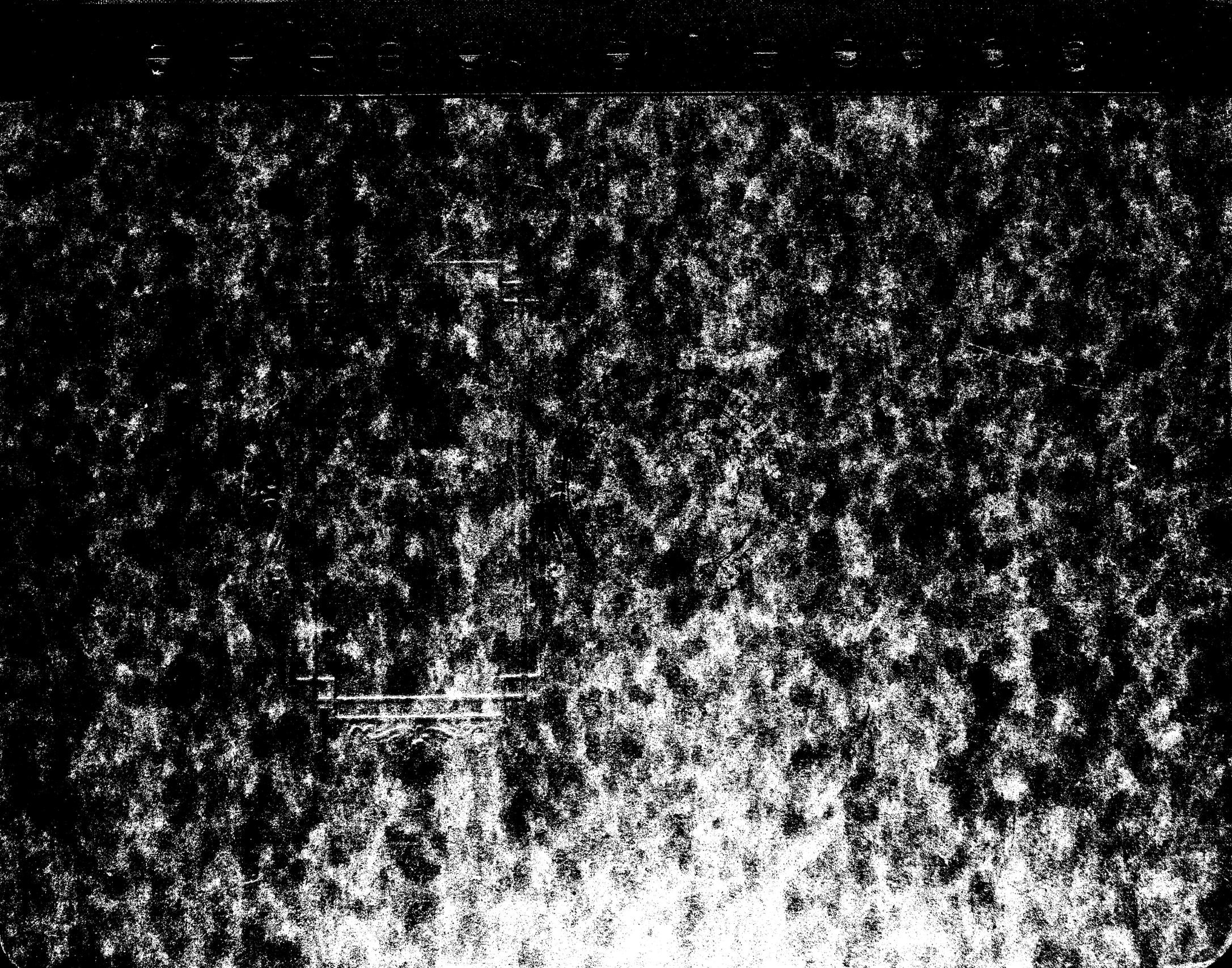




James F. Pepper

Some Features in the Occurrence of Marl Noted During the Field Season of 1925

Marl

Introduction

Previous investigation and authorities

Acknowledgments

Summary

Composition

Definition

Tables and data of 1925 analyses

The average marl sample

Variations

Comparison with limestone

Physical properties of marl

Color

Color range

Variations between surface and depth

Inadequacy of color as a criterion

Feel

Gritty - sand or granular marl

Greasy - often due to clay content

Smooth - best type for agriculture

Taste

Clayey

Marl or lime taste

Easy determination of silica by biting

Occurrence

Lakes

Early stage

Data unavailable.

Middle and closing stage

Occurrence relative to the lake basin

(a) Protected bays

(b) Marl terraces

(c) Points

(d) Connecting necks between lakes

(e) Islands

Final or swamp stage

Relation of the muck cover

Springs

Deposits on hillside slopes

(description - profiles)

River flats

Possible deposition thru flooding

(marl alternates with silt)

Intimate character of the marl deposit

Bottom

The variable clay layer

Marl

Relation of marl to sand, clay and peat

Cover type

Order of succession

Relation of present existing plant growth

to underlying marl

Cat tail rush

Swamp grass etc.

The relationship of marl to surrounding physiography

Porous material and the clay content

Pit lakes

Morainal lakes

Intermorainal lakes etc.

The process of marl deposition and accumulation

Theories of deposition

By plants

Chara

Algae

By mollusks

By chemical precipitation

Accumulation

By wave and current action

Addenda

1. Jointing in marl
2. Relation of timber to marl deposits
3. Fossil marl?

Bibliography

Maps with descriptions

Introduction

The Agricultural Department of Michigan State College has long been interested in marl as a corrective for acid soils. It has been their aim to substitute marl for the more expensive ground limestone and this naturally led to the question of the quantity and quality of supply of the former. At their suggestion the State Geological Survey commissioned Dr. C. B. Slawson to make a reconnaisance of demonstration locations and later to make a detailed survey County by County. In this manner the field season of 1925 was taken up.

From a scientific standpoint these surveys have been somewhat unfortunate as to the methods of procedure, for the aims have been strictly utilitarian. To date there have been three. Blatchley and Ashley in Indiana in 1900 surveying for the cement industry state in their report that "It was planned to be only a reconnaisance, made for the purpose of determining in a general way where workable deposits lay. Such details as may be given were obtained incidentally to the necessary examinations". Hale's report of 1900, in Michigan, was also for the cement industry but fortunately he was able to draw a number of conclusions from the assembled data. The survey of 1925 fared little better, being strictly utilitarian and limited in time. Observations were incidental and few notes were kept, altho the purpose of the survey we accomplished. It is for this reason that little that is new will be brought out in this paper. The report is not intended to be complete but aims to include, besides a very brief general survey, certain new or unstressed features. Not noted by previous investigation.

Acknowledgments

During the field season of 1925 a great deal of discussion took place between Dr. Slawson and the writer as to the method of marl deposition. Later, as no notes were kept, data had to be obtained from verbal comparisons. Therefore a great deal of credit is due Dr. Slawson. It is suspected that after reading the report he will disown interest, however the writer hastens to assume full responsibility for all mistakes, defects, oversights and half digested ideas it may contain. Besides the data obtained from Dr. Slawson, the writers thanks are also due for the use of such maps as are reproduced. Thanks are due Prof. Mussleman and the Dept. of Chemistry of M.S.C. for the use of the analyses of marl samples.

Summary

The writer has attempted to show, by no means conclusively, what he considers as certain new points or at least points ordinarily missed. He would summarize these points in the order of their importance as follows,

1. The recognition of the fact that most marl beds have a suprisingly close agreement to the general areas of the outwash belts. No specific note of this has been found in the literature, altho more exaustive search may prove the writer a poor bibliographer.
2. The attempt to show that the marl terrace is built up in large measure by wave and current action.
3. Some crude physical tests that may be applied in the field, which by experience may aid in the recognition of various types of marl.
4. The recognition and proof that marl may be derived from direct from calcareous tufa which in turn is chemically precipitated from spring waters.
5. Points of interest may be found under, - Jointing in a marl bed. The possible effect of timber on deposition, etc.

The writer has written very little on the process of deposition of marl for this has been a favorite battle ground for investigators and may well be left alone by the writer with his present slight knowledge of the subject.

Marl is a complex compound. The name is a blanket term applied in much the same manner as Bauxite to the compound Aluminum Hydroxide. No formula or definition can definitely cover the term marl but for the purpose of this paper marl may be considered as an unconsolidated deposit of calcium carbonate containing impurities in variable porportions. A three page article in Economic Geology deals with the diversity of mixtures

---

Econ. Geol. Vol. 4, 1909 Stewart C.A. Definition of marl.

---

to which the name is applied with equal authority for all.

Modern authorities on marl are few and investigations have been so limited that much work must be done before the geological history of marl is complete. Field data are lacking or at fault and such as have been collected are in certain particulars open to suspicion. The older methods of sampling are not to be trusted as certain commercial companies have found to their economic loss.

Physical Properties of Marl

Color

Mary may range in color from gray through blue gray, light brown dark brown to nearly black. Various shades of grey and blue gray are most common. Shades of brown are most notable when considerable organic matter is present. Black marls are often very high in organic content. Hale (loc. cit. pg. 7) states that organic matter may be roughly estimated by the color of the mixture "The darker the sample the greater the percentage of organic matter" Such we have not found to be consistently true. Certain very dark marls have tested 90-92% $CaCo_3$. Ries states that 5% of organic matter will color a clay dark.

Ries

Undoubtedly the same holds true in some measure for marl. As a test during the field season of 1925 estimates were made on the percentage of $CaCo_3$ present in various colored marls. These estimates were later checked with the M.S.C. laboratory tests. In most cases the estimate diverged considerably, some cases of dark marls differing as much as 40%. The conclusion was reached that estimation of $CaCo_3$ content by color range was not a safe field test, at least with the limited experience of a single field season as a background.

Feel

The feel of marl is a much more valuable field test than color. A gritty or granular feel may indicate either of two things,

1. The marl is coarse and not broken down
2. That sand is present.

In either case the marl should be tested by biting as the feel of sand is not entirely certain and all marl does not crush easily between the fingers as stated by Hale (loc. cit. pg. 8). Biting is a very sure test in this instance as the tongue and teeth quickly separate and test the individual particles. A greasy feel is usually imparted to marl by a varying clay content. Most clays in marl are very finely divided and doubtless considerable colloidal matter is present. In certain instances organic matter may also give a greasy feeling especially if somewhat colloidal.
By smooth marl is meant finely divided material without grit or a greasy feeling. This type of marl is usually quite pure and is most valuable for agricultural purposes as it breaks down easily when spread as fertilizer. Granular marls on the contrary often take a period of several years before breaking down sufficiently to be available to plant growth.

Taste

Feel is closely allied with taste in these tests and may be used as a check. If the marl has a greasy feel in all probability it will also have an earthy or clay taste. The taste of fairly pure marl is analagous to that of lime. Organic matter if present in sufficient quantities impart a woody or moldy taste to the marl. These distinctions can only be noted by experience and in any case should not be considered infalliable. They offer a valuable field check within limits. Doubtless further field experience will limit or modify all of them.

Occurrences

By far the major portion of marl deposits occur in lakes. These lakes deposits have been divided into three stages by Hale who arranges them as follows,

1. The shore or marsh of marl bed grown to water level and sealed over by marsh growth.

2. The actively depositing marl of the fringing shallows.

3. The deeper parts which are more slowly filling up with a cruder and more impure marl. (loc. cit. pg. 17)

Perhaps this is the better method of division as the processes of growth of a marl bed are not sharply defined but overlap considerably. The present writer however wishes to divide the formation of marl beds as follows,

1. Early stage.

2. Middle and closing stage.

3. Final or swamp stage.

Early stage

Of the early stage nothing may definitely be stated. It is impossible to know at exactly what point or period the first deposition of marl took place. Seemingly from a geological point of view the time must have been very recent. Deep marl beds are somewhat of a rarity and the writer believes that 25 ft. would be a fairly high average for most beds. If the longest period of Pollock's scale is used (Pollock loc. cit. pg. 253) of 1 ft. of marl deposited in 100 years , it will be seen that many of them may be included in the human time scale. Of course certain deposits have been "sealed" (Hale's term) by muck and there is no chance of determining their age. The writer believes that most marl deposits are very recent,

1. Because many shallow beds are depositing at present.
2. The rate of deposition is relatively rapid.
3. Many beds of considerable depth show well preserved logs and other organic matter.

It is likely that since the glacial period, only the last 10,000 years are concerned with marl deposition in lakes. This is rather a rash statement and if it must be modified it may be stated, - or at such time as the present type of vegetation followed the retreating ice sheet. Only one case of "fossil marl", so called, was located during the season of 1925, this may have been of considerable age. (see pg.). There seems to be no possibility of checking the time of deposition by any scale of erosion, for this is of small amount in most glaciated areas. At the present day it is possible to find marl beds in all stages of deposition, but it is impossible to determine whether such conditions are similar to late Pleistocene.

Middle and closing stage

In a lake basin one may find the marl deposited at a number of different points, probably depending not only upon the convolution of the lake bottom but upon the stage of deposition the marl is passing thru. For example an early stage may be conceived as taking place in protected bays such as fig. 5 (a) pg. ( ) or in map 1. (see attached description). Perhaps algae find such locations most suitable for deposition, but the writer is inclined to believe that since nearly all driftwood of any considerable age is thickly coated with algae, it may drift into some protected bay along the lake shore and become stranded, thus more or less arbitrarily placing the point at which deposition begins. As the deposit grows it spreads lateraly as well as into the lake, and in time reaches beyond the protection of

of the bay. If the more exposed position is a steep bank as well, a narrow but deep terrace is started as at (a) fig. 14 or preferably as in fig. 10. Deposition takes place for a considerable period rather close to the shore line and the terrace is built out into the lake, partially at least, by wave and current action as in fig. 11 or fig. 14b. (This is not considering the possible influence of dense timber see pg.). If such were true according to the writer's opinion the marl near shore would be relatively compact, while the marl on the edge of the terrace would be very soft and easily disturbed, and such is usually found to be the case. (see also current action pg.). On many terraces the angle of repose is quite high probably as much as 45 degrees, for the marl fragments are somewhat angular and of low sp. gravity. This at least suggests that the material has been rolled out to the edge of the terrace and dropped. If reference is made to fig. 14B, it will be noted that the slope (a) has an appreciable gradient. This gradient suggests the modifying influence of current and wave action. As far as the writer recalls the depth of (b) fig. 14 varied with the size of the lake, for the latter would effect the wave size. That is, on large lakes point (b) would be located some 3 or 4 feet below the water surface, while on small lakes the same break in the slope may be only 6 inches below the surface. Doubtless the incoming waves break at some point near (a) and the back wash carries the loose marl fragments over (b). On such a shallow slope as at a ice movement must have some effect, altho no data has been obtained to show what the nature of the effect may be. Future investigation should determine the slope angles and the variation of the "break" below the surface. (i.e.: point b)

Points

Marl frequently deposits along one, sometimes both, sides of a point.

Why these more exposed locations should be favorable is not clear to the writer. It is possible that single deposits on one side of a point may be on the lee side from the prevailing wind and currents. Further investigation should determine the reasons for this type of occurrence.

Connecting necks

Between two lakes if the connecting channel is deep, may often be found the deepest and most extensive marl bed of the area. Such a case is illustrated in map 8, while an unusual concentration is seen to have taken place in (a) fig. 8 and in (a) fig. 9 page ( ). Why these necks are more favorable to deposition is not quite clear, unless due to slow current action a greater amount of carbonates may be available. In the particular case of map 15 the neck was narrow but very deep in porportion. The lake proper, however, was very deep with steep banks. Doubtless in this instance the neck offered the most favorable area for deposition while the terraces as noted by dotted lines were formed later. (see pg.)

Islands

Frequently in lake bottoms certain portions may be relatively near the surface, mainly as small mounds or noses. On these points marl may be deposited until accumulation is sufficiently near the surface for marsh plants to take root. In consequence a small island is formed. Hale (loc.cit.) noted the ridging or mounding of the bottom as an essential, but states little as to the probable method of deposition. If such ridges are more than 10 or 15 ft. below the surface at their highest point, it is not clear to the writer how the marl may be deposited. Only one island was tested in the season of 1925 and this only on the edge as the center could not be penetrated. The edge showed a depth of marl of 13 ft. which increased rapidly towards the outer rim, altho the repose slope was very steep.

Final or swamp stage

When at any stage the conditions for plant growth are more favorable than for deposition of marl, the muck cover begins to form and marl deposition does not take place, or if in process, ceases until conditions are reversed. Thus conditions in the shallows at the shores edge are such that marsh plants may readily take root and the marl depositing algae are consequently pushed further out. In some cases the marl deposition keeps well ahead of the enroaching plant growth. In others the plant growth marches so rapidly that the marl has no chance to be deposited except in the very earliest stages. Maps 5 and 7 show this feature very well. Diagram no. 4 pg. ( ) shows the section from points (a) to (b). The section is not considered accurate due to the lack of knowledge of the difference in elevation between the points (a) and (b). Fig. 15 page ( ) shows an ideal section of the condition that may prevail when no terrace is formed. This figure practically covers a section of the south end of the deposit in map 7 While the north end of the same deposit shows how conditions may be so unfavorable that no marl will be deposited. In a case of this type it seems probable that a thin springy bog formed over the surface of the water and the lake slowly filled in from the under side of the bog.

Springs

In the brief field season of 1925 only one authentic deposit of this type was noted by Dr. Slawson, altho there were a number of deposits considered as possibly of this type. The particular deposit was located on a hillside slope, (see fig. 16) the topography being such that there was no possibility of a lake having been present in the vicinity. Calcareous tufa outcroped in certain areas while others could not be plowed, except with difficulty, because of the thin layer of soil covering the surface. Near a point in the slope where a large spring emerged a considerable quantity of marl had been removed. Inspection showed that from the top of the marl to the tufa was a perfect gradation of weathering. The top was a clean quality of marl testing 95%. This continued about 3 feet in depth but near the base became somewhat more granular and gradually merged into solid tufa. As might be expected the tufa structure was perfectly preserved in the weathered material just above the tufa but became more indistinct toward the surface. Another deposit strongly suggestive of spring action is shown in map No. 2 (see also description)

River Deposits

River deposits are not of importance as a source of marl. They are, however, of interest because of the occasional interbedding of other material shown. It is doubtful if such marl is deposited in the main portions of streams, or in any place affected by rapid river currents. The deposits referred to were all located in slack areas, or areas which were flooded in times of high water, this later case predominating. The process may take place as follows. In certain years the river overflows andold meanders and oxbows become filled. The water at this period is usually muddy so that on settling a layer of silt forms at the bottom. Marl is deposited on this silt layer for a period of years and later reflooding repeats the process. (see fig. 20) Deposits of this type were the only ones to show fairly distinct bedding. Peat was occasionally present in narrow streaks, while the total depth of marl and clay seldom exceeded two feet. Prof. Cook has mentioned an occurrence of this type near Mud Lake where a stream at certain times overflowed its banks. Pollock (loc. cit. pg. 252) figures at the maximum rate one foot of marl may be deposited in fifty years. Certain of the marl beds were between 3 and 4 inches in thickness, which would mean a period of 12 to 16 years between flooding. It seems as tho some other means of deposition must have taken place, or the rate must have been more rapid altho it is possible that the areas were not flooded for this period of time. Such deposits are not in the normal order, for in the greater number of deposits there is no interbedding of other material with the marl.

Intimate Character of the marl deposit.

Bottom

Since all marl deposits of Michigan, other than springs are in lakes they must conform closely to the lake bottom. The configuration of the bottom depends upon the type of glacial topography in which the lake is located, whether in moraine, tillplain, outwash or pit lakes. Occasionally even bottoms are found but by far the greater portion of marl lakes are located on very uneven glacial topography. In such case the marl tends to fill in the deeper bays and hollows along the shore, while gradually spreading it's terraces out into the lake, so that in time the marl would have lenticular shapes as shown in fig. (19) In composition the bottom is nearly always sand altho clay is not uncommon.

The variable clay layer

Between the marl and lake bottom is often found a band of blue or green material varying from 1 inch to 1 foot in thickneww, this the writer has always taken to be clay, but according to Hale (loc. cit. pg. 27) "Just before the sounding apparatus penetrates the sand or clay underlying the bed, it passes thru a thin layer of nearly pure organic matter which seems to be finely compressed and decomposed residue of plant life". He also further states that the layer is green or blue in color. The writer cannot entirely agree with the viewpoint that the material is organic matter. Altho no tests were made to prove or disprove the nature of the material in question is tasted and felt like clay. No organic matter was noted altho it is possible that such may have been present in a finely divided form. The question may be left open until further field and laboratory tests have decided the point.

Marl

While the purity of marl may vary in all porportions, it is by a rather thoro mixing of impurities for rarely does a marl bed of any size show bedding. (This is considering a larger and more common type of bed than described under River deposits pg.) The effects are nearly always graditional. When marl rests on a sand bottom, however, the plane of contact is likely to be sharply defined for the sand layer has usually been present a long period before the marl was deposited and is therefore in a relatively stable and settled condition. When the clay layer is present the contact may be very sharply defined but often the upper surface of the clay gradually merges into marl. Probably in such a case deposition of marl and clay was more or less simultaneous for a period. The writer recalls but few cases of a clay layer between beds of marl and the occurrence is doubtlessly rare. Interbedded peat was noted on only one occasion. It was a 2 foot bed lying between two marl beds each several feet in thickness.

The deposit may be explained in two ways.

1. Drifting organic matter settling to the bottom and preventing deposition of marl until a more favorable period.

2. By a damming of the outlet with a consequent raise of water level and a reoccurrence of marl deposition.

Silica may occur in the marl bed proper as noted by Hale, (loc.cit. pg. 28) who states "that an amount running from 1% to 3% of fine quartz sand is fairly well distributed thru most deposits of marl. This seems to be strictly separate from the ordinary surface washings of coarse sand". It is well known that certain plants deposit silica along the margins of their leaves and this may be called upon to explain the presence of such material in the marl deposit.

Cover type

According to Hale (loc.cit. pg. 29) it is impossible to tell the age of a deposit by the thickness of the peat cover as there are wide variations in the growth of plants. The field party of 1925 was able to determine, in a general way, from the peat cover certain characteristics as to the nature and depth of the underlying marl. This is an experience that may not readily be written up as the writer is not a botanist. It may be stated however, that where the cover is a rather sparse wiry grass the marl is usually of good grade and very near the surface. On the other extreme from a number of tests, marl was not found under cat-tail beds, altho marl was located at a relatively short distance from these plants. Again no marl was located in muskeg bogs altho a number were tested. Practice in spotting with a notation of the cover type should be of value in quickly determining the likely locations of a marl deposit.

The relationship of marl to surrounding physiography.

The writer is strongly inclined to believe that there is a very close relationship between lake deposits of marl and the type of glacial physiography in which the lake is located. Unfortunately the locations selected for demonstration in 1925 do not lie in any of the quadrangles mapped by the U.S.G.S., however comparison of locations with Leverett's glacial map of Michigan give some interesting results. In nearly every case the deposit is found to exist in or close to outwash. Probably on a more detailed map the variations would be greater, but in general it may be said that the areas are typically outwash in character. An instance may be cited at Coldwater in Branch Co. where the local cement plant hauls marl by barge thru seven miles of connected lakes. These lakes all lie in outwash but are bordered on the east by till which according to Leverett's map may be sandy. On page ( ) of this report it will be noted under number 2. that Blatchley and Ashley conclude, "that the original source of marl material is the glacial clay in the region surrounding the lakes". The writer believes this statement misleading, for tho clay may be a source of carbonates no marl was found in typically morainal lakes during the field season of 1925. Fig. (13) may be cited as an example encountered in Allegan Co. where the clay was so dense and hard that the lake had not broken thru a relatively narrow neck to reach a much lower level. No marl was found in this lake or any others of the same type. Scott speaking of morainal lakes states that, "the bottom is composed of a clay mud where not covered with peat".

Scott, I.D., Inland Lakes of Michigan, Michigan Geol. Survey Publication 30 Geol. series 25.

On the other extreme a lake located in a sand area would have no marl deposited because of defeciencies in carbonates. A very sandy clay might contain considerably more carbonates and still be porous. Many clay soils are high in carbonates but are not porous. Pit lakes if the outwash in which they are located contains considerable clay, seem to be the best suited for marl deposition after which fosse lakes and intermorainal lakes may be considered as fairly suitable. Marl was not found in tillplain lakes, evidently the soil was tight and the circulation insufficient.

The writer has stated what he considers as two essentials in marl deposition,

1. Porous material such as outwash
2. High carbonate material such as clay intermixed with the outwash.

A third may be stated if time is a factor. That the greater the relief of the surrounding topography, if the first two conditions prevail, the more rapidly will the marl be deposited. This is logical for the more rapid circulation of water thru the material and the greater distance traveled will bring more carbonates into the lake.

A fourth factor is suggested. That marl forms more rapidly in bodies of water having an outlet than in a closed body. Lane (pg. of this report no. 5) states that, "In a chain of lakes the marl is generally deeper and of better quality in the lakes toward the head of the chain". The reason as the writer sees it, is that in a closed lake circulation depends on the amount of movement in the water table which would necessarily be slow, while in lakes with outlets the flow is entirely into the lake from the water table. These statements all need positive verification as the purpose of this paper was to bring up questions or suggestions to be verified or discarded by further investigati

The Process of Marl Deposition and Accumulation

Plants

Davis in 1900-03 believed that the alga Chara was the most responsible for marl deposition, altho he recognized that blue-green algae might also play a minor part. Hale and Lane (loc.cit.pg.) were strongly inclined to believe that more microscopic forms played the major roles and that probably collectively they were more important than Chara. In 1917 Pollock

Pollock, Jas. B. Blue-Green Algae As Agents in the Deposition of Marl in Michigan Lakes. Mich. Acad. Sci. Rept., 1918.

confirmed certain views of Lane and Hale by observations at Ore Lake and gives good proof, "That Chara is not concerned at all in that portion of Ore Lake where deposition is most active, and where Chara is present the deposition of marl is not nearly so rapid nor is the marl so pure in quality". He found that marl pebbles, common to many lakes in the eastern part of the state at least, were formed of a closely interwoven mass of blue-green algae which held together the deposited calcium carbonate. He states, "It seems well established now that these algae pebbles, or a continuous bottom growth of the algae, are associated with marl beds of the highest purity in calcium carbonate, and that the abundance of the pebbles coincides with the degree of purity of the marl beds". Brief experience leads the writer to believe that by far the greater number of marl beds were formed by algae altho observation has failed to show, except in a few instances

the presence of marl pebbles. This does not invalidate the pebble theory as it is quite possible that deposition had ceased and that disintegration of the marl pebbles had been complete so that only the soft marl was left.

Mollusks.

Certain forms of mollusks are often very common in marl deposits and often they appear to form a very high percent of the contents. No deposits were noted that appeared to be entirely accumulated by this means and such was also noted by Hale (loc.cit. pg.43) who also states that, "They are, however, but a minor agent in the formation of most beds". An addition by reconcentration to an existing marl bed was noted by the 1925 survey, where, due to the lowering of a lake a new shore line was developed. The concentration consisted of the cutting down of a 2 ft. bank of peat which contained a very high percent of shells. These shells were washed out and laid down a few feet from the shore edge like ordinary beach shingle. (see fig. 21) This deposit was unusual in every respect but illustrates a single remote possibility in the concentration of marl.

Chemical

Hale refutes the chemical precipitation of lime in marl deposits by stating that should chemical precipitation take place there would be a large precipitation of marl around the spring mouth of, if the lime escaped to the lake an even distribution of marl would be found over the lake bottom. Neither condition was found to exist as far as noted. (except the calcareous tufa type noted on pg. which was of course not a lake type). He further

states that deposition cannot take place precipitation of bicarbonates from a saturated solution because the spring waters are far from being saturated. Davis (loc.cit. pg. 68) believes that the scaly calcium carbonate on plant stems "is formed incidentally by chemical precipitation upon the surface of the plants, and in performance of usual processes of assimilation of the plant organism". The present writer is unqualified to advance an opinion, altho believing that within limits some chemical precipitation takes place.

Accumulation

In steep shored lakes such as map 8 the writer is inclined to believe (without being absolutely sure) that accumulation along the shore at (b) is mainly by current action. The main area of deposition is in the channel at (a) and this point is also the most open. At the time of examination of this deposit the wind swept the lake from the west. It also may be noted that there is very little marl on the east end of the lake. The marl filled the channel at (a) which at present time is firm enough to walk across on, but at (b) the writer sank in nearly to the hips at a distance of about 4 ft. from a firm shore. A possible hypothesis may be advanced, that on terraces where current and wave action is prominent the material remains essentially loose, but on terraces where deposition is the dominant factor the material is essentially stiff altho unconsolidated. The hypothesis must be applied with considerable care for at point (b) map 8 deposition is at present taking place on down timber (see also pg.) It is easy to see, however, that a breaking down of marl pebbles by weathering would give a fairly stiff firm marl, while a slow settling from water suspension would give a deposit of soft loose material.

Relation of timber to marl deposits.

It would be interesting to note the effect of timbering in its relation to the deposition of marl and it seems as tho the effect might be determined. The surface runoff is greater in the case of timbered lands, while in the untimbered country the moisture is long held and is fed slowly thru deep drainage channels to the lakes. In this manner the calcium carbonate content would be greater and precipitation would consequently be increased. Timber also formed an excellent shelter for many small lakes, and this undoubtedly had an effect on deposition as it surely did on the accumulation of marl. This may be noted in the formation of terraces. The writer does not mean that any such effect may be noted since timbering but that wide shelves are more liable to occur in open places where shore currents and waves may be more active. Another possible effect is that heavy timber may so overshadow a shore line that algae may not find the location suitable for deposition, especially in this true if the lake has steep banks. In such cases it is probable that the water remains considerably colder. Numerous small lakes contain a great quantity of down timber along their shore lines and it is surprising to note the amount of deposition (often several inches in thickness) that has taken place on the trunk and branches. This may offer a possible check to Pollock's observations. Of course it must not be forgotten that ice may have some effedt in removing the marl during the winter. Thick timber shows its effect in map no. 8 of Kent county. Both sides of the lake are quite densely timbered, but the north side particularly so with the additional shelter of a steep high ridge. Fig. ( ) shows a section comparable to point (b). The figure also shows how deposition may take place on down timber.

Jointing in a marl bed

The survey pabty of 1925 noted one very interesting case of jointing in a marl bed. This was in connection with a demonstration in which a trench some 100 ft. long and 6 ft. wide was scooped out by the Musselman marl bucket. The faces of the trench showed very distinct hexagonal jointing, the jointing running down to the water line, to a depth of 5 ft. The marl was of a light gray color, but the joint faces were exceedingly dark due to ironstain, organic matter and fine silt. Water circulated fairly freely thru the system as springs issued from the joint planes along the walls. Of course hexagonal jointing suggests tension but the reason for tension in this location with consequent development of the joint system is not clear. (see block diagram fig.)

Fossil marl?

A peculiar deposit of what appeared to be fine grained, compact marl was located in Allegan co. This deposit was on the top of a knob located in material mapped by Leverett as sandy lake bed. This "fossil marl" appeared to be of a very considerable age, much older in fact than the more modern lake deposits. It is a question as to just what period or lake stage the material might have been deposited.

Map No. 1

Mecosta Co. Wheatland Township. Sec. 19.

This map shows exceptionally well the restriction of marl to certain areas in a lake. The sand shore to the south has a rather gentle slope. It is possible that the area marked (a) has at one time been an inlet. It would appear from this map that the deposit was in an early stage of formation, that is to say, as regards filling and not in a time sense. The water is probably low in lime content andthis seems logical since much of the area surrounding the lake is sand, while low hills to the north are of a rather sandy clay. Plant growth has not yet caught up with the marl andthe latter is still in a stage of deposition as suggested by the flaky lime coating on plant stems. Evidences of a shore line show that at some period the lake was several feet higher.

Map no. 2

Oceana Co.

This location shows good evidence of having been spring deposited. The marl is in a long narrow strip bordered on the south by the present stream. The marl is deepest at this point but thins rapidly to the north. A strong spring issues from the point indicated which is at the foot of a steep knob. North of the deposit the area is composed of steep knobs of sandy clay, while the area south of the deposit is more sandy. Prospecting near the spring did not bring to light any calcareous tufa. The marl in the deposit was a creamy to pure white and of about the consistency of rather thick batter as it flowed easily from the sampler tube by gravity. It is suggested that the deposit may possibly have been formed from tufa by a long period of weathering under water. The reasons for suggesting this are:

1. Purity of the marl which is nearly clear white and shows no organic matter. The cream color is due to iron stain.

2. Sharp demarcation between muck cover and marl.

3. The heavy brush and tree growth on the muck.

4. The limited extent of the deposit.

Separately these factors may not mean a great deal but collectively they seem to point to tufa as a source rather than algae. Considerable weight is attached to the brush and tree growth over the marl because normally this growth is a slow process and the brush and tree line keeps well back on the muck and enroaches but slowly. Here it would seem that the growth of both was practically at the same period because the muck is very thin. Therefore the marl must have been relatively firm, certainly tree growth could not have taken place on the present thin marl.

Map 3.

The writer formulates the following hypothesis to explain why marl is here isolated in the deepest portions of the lake bed. (The lake has been entirely drained) The suggestion is, that within certain limits of basin size the marl tends to be deepest in the deeper portions of the basin, but as the basin increases beyond a certain limit the deepest marl tends to be on the borders of the lake basin. At least two factors modify this hypothesis,

1. The amount of calcium carbonate in the water.

2. The rapidity of the plant growth.

Of the two the last is the dominant factor.

Considering the shallow basin type. Up to a certain point say 10-15 ft. algae would not be particularly affected by depth, that is in a lake basin in which such depth was the maximum to be found, for in the summer period the water would be warm and the growth active so that deposition might take place with equal rapidity at all points in the deeper portions of the basin. While in the shallow portions deposition might not take place because of the activity of plant growth which forms the muck cover. Repeating-When at any point conditions for plant growth are more favorable than for deposition of marl the muck cover begins to form and marl deposition does not take place, or if in process, ceases until conditions are reversed. Referring to map 3, it will be seen that deposition has been localized to the deepest portions of the basin while the arms show peat to a depth of 4 ft. At these points probably grew lily pads, sedges, the cat-tail rush and similar plants to profusion but they did not advance rapidly over the deeper portions of the basin. Undoubtedly the lake was also defecient in carbonates as the surrounding material is very sandy.

Map no. 4

Tuscola Co.

This location was included to show:

1. That in bayou marl tends to be lenticular in shape as between points A and B. This is most common in deposits ofthis type.

2. The local effect of streams on marl deposits as at C. At this point marl alternates somewhat with sand, but it is probably material reworked by the stream which has built up a small delta. At present the stream is cutting thru an older delta for the lake has recently been lowered. (See also block diagram pg.)

Map no. 6

Hillsdale Co.

This map shows a not uncommon phase in marl deposition of a marl bar traversing a lake. In most bars so formed there is a basic shelf or platform of sand in this case the shelf is not prominent for depths of 20 feet failed to reveal it. The uncommon feature of this deposit is the fact that the bar entirely traverse the lake dividing it into two parts. Of course this area has been drained and the water level was previously some 5 feet higher, the old shore line being near the heavy black line at the right. If reference is made to pg. it will be noted that marl bars may extend for considerable distance across a lake. Fig. 7 shows a shallow bar containing along its ridge from 4 to 11 ft. of marl. Fig. 8 shows a bar of which the marl is over 16 feet in depth. When a lake is once divided in this manner the filling in of the smaller areas would take place more rapidly.

Lane notes the following concerning marl and its location but states that the rules must not be taken as fixed:

1. Marl is always found in some place that was originally covered with water.

2. The water above marl is usually hard, containing first of all magnesium and calcium carbonates.

3. Hard water springs are everywhere found in close connection with marl lakes.

4. A general rule, that of two depressions, the one most deeply indenting the surface of the land will contain marl.

5. In a chain of lakes the marl is generally deeper and of better quality in the lakes toward the head of the chain.

6. In a large lake or one unevenly and thinly underlain with marl the deepest marl is often found in bayous or indentations of the shore line. In such cases the marl generally thins very rapidly to the deeper portions of the lake.

Blatchley and Ashley conclude,

1. That the marl deposits of Indiana have been formed in the still waters of lakes now in existence or in former lakes, now extinct.
2. That the original source of the marl material is the glacial clay in the region surrounding the lakes.
3. That the deposition of the marl is caused by the loss of carbon dioxide from the sub-aqueous spring waters which bear the marl material into the lakes.
4. That this loss of carbon di-oxide is, for the most part, caused in three ways, viz.:
   (a) By the increase of temperature of the incoming spring water.
   (b) By the decrease in pressure as the spring water rises to the surface of the lake.
   (c) By the action of different aquatic plants in abstracting the carbon di-oxide for food.

Bibliography

The following list is by no means exaustive but is the one used most frequently by the writer as a reference. Other works are mainly botanical in nature and are of slight value in this report.

1. Blatchley and Ashley, Geo. W., The Lakes of northern Indiana and their associated marl deposits. Ind. Dept. Geol. and Nat. Resources 25th annual report, 1900.

2. Davis, C.A. A contribution to the natural history of marl. Jour. Geol. Vol. 8, pp 488-497, 1900.

A remarkable marl lake. Jour. Geol. Vol. 8 pp 498-503, 1900.

A second contribution to the natural history of marl. Jour. Geol. Vol. 9 pp 491-596, 1901.

A contribution to the natural history of marl. Geol. Survey of Mich. Vol. 8 part III, Chap. 5, pp 65-96, 1903.

3. Hale, D.J., Theories of the origin of bog lime or marl. Geol. Surv. Mich., Vol. 8 Chap. 3 pt. 4 pp 41-47, 1903.

4. Lane A.C. Notes on the origin of Michigan bog limes. Geol. Surv. Mich., Vol. 8 pt. 3 Chap. 8, pp 199-223, 1903.

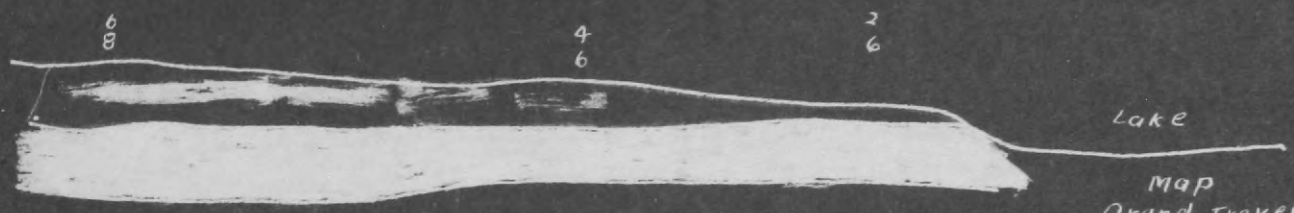
5. Pollock, Jas. B., Blue-Green algae as agents in the deposition of marl in Michigan lakes. 20th Mich. Acad. Sci. Rept. 1918.

No 1



Map
Branch Co.

No 2



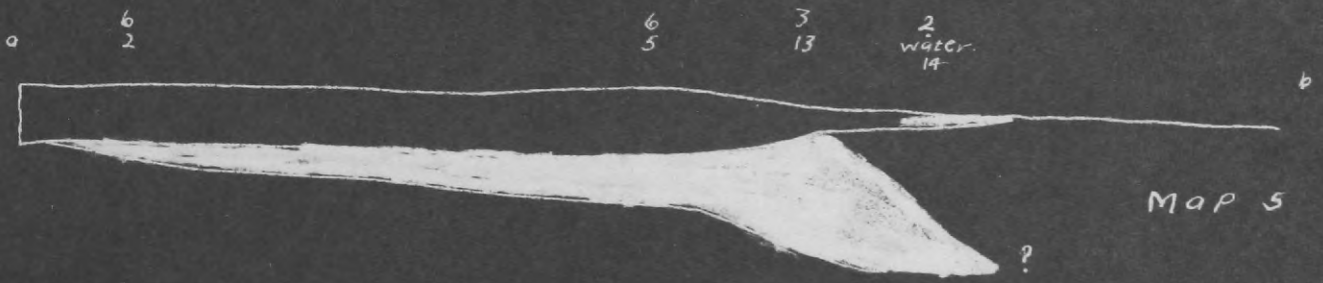
Map
Grand Traverse

No 3



Map 4

No 4



Map 5

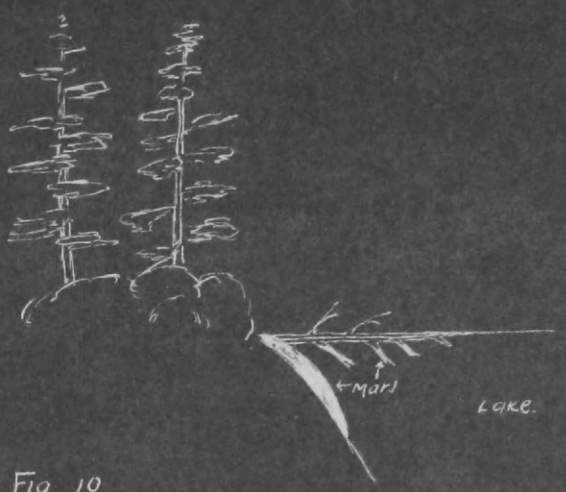


Fig 10

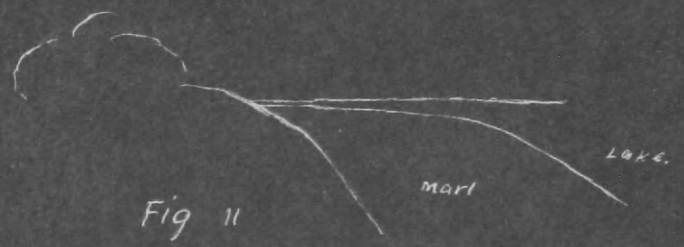


Fig 11



Fig 12

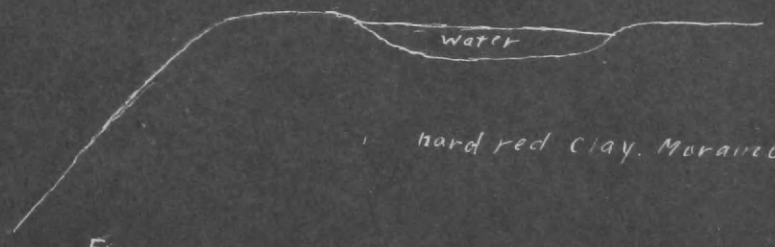


Fig. 13

Fig. 19

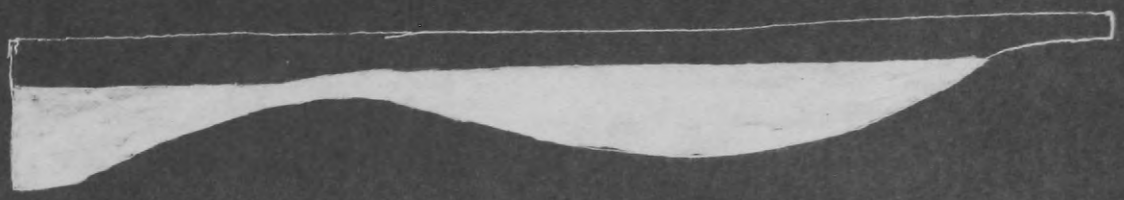


Fig 20

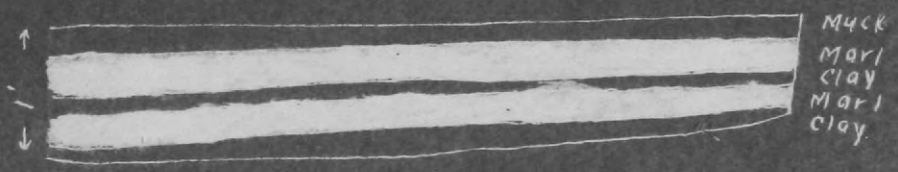


Fig. 21.

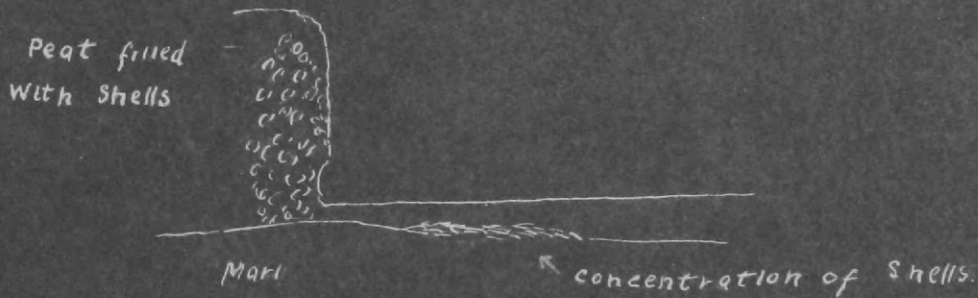
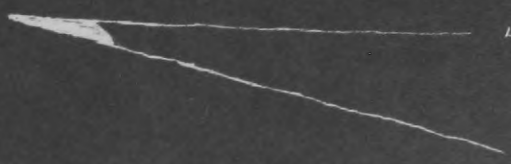


Fig 14 (A)



(B)

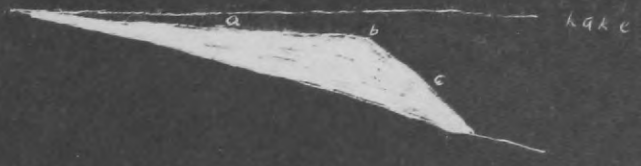


Fig. 15



Fig. 16.



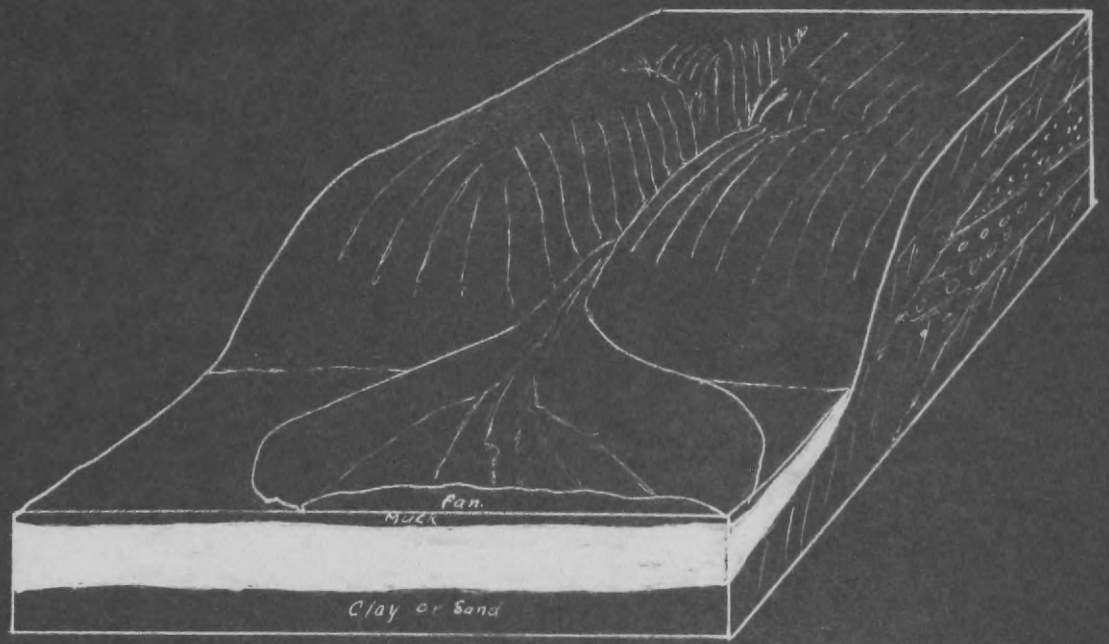


Fig. 17 Alluvial Cone Covering the border of a marl bed.

Pepper

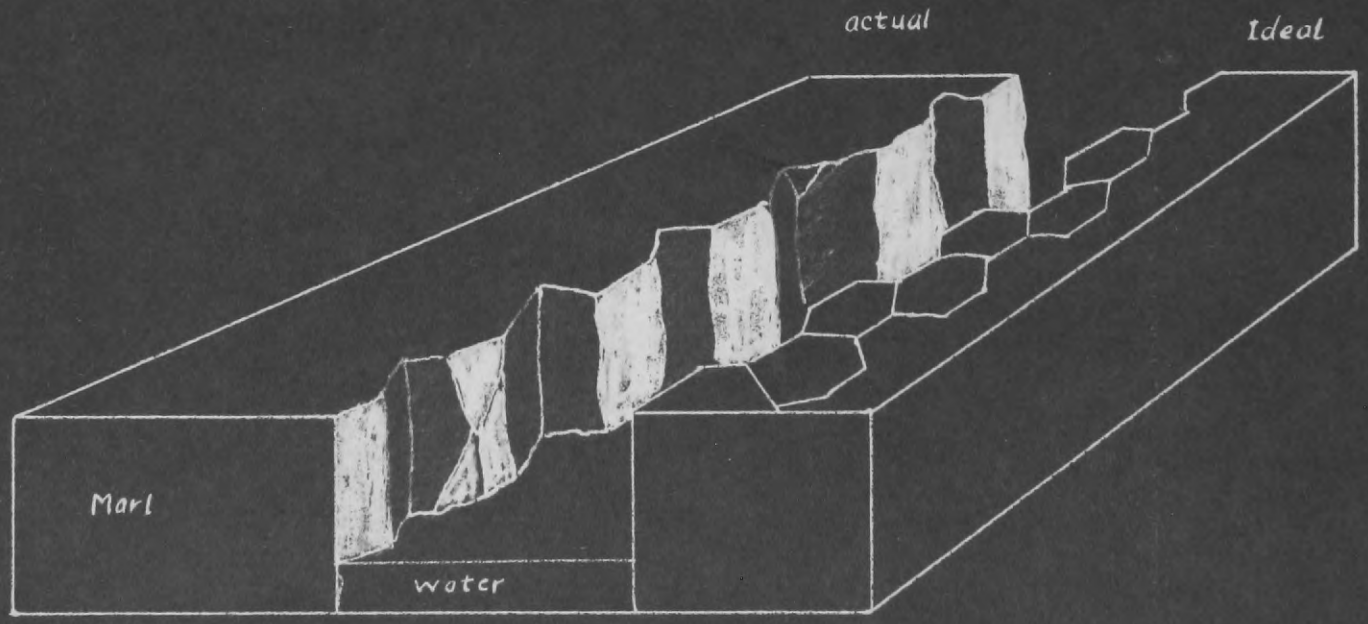


Fig. 18

Block diagram Showing Jointing observed in a marl deposit

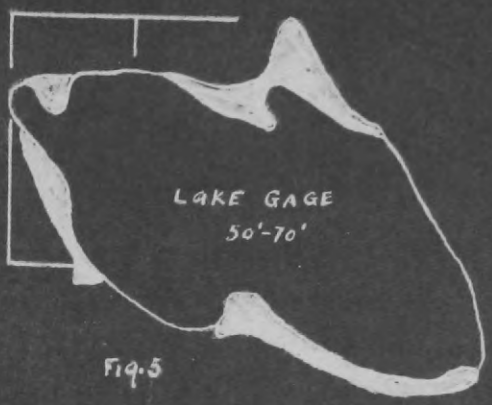


Fig. 5



Fig. 6

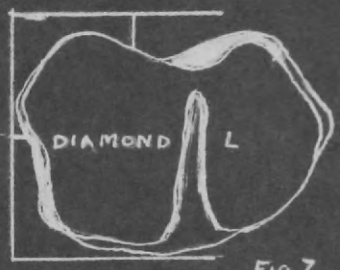


Fig. 7

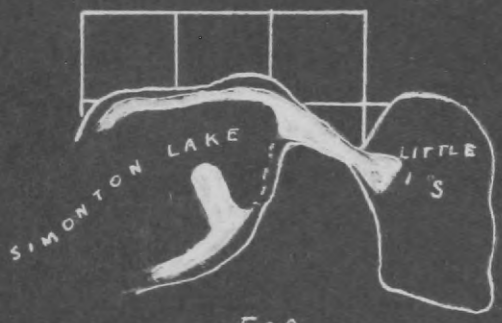


Fig. 8

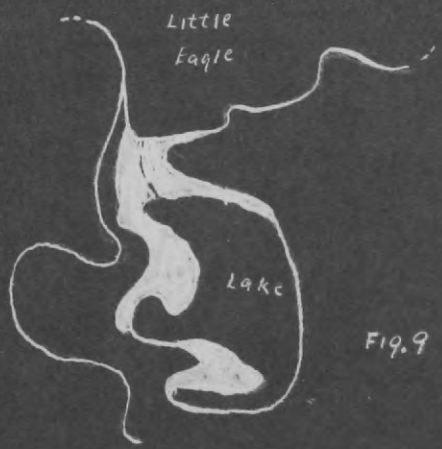


Fig. 9

Maps taken from
Blatchley and Ashley
1900 Ind.

= Marl over 16'

1 sq. = 20 acres.

MAP 1

Mecosta Co.

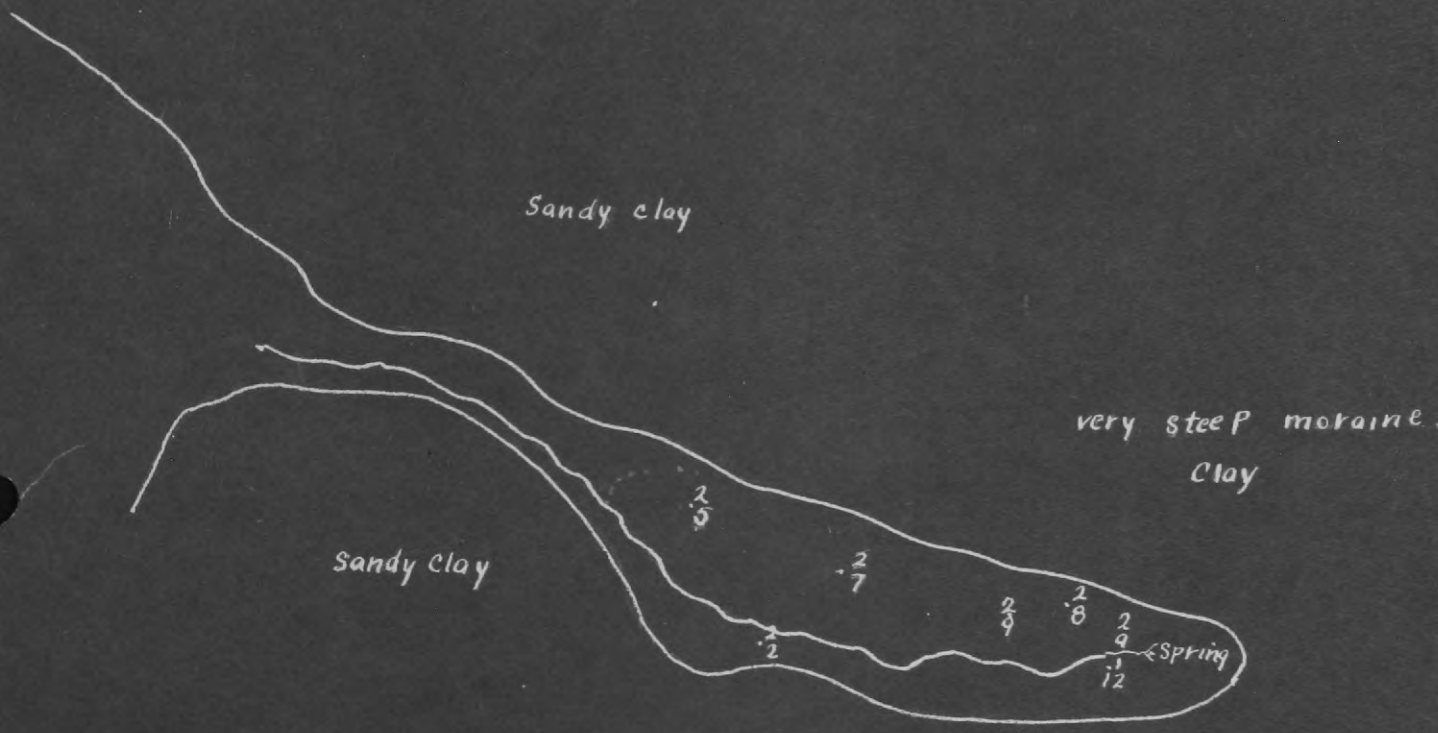
Wheatland Sec 19



Map 2.

Oceana Co.
Golden Sec 28

1" = 165

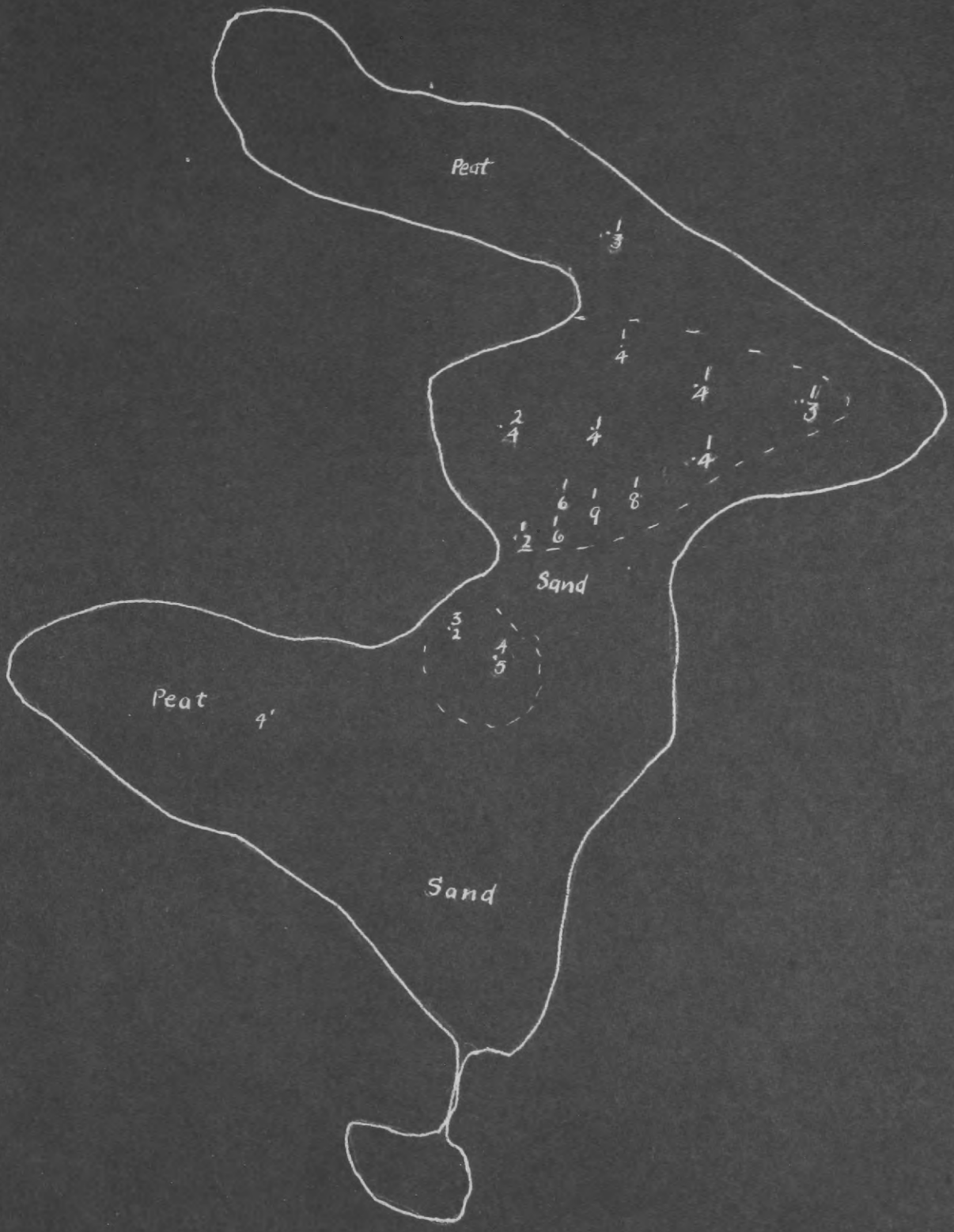


Montcalm Co

Montcalm

1" = 165

Map 3

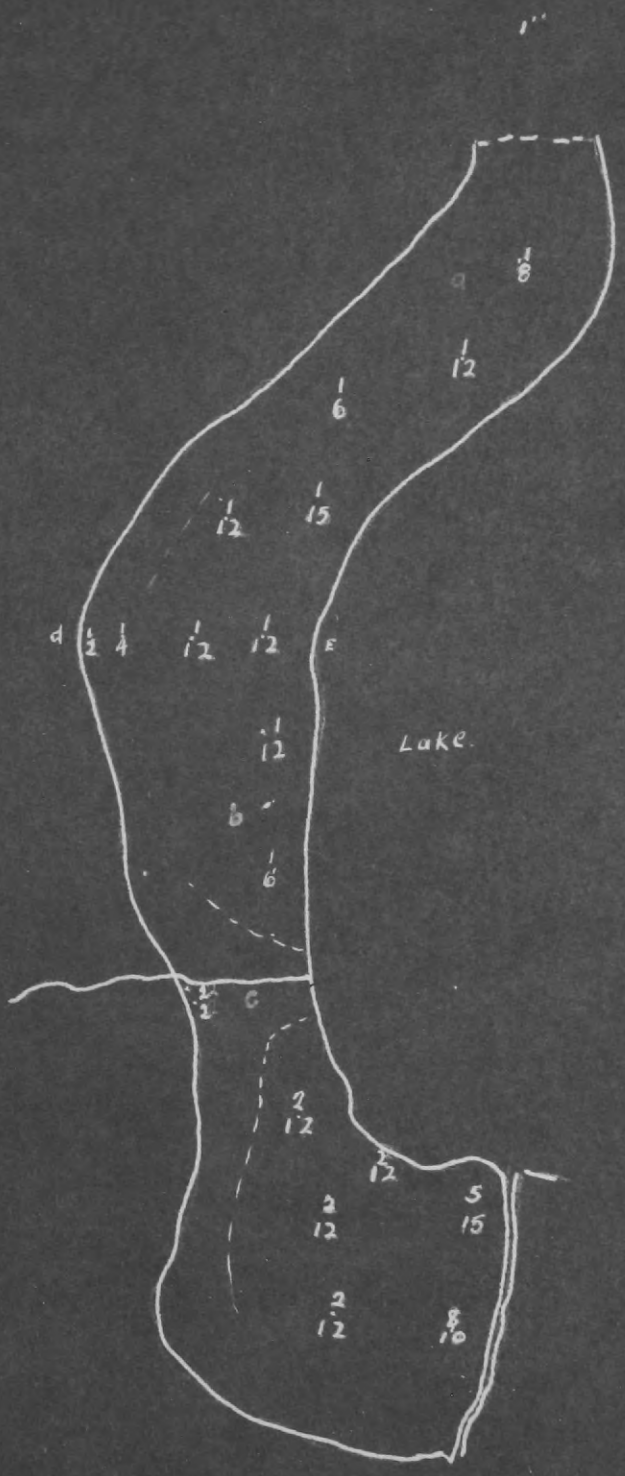


Map 4

Tuscola Co

Dayton Sec 14

1" = 330'



Map 5.

Eaton Co

Windsor Sec 30

1" = 330'

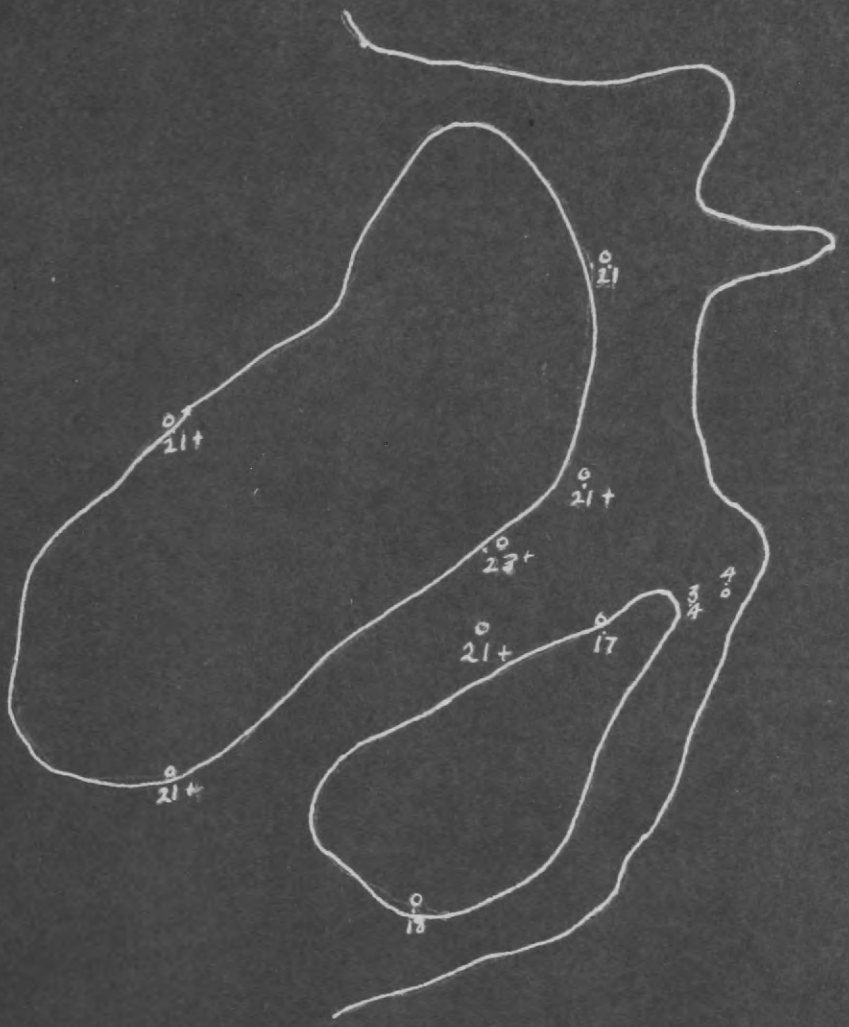


Hillsdale Co

Cambria Sec 21

1" = 330'

Map 6

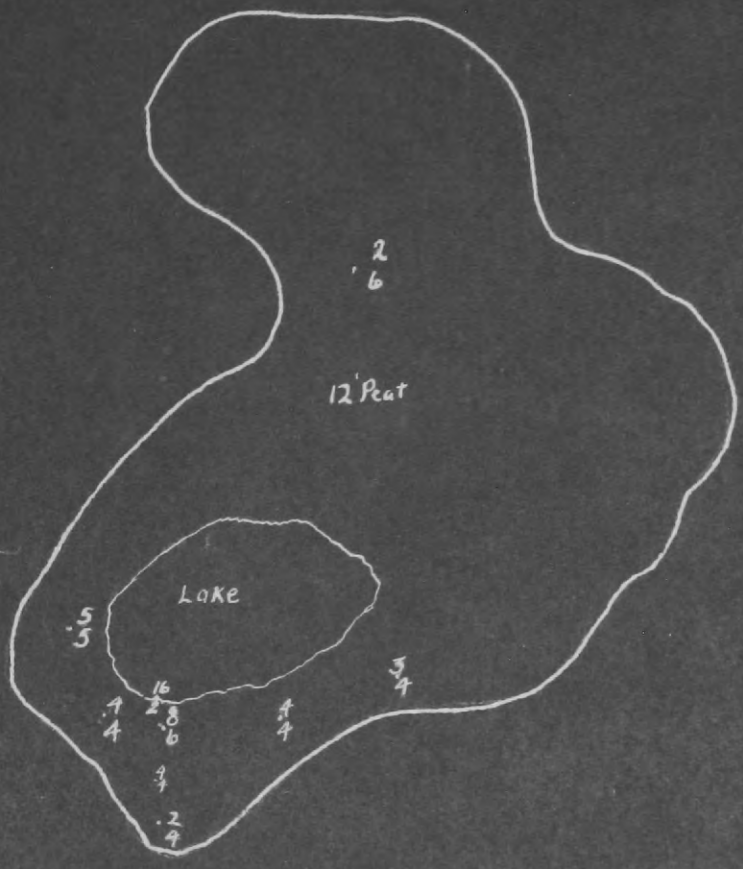


Map 7

Allegan Co

Martin Sec. 31

1" = 330'

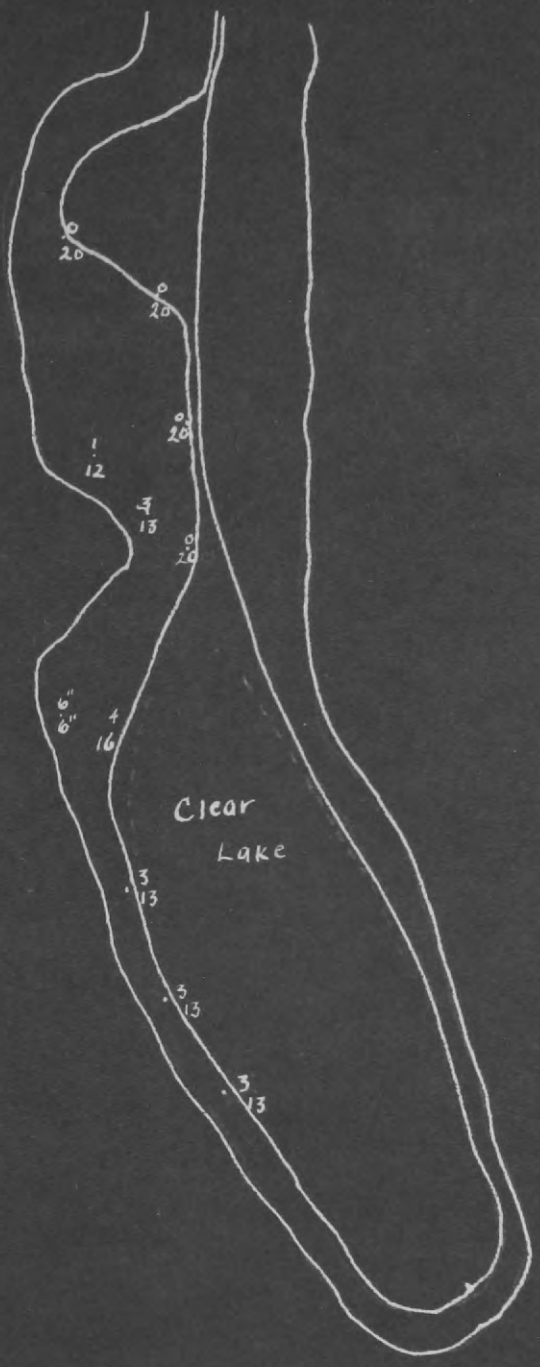


Kent Co

Solon Sec 18

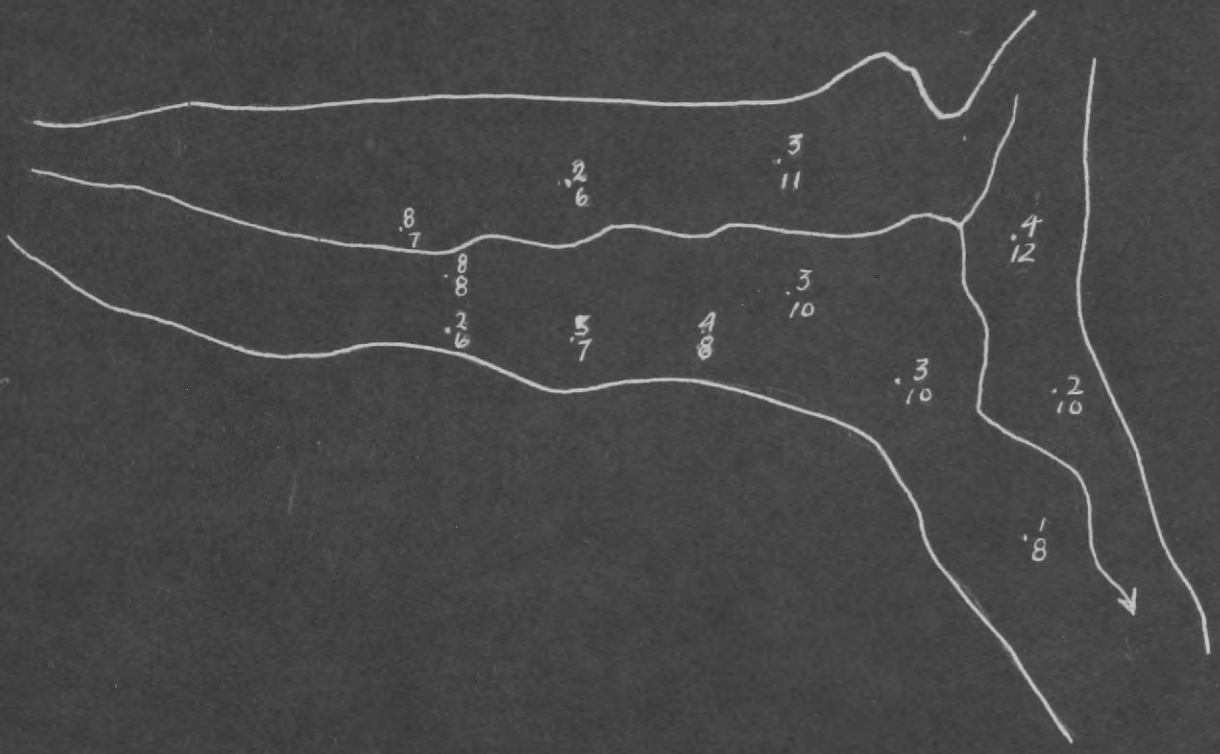
1" = 330'

Map 8



MAP 9

Wexford Co
Hanover Sec 8
1" = 330'



UNIVERSITY OF MICHIGAN
3 9015 00326 9365

