Marl, Its Formation, Excavation, and Use
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and C. E. MILLAR

AGRICULTURAL EXPERIMENT STATION

MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

SECTIONS OF GEOLOGY, AGRICULTURAL
ENGINEERING, AND SOILS

East Lansing, Michigan

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The wide variability in the composition of marl makes it difficult to frame a definition that will completely satisfy all conditions of its occurrence. From the geologist's standpoint, marl may be defined as a loosely consolidated, earthy material composed largely of calcium carbonate. It is essentially a form of limestone which has undergone partial consolidation, but it varies considerably in composition from one deposit to another and often within different portions of the same bed. To the farmer, marl is a substance containing lime carbonate which may be applied, with satisfactory results, to lime-deficient or sour soils just as ground limestone or hydrated lime is used.

Deposits of marl are widely scattered in the region of the Great Lakes, extending through Canada and southward into the states of Michigan, Wisconsin, and Minnesota and also the northern parts of Indiana, Illinois, and Ohio. Its wide distribution throughout Michigan affords a source of agricultural lime which is almost unlimited. Fortunately, the soils in the portion of the states where marl is found most abundantly are particularly in need of lime. It is not probable that the use of marl will become general in sections where marl does not occur because of the expense of excavating, transporting, and applying the material to the soil.

During the past few years, a decided interest has developed in the use of marl for application to lime-deficient soils. It is primarily of greatest value to agriculture since its use on sour soils makes possible a soil rebuilding program based on the growing of legumes, principally alfalfa, sweet clover and red clover. Where it is more readily accessible and its value is fully understood, the quantity of marl which could and would be used to advantage is almost incalculable. To indicate possibilities in this respect, a square mile, 640 acres, of lime-deficient land will require approximately 2,560 cubic yards of marl for one application. Ultimately, the application would need to be repeated although experimental results indicate that such an application on many soils should be sufficient for ten or more years.

Marl has from time to time been employed in the manufacture of Portland cement; and, in various parts of the State where it is abundant, cement plants have been erected to utilize this product. In most instances, however, the life of the industry has been short and the number of plants operating in the state today and depending entirely upon marl for cement manufacture is relatively small. In order to supply the needs of a cement industry, there must be available an almost inex-

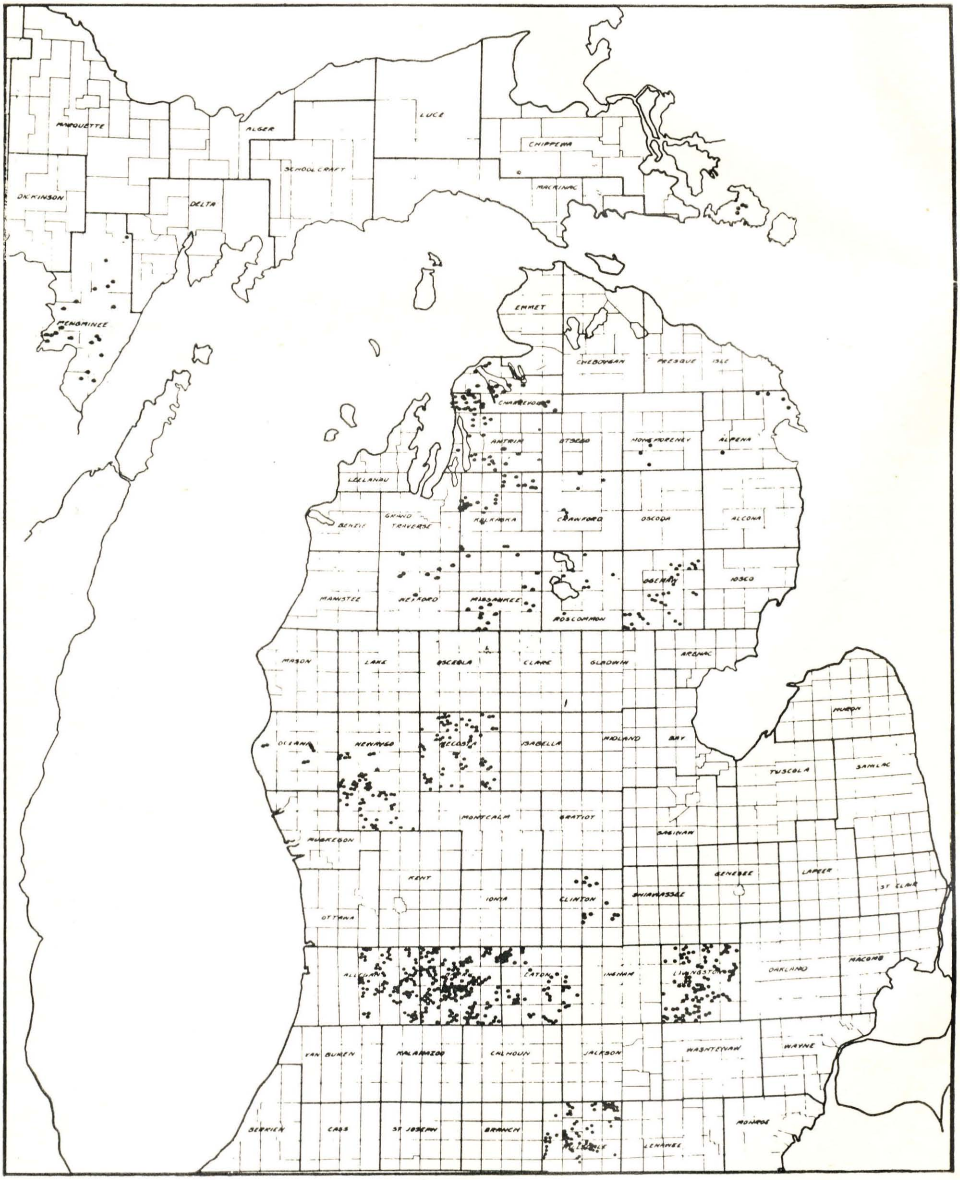


Fig. 1.—Marl deposits in counties covered by marl survey conducted by State Geological Survey. Other counties not surveyed.

haustible supply of marl of good, uniform quality, together with an abundance of high grade clay or shale.

Of particular interest to the housewife should be the use of marl as a scouring powder. Relatively pure marl is usually free from the undesirable grits that scratch and abrade. The material is fairly soft and generally smooth and makes an excellent all around kitchen cleanser. Impure marls containing a large amount of sand and grit should be avoided for this purpose.

THE FORMATION OF MARL

S. G. BERGQUIST

Water as it falls in the form of rain or snow is relatively pure, containing only very small traces of such substances as ammonia, sulphur, and nitric acid that it washes out of the air. As soon as it reaches the surface and begins to percolate through the soil, however, it dissolves small quantities of the minerals with which it comes into contact so that, when it encounters a stream or lake or issues forth in a spring or is pumped out of a well, it contains many substances in more or less dilute solution. Often, the kinds and quantities of materials that spring or well waters contain are such that their presence can be recognized by the taste of the water. Naturally, both the nature and quantity of mineral substances carried in solution by water depend on the character of the soil or rock with which it has been in contact in its circulation. Of all the substances found in the waters of rivers, lakes, springs and wells, lime carbonate is the most common and often it is found in much larger quantities than is any other material.

In many places throughout the glaciated areas of Michigan, the drift or glacial debris, from the weathering of which the soil has been in large part derived, contains considerable quantities of limestone fragments and likewise in many places is underlain with bed-rock limestone. The limestone included in the glacial drift is often found as large boulders or may be present as small nodules and even in the form of finely ground rock flour. It is but natural, therefore, that both surface and ground waters flowing over the calcareous rocks and through the calcareous drift should have a tendency to dissolve out a great deal of the soluble calcium and the water gradually become impregnated with calcium bi-carbonate, $CaH_2(CO_3)_2$.

Chemical Precipitation—As the lime-charged waters flow naturally into basins or depressions, some of the carbon dioxide (CO_2) is liberated and the insoluble calcium carbonate ($CaCO_3$) is precipitated and deposited on the floors of swamps, lakes and stream channels. This deposit is known as marl. Through the thousands of years since the last glacial retreat this process of precipitation has been in continuous operation, with the results that vast but disconnected deposits have been formed.

Accumulation by Plants—In some areas and under certain circumstances, chemical precipitation of lime carbonate from the waters of swamps, lakes, and streams has been greatly aided by the growth and activity of certain types of plants and animals. Such plants, for instance, as *Chara* and *Potamogeton,* which grow only in lime-impregnated waters, extract large quantities of lime from the water, their green coloring matter or chlorophyll gradually becoming incrusted with lime carbonate. When the green coloring matter is destroyed, the plants die and their remains, which have come to be largely calcareous in nature, are deposited on the floor of the lake or swamp along with the material of a similar nature that is being chemically precipitated. Gradually, more plants develop and die; the process continuing more or less indefinitely.

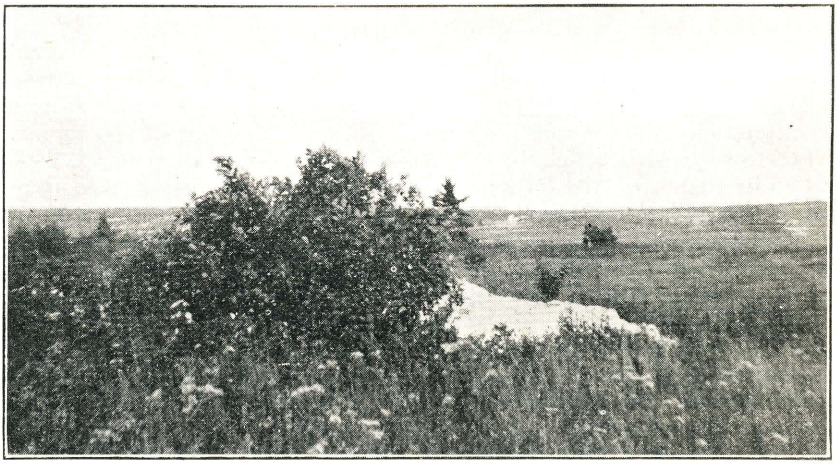


Fig. 2.—Lowland area of marl deposit. The marl in this bed is located in a poorly drained swamp. It is saturated with water and is covered with a layer of peat and muck.

Accumulation by Animals—Similarly, many of the lower forms of animal life inhabiting lime-impregnated waters accumulate lime which is in turn deposited on the floor of the lake or swamp when they die. This is evidenced by the numerous fragments and shells of molluscs and other shell-forming animals found in many of the marl deposits.

The wide distribution of these animal and plant remains in marl beds of Michigan indicate that organic agencies have been active in their formation. However, the fact that many deposits contain no such remains leads to the opinion that they have been secondary in importance to the more strictly chemical processes. Presumably, the organic agencies did not become operative until the proper conditions of alkalinity had been reached in the waters while, in the meantime, chemical precipitation had been steadily progressing.

TYPES OF DEPOSITS

Based on their relationship to the water table, marl deposits in Michigan may be classified into two groups, namely, lowland and upland types.

Lowland deposits are those which are found below the normal water table and in such positions as to be saturated with water. They occur in layers of varying thickness up to 30 and more feet, in swamps and marshes, in lakes, and occasionally in river beds. The beds are generally covered with a layer of peat and muck which in many instances has accumulated to fairly extensive depths. In some localities, however, marl is still in the process of formation and is accumulating more

Fig. 3.—A marl deposit located in the lower terrace or flood plain of a stream. The material is below the normal water table and consequently is water saturated. The bed is mantled with a thin cover of peat intermixed with sand.

rapidly than is the encroaching vegetation in the basins. In some lowland types, layers of marl are separated by thin layers of peat. Such conditions indicate interruptions in deposition and changing environment during the process of sedimentation.

Marl which has formed completely under wet conditions usually contains a large amount of excess water and is sticky and difficult to handle. It should be heaped up in piles and allowed to drain and to weather thoroughly. This process tends to remove the excess water and allows the included gases, if present, to escape. The marl is thus rendered more friable and made less difficult to apply to the soil. Ordinarily, a thin, hard crust forms on the outside. If this is broken up from time to time, drying will proceed more rapidly, though this is not necessary with marl of a relatively high grade. Marl that has considerable clay intermixed is so sticky and dries so slowly that the practicability of its use as a soil amendment is questionable.

Upland deposits are more limited in their distribution, but, in some sections of Michigan, constitute deposits of great importance. The marl is concentrated largely in beds that lie above the present normal water table. It is found in terraces of lakes, in which the water level has subsided, and in the upper flats, terraces, and old meander channels of rivers and streams. The deposits are relatively thin, seldom exceeding 10 feet, and often are subject to inundation in periods of excessive rainfall.

Fig. 4.—Upland area of marl deposit. The marl in this bed is situated in the upper terrace of a stream which now flows in a channel about a quarter of a mile distant. The deposit lies above the normal water table, is comparatively dry, friable and easily worked. It has a mantle of only a few inches of wind drifted sand.

The surface cover in the upland deposits is generally so thin as to be practically negligible. It consists merely of a few inches of muck or occasionoally a thin mantle of wind-drifted or water-laid sand. In some of the beds, thin streaks of sand are interbedded with the marl, but not in sufficient amounts to be of serious consequence in the economic handling of the deposits.

The upland deposits are usually dry and consist of marl which is ordinarily friable and for the most part pure. They are readily accessible and easily worked. The marl in these beds lies sufficiently near the surface to be subject to weathering activities. As a rule, it is porous enough to have become completely aerated and may be applied directly to the soil with effective results.

DISTRIBUTION OF DEPOSITS

Marl is very widely distributed throughout the State and some accumulation of it is quite likely to be found in most of the depressions which are situated in the calcareous drift of the various morainic areas. In the sandy outwash areas, especially where the soil is more or less acidic in character and contains little or no calcareous material, marl either does not accumulate at all, or if it does form, develops at a very slow rate. Consequently, the depressions in such areas are more of the bog type filled with acid peat and supporting a growth of acid-loving plants.

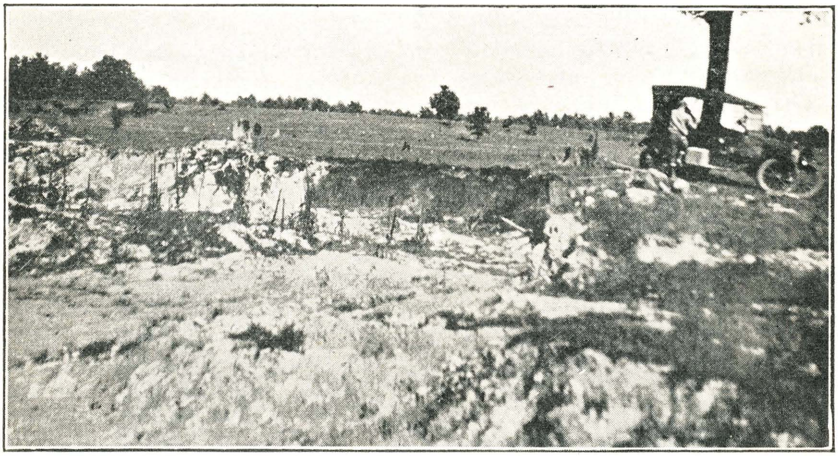


Fig. 5.—Upland marl deposit. Marl beds of this type, situated above the level of ground water, are permanently dry and may be worked with little difficulty or expense. They are accessible at all seasons of the year.

Lowland deposits of marl vary considerably in extent and thickness, depending in a large degree upon the character of the basin in which they develop and also upon the supply of calcareous material available to the inflowing water. Many of the larger, as well as the smaller, glacial lakes of the State are floored throughout with marl of varying degrees of thickness. In others, the marl may occur as a narrow rim or shelf around the margin which occasionally develops to a considerable thickness. The swamp deposits of marl are limited in extent and thickness by the depressions which confine them. They range in area from merely a fraction of an acre to several square miles in some localities and often reach a thickness of 30 and more feet.

The upland deposits are naturally restricted in extent and thickness. They may often cover an area of many square acres but never reach the magnitude of the larger lowland types. They occur usually as narrow strips or belts which follow along the older stream courses or as terrace lands which skirt the borders of receding or decadent lakes. Deposits of this type are normally not continuous over long distances and as a rule do not average more than five or six feet in thickness.

PHYSICAL PROPERTIES OF MARL

Color—The raw marl, as freshly dug, generally contains a considerable quantity of water, together with varying amounts or organic matter. Its color depends to a large degree upon these associations and varies from light gray when pure to a darker gray when intermixed with quantities of vegetable remains. Upon losing moisture, the material gradually assumes a lighter color and may be almost white when free from impurities. Though color is not a reliable index to the purity of the marl, it usually follows that the lighter the color the more pure will be the material. Some of the dark gray deposits, however, have shown analyses much higher in calcium carbonate content than many of the lighter colored ones.

Structure—In the moist condition, pure marl has a tendency to be smooth and rarely, if ever, gritty. When clay is intermixed it assumes a plastic or sticky feel, a property which increases with the amount of colloidal material present. Upon drying, the marl breaks up into a lumpy structure and becomes friable or powdery when exposed for some time to the activities of weathering. The material never occurs in the crystalline state but always maintains an amorphous or noncrystalline form.

Impurities—The depressions in which marl accumulates are generally so situated as to form natural drainage pockets for waters which flow from the higher surrounding areas. Land-derived sediment, such as sand, silt, and clay, transported in the surface water is carried into the basins and becomes interbedded with the marl. Shore wash along the margins of lakes in which marl is forming tends also to contaminate the deposits with undesirable impurities. The prolonged accumulation of sediment ultimately results in the filling of the basins and the development of marshy and swampy conditions.

The growth and decay of plant life within the marshy borders often results in the formation of an organic layer of peat which tends to seal up the surface of the area and prevent further marl accumulation. In this manner, the marl becomes buried beneath a mantle of peat and muck often to considerable depths.

EXCAVATING AND HANDLING MARL

H. H. MUSSELMAN

The occurrence of marl in the light land areas of Michigan and the other Lake States makes it of considerable importance to agriculture in this section. Its use for correcting soil acidity is particularly needed in the areas in which it is found. Michigan probably has enough marl to supply, for generations, the farmers within hauling distance of the beds but; it is not likely that its use will extend outside these areas because of economic limitations connected with its excavation, handling, and application.

Marl is usually found in or near fresh water streams, lakes, and marshes. For that reason, the deposits are likely to be concentrated at places where it is more or less inaccessible because it is usually inundated or saturated with water. Considerable expense is involved in excavation and transportation. The amount which may be taken from any one deposit is limited by the needs of the land, the expense of getting it from deposit to field and the inclination or ability to make use of it by those whose land would be benefited. The extensive use of lime and marl is comparatively recent, and not all possible users are fully apprised of its value. Limestone is sometimes preferred to marl for correcting soil acidity on account of favorable economic factors.

Fig. 6.—Soft marl is found even where little water collects in the trench. Relation of overburden to depth of marl is also illustrated.

It is possible to secure limestone at any time, and it is spread more easily than marl. These advantages are frequently offset by the smaller cash outlay required for marl and the fact that its use is often possible where labor and farm transportation facilities only can be used.

The commercial possibilities for marl for uses other than agriculture appear limited. Its use thus far has been principally as an ingredient for making Portland cement. For this purpose, very large deposits and a favorable market are necessary to justify the establishment of a manufacturing plant and facilities. Other commercial uses may be found; but, since limestone will meet many of the requirements of a material of this nature, it is improbable that a large market will be afforded. The problem of utilizing marl is one of making this natural resource available to agriculture. The use of large quantities is an important factor in this plan, since quantity is necessary to justify the overhead and operating cost of equipment which is often indispensable to place it at the disposal of the user.

Properties of Marl

Marl is found in locations and has properties which, from a material handling standpoint, make it unique. Saturated, a unit of marl weighs about 50 per cent more than an equal volume of water; when air-dried, a considerable loss of water as well as volume takes place so that the material weighs about 1,500 pounds or more per cubic yard. Careful measurement, on piles of marl excavated for use after air-drying, indicates that shrinkage may be 25 per cent or more after excavating. This may account for discrepancies found between amounts excavated and amounts actually available for use. When mixed with water, marl which is in a very finely divided state remains in suspension for a considerable length of time. Though it does not readily dissolve or mix with water, the stirring caused by excavating equipment may be sufficient to cause a considerable loss of material as well as a decreased efficiency of operations.

A spade or shovel thrust into marl reveals it as soft, spongy, and extremely sticky. The latter property of adhesion has made its excavation with the slip scraper and other small equipment practically impossible. This property does not interfere where larger masses are handled, probably because the weight is greater in proportion to the surface to which it clings, and because the coherence of large masses is less effective than in small masses. The adhesion of marl, especially to surfaces of excavating equipment, combined with the partial vacuum or suction effect, makes it necessary to take these properties into consideration in the design of excavating equipment. The spongy characteristic is encountered in attempting to set anchor posts, which must be weighted and twisted into the marl instead of driven. Marl has little abrasive action and forms an excellent lubricant when mixed with water.

Not all marl deposits can be profitably excavated. Usually, the deposits are in a lake with marshy shores or in a marsh overlaid or partially overlaid with water. Often the deposit becomes thinner near the edges so that it may be necessary to go a considerable distance over the muck and marl before a sufficient depth of marl is found to warrant the expense of excavation. With water present, it is necessary to have the marl delivered on solid ground before transportation can be used readily. In rare cases only is the deposit of marl exposed on the surface. Any considerable depth of overburden, usually consisting of muck and peat, increases the cost of excavation. Figures from the State Geological Marl Survey, Barry county, show the ratio of average depth of overburden to depth of marl for beds of marl workable by hand to be 1 to 6½. For deposits workable with power equipment, the ratio is given as 1 to 8¾. The surface is sometimes covered with tough marsh grass which makes the removal of overburden difficult. Explosives may sometimes be used to advantage, although their use demands some skill on the part of the user and entails considerable expense.

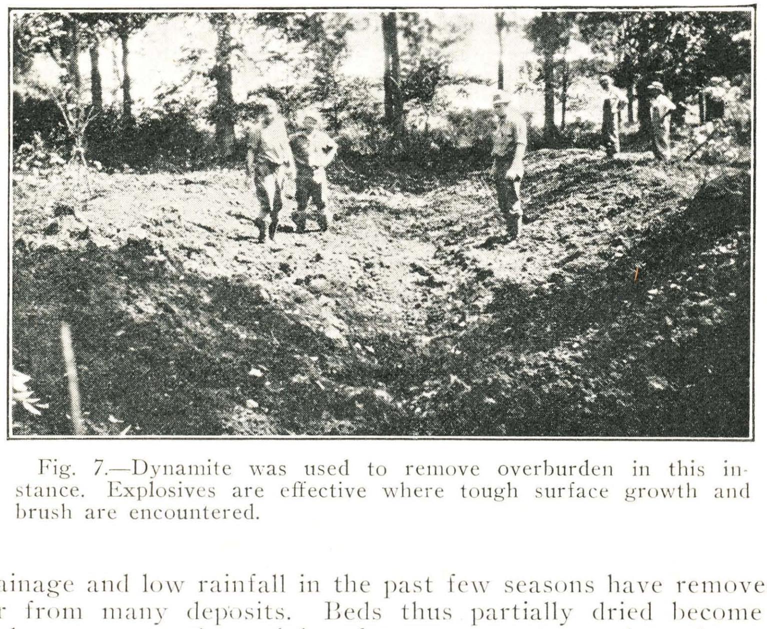


Fig. 7.—Dynamite was used to remove overburden in this instance. Explosives are effective where tough surface growth and brush are encountered.

Drainage and low rainfall in the past few seasons have removed the water from many deposits. Beds thus partially dried become firm enough to support the weight of teams, wagons, and trucks so that excavation by hand shoveling directly from the beds has become more general and accounts in part for the great increase in the use of marl.

Marl is Excavated in Several Ways

Digging by Hand—Many methods of digging have been devised, prompted in most cases by local conditions and equipment available. Since the amount of marl dug is limited, adapted commercial equipment is not available for this purpose, although some of the larger units are adapted to digging economically.

In 1931, due to lack of rainfall, about 80 per cent of the pits were dug by hand. In some cases, the marl was firm and dry enough to permit driving wagons into the excavation, which made the problem comparatively simple. In many cases, however, it was necessary to drive alongside the excavation to elevate the material a considerable height. Sometimes, planks, brush, or timber were used to construct a ramp into the pit so that the wagon or truck could be backed into it. Marl on the surface tends to make the drive and ramp very slippery. A long rope is sometimes attached to the vehicle in the pit and to a power unit outside the pit where the traction or footing is better than in the pit or on the ramp. Marl may be dug by hand during the winter months. A frozen surface will provide support for the hauling equipment and, in some cases, shut out surface water from the pit. If

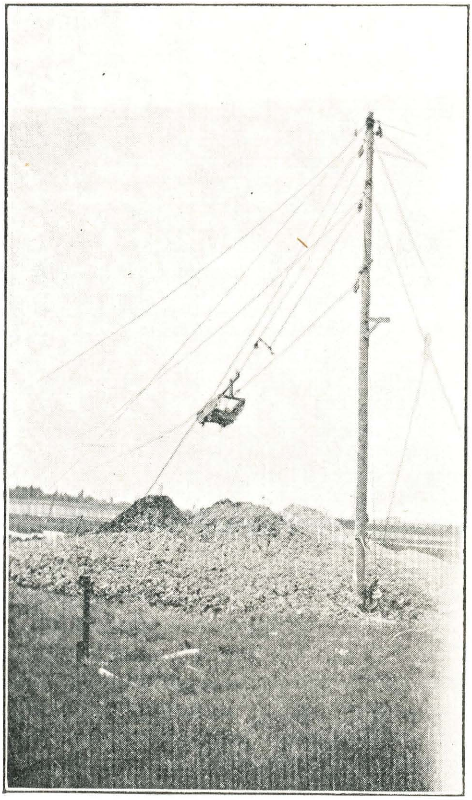


Fig. 8.—This is a single pole mast and cable rigging.

seepage into the pit occurs, the water may be removed with a hand or power driven pump.

Farm Owned or Cooperatively Owned Equipment—Farm owned or cooperatively owned marl digging equipment has accounted for approximately 10 per cent of the marl dug during the past season. In wet seasons, machine digging will probably increase. The small outfits used by individuals or small groups have consisted of special buckets and other equipment devised and assembled by the operators themselves. Horses, rebuilt automobile engines and tractors have supplied power which has been applied as direct pull on the cables carrying the bucket, or through single or double drum hoists.

Contract Digging—Most of the remaining 10 per cent of the total number of pits were dug with portable, contract equipment which could be moved at a reasonable cost. There are a few stationary plants where marl has been dug for a number of years. Within the past two seasons, a few publicly owned road building cranes, equipped with clamshell buckets, have been used. They have made excellent records for low cost digging, although a large quantity at one place is necessary to justify overhead and moving expense. This plan should be encouraged where it is possible to carry it out.

History of Digging—Experimental work on digging equipment was begun in 1915-1916 by the Agricultural Engineering Section. This work was begun in response to numerous inquiries about types of equipment which could be used for digging. The equipment, later described, is the outcome of work along this line for a number of years. At the time the experimental work was started, there were many ideas as to methods. Practically all of these were tried in one way or another by different parties. As a result of all these trials, it appears that two general ideas survived.

One of these is the portable slack-line cableway which carries the bucket on a slack cable, with a special bucket for the smaller outfit. The other is the crawler tread road building crane using the clamshell bucket for handling the marl, mentioned above as being economical when large quantities are excavated. The drag-line system used in gravel is not suited to digging marl, because the bucket, dragging in the trench, tends to pull marl back into the pit.

One of the first efforts at mechanical digging was made by Joseph Carnes, Ceresco, who followed the plan of using a centrifugal pump with a separate agitator for mixing water with the marl to prepare it for pumping. This idea was developed to a point where several thousand yards were taken out in one season. Considerable equipment and labor to operate successfully were required. Perhaps for this reason, it has not come into wide use.

Special Marl Digging Equipment—The original plan for the development of marl digging equipment demanded an outfit which could be afforded by the marl bed owner, or one on which the costs, overhead and operating, would be justified by the amount of marl used by one man. This development was begun at a time when the use of lime and alfalfa was comparatively new, and not many farmers were convinced that marl had real value. It was thought that such an outfit would do much to promote the use of both marl and lime, and increase the users of marl as they discovered its merits. It appeared, at one time, that the low cost outfit was impractical, so a larger contract type of outfit was worked out. This did not completely serve the purpose. One of the difficulties was the cost of the double drum hoist of sufficient strength to operate the equipment. Later a smaller outfit was designed which permitted the use of either horses or tractor on a direct pull. This eliminated the cost of a hoist, although it too could be operated at greater capacity with one. It was operated in 60 locations during the season of 1929-31 and has proved its adaptability to practically all conditions, except where very thin or soupy material is encountered.

Equipment for digging marl developed at this Station is designed to meet the following requirements:

1. Low first cost of outfit; 2. Durability; 3. Built as far as possible from standard, easily obtainable materials; 4. Should not require excessively strong anchorage or high, unwieldly mast. Should be adapted to anchorage in practically any location, even in the marl bed or lake, if necessary; 5. Should not require excessive pulls or lifts; 6. Should be easily adapted to either horse or tractor power on direct pull; 7. Should

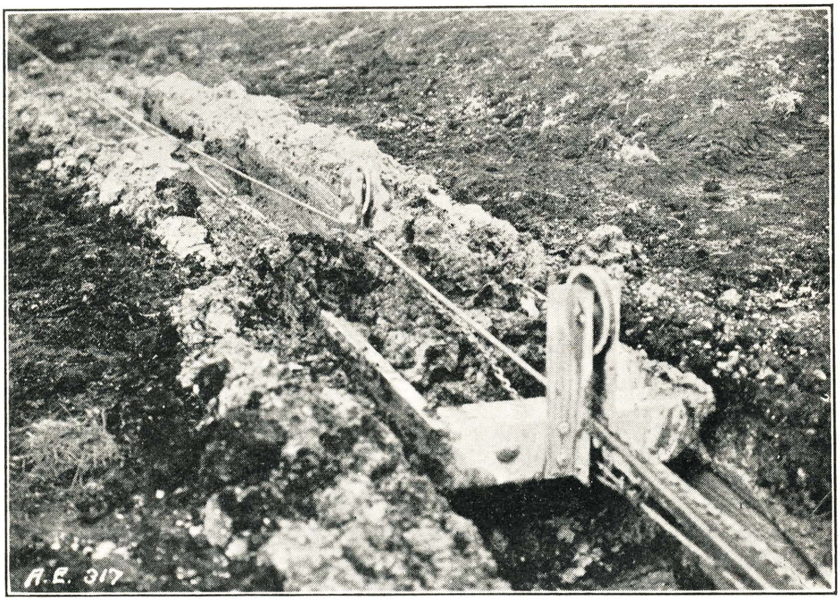


Fig. 9.—Showing front of a special marl bucket at the outer end of trench which is being opened. This marl had little overburden.

not require highly skilled operator; 8. Should be easily transported and set up for service in more than one community, if desired; and 9. Should justify overhead cost in excavating not over 200 yards per year.

Design of Bucket—The size of the bucket which is rated at one-fourth of a cubic yard was selected as being most suitable for small power units. It represents an attempt to select a satisfactory size for varying conditions as to investment, capacity, anchorage, pulls, and ease of operating. It is realized that a larger size would give greater capacity, but since it is a type of equipment, which, like many other farm machines, may be used only a few days a year, additional size, calling for larger equipment and more power, would tend to make costs prohibitive on small operations.

A few features of the design should be noted. The stickiness of marl has made a positive unloading device necessary for the small unit. This has been accomplished in this design by using a wide rubber belt to line the bottom and back of the bucket. This belt is riveted to the cutter at the lower end, and has a push rod tripping device which pulls the upper end forward when actuated by a stop on the cableway. As the upper end of the belt lining is pulled forward, the load is rolled out of the bucket. The flexibility of the belt tends to make it slip over the surface of the marl and prevent sticking. The bucket is also designed to slice the marl from the surface of the cut in as thin a layer as possible. In hard marl, this may be as little as two inches while for softer material it may need to be cut six inches or more. Thickness is determined by a plate set at an angle in front of and above the cutter. Both angles of plate and the distance ahead of the cutter are adjustable.

Bill of Materials for Special Bucket for Marl Digging Equipment

1. "Musselman" bucket ¼ yd. capacity	$60.00
2. 300 ft. ½-in. 19 strand plow steel, trolley cable (wire rope) @ 9c	27.00
3. 1,200—⅜-in. 19 strand plow steel working cable (wire rope @ 7c	84.00
4. 6-8-in. wire rope tackle blocks @ $4.50	27.00
5. 1 set double tackle blocks with 100-ft. rope ¾-in. rope	6.00
6. 8 pieces chain 3 ft. long. Each fitted with grab hook..	4.00
7. 1 doz. ½-in. cable clamps	1.00
8. 1 doz. ⅜-in. cable clamps	1.00
Total	$210.00

The estimate of cost is based on 1931 prices.

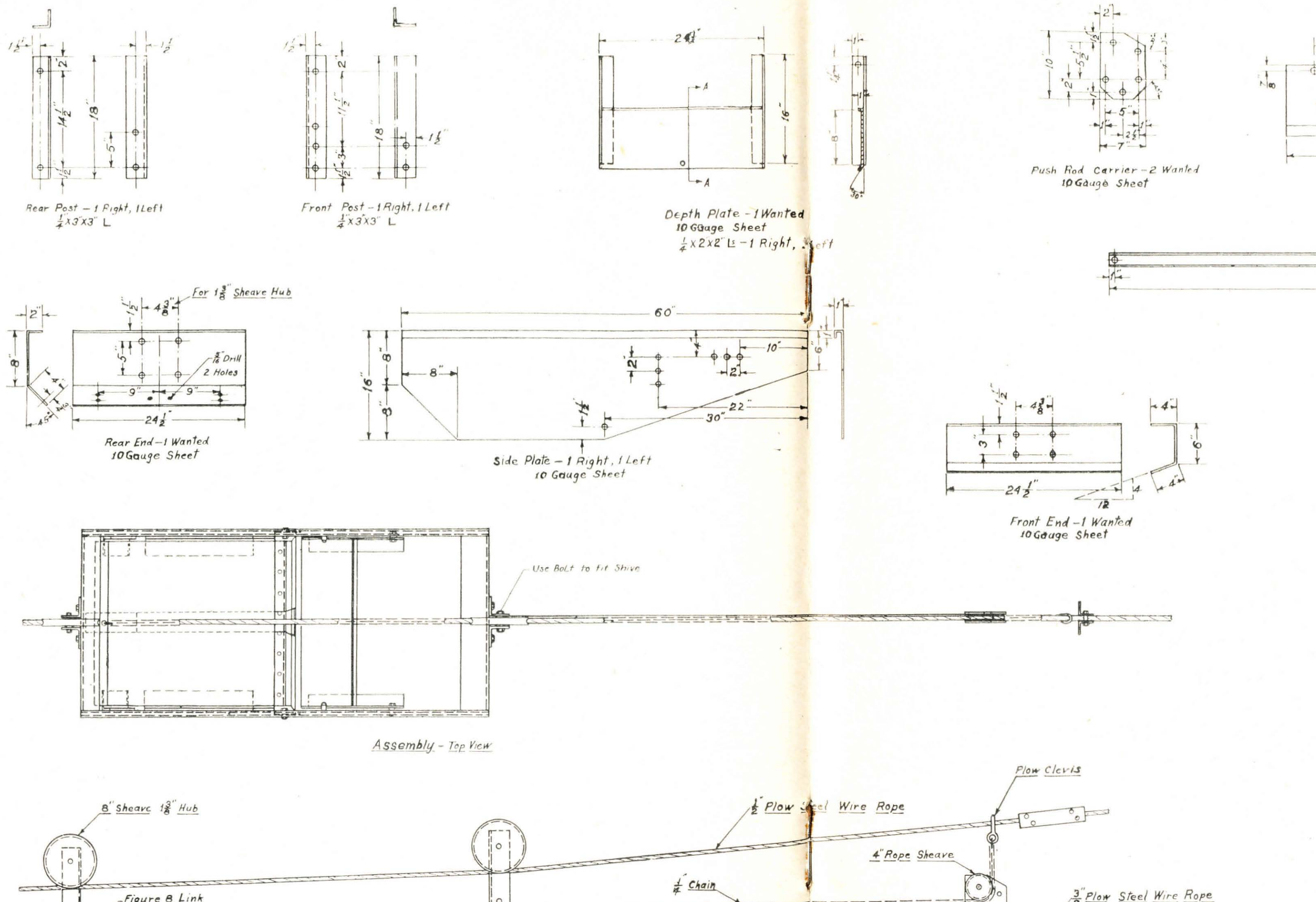
Enough ⅜-in. cable is included to guy the mast. The material, except for the bucket, may be purchased through the local hardware dealer or other sources. Assembly and detail plans for the construction of the bucket are shown in Figure 10. It may be made by any good metal working shop or purchased from sources suggested by the Agricultural Engineering Section of the Experiment Station. In addition to the above material, which must be purchased, the following items will be needed which can be supplied at a small cost locally.

Mast—1 stiff pole 20-25 ft. long 6-in. top diameter.

Cableway anchors—2 sections of logs or poles 6-in. diameter, 5 ft. long.

Mast and extra anchors—7 sections of logs or poles, 5-in. diameter, 5 ft. long.

Direct Pull Operation—To eliminate the expense of a double drum hoist for operation, the method of direct pull is substituted by adopting the triangle arrangement of cables. In using this arrangement, the bucket travels back and forth along one side of the triangle, and the power back and forth along the second side, loading the bucket in one direction and returning it in the opposite direction. The third side forms a complete circuit of the cable, each free and being attached to the bucket. Various modifications of the triangle permit the power to travel in a selected path in almost any direction in relation to the


Rear Post – 1 Right, 1 Left
1/4" x 3" x 3" L
Front Post – 1 Right, 1 Left
1/4" x 3" x 3" L
Depth Plate – 1 Wanted
10 Gauge Sheet
1/4 x 2 x 2" L – 1 Right, 1 Left
Push Rod Carrier – 2 Wanted
10 Gauge Sheet
For 1 3/8" Sheave Hub
3/16" Drill 2 Holes
Rear End – 1 Wanted
10 Gauge Sheet
Side Plate – 1 Right, 1 Left
10 Gauge Sheet
Front End – 1 Wanted
10 Gauge Sheet
Use Bolt to fit Shive
Assembly – Top View
Plow Clevis
8" Sheave 1 3/8" Hub
1/2" Plow Steel Wire Rope
4" Rope Sheave
1/4" Chain
Figure 8 Link
3/8" Plow Steel Wire Rope

path of the bucket and at any reasonable distance from it. The triangle system of operating is shown in Fig. 11.

Setting Up Equipment—Material is first assembled. A survey is made of the ground to determine the exact location of trench which will yield a good quantity of marl, and permit piling it upon solid ground. To determine the depth of marl available, a fish pole or long iron rod may be pushed through it at different points along the line of the proposed cut. The possibility of using trees or posts for anchorage should also be considered, as well as the location of the runway for the power unit in operating.

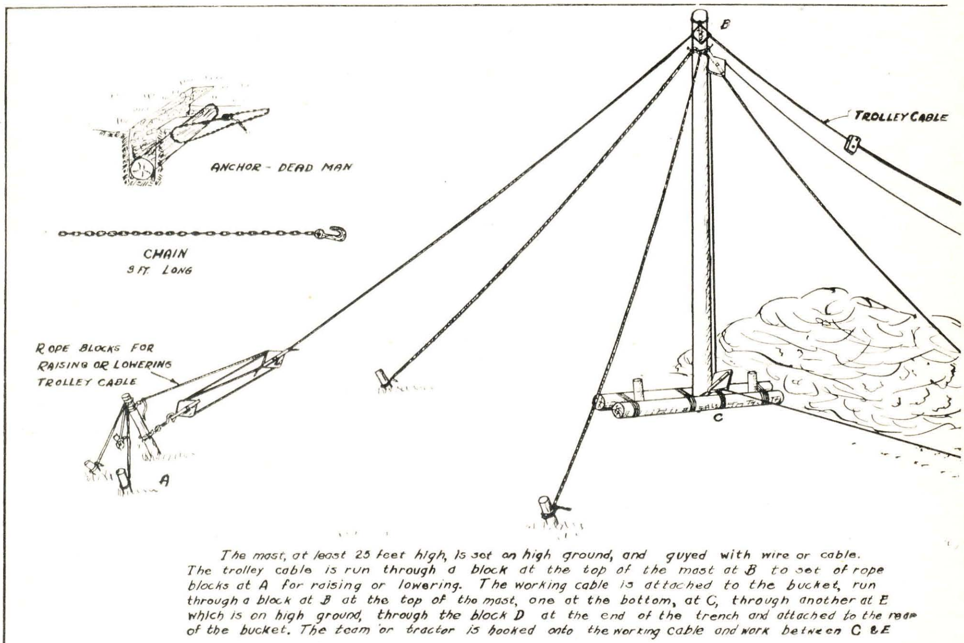
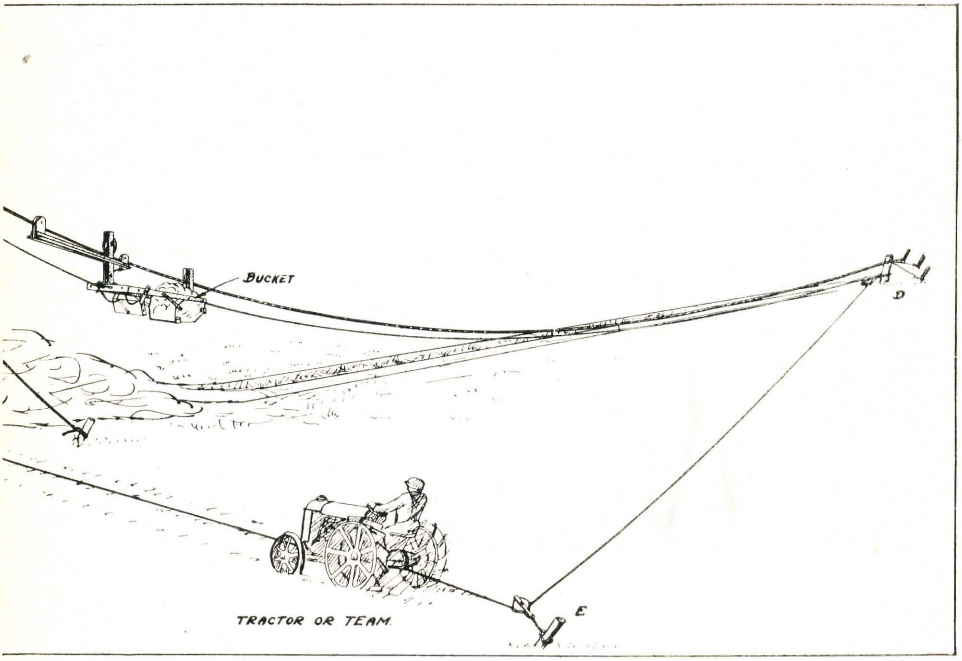


Fig. 11.—System of arranging cables

Anchors—Trees or posts may be used in many cases for anchors. The points of anchorage and location of the mast and cableway anchors should be marked with stakes. In setting anchors, the "dead man" type shown in Fig. 11 has proved most satisfactory for the cableway anchorage. This consists of a pole or log five inches or more in diameter and three or more feet in length buried to a depth usually of two feet. A chain around this log with both ends free, makes a good point of attachment for the trolley cableway. With both ends free, the chain may be pulled out without removing the anchor when through using. Anchors for the guy cables may consist of posts four to six inches in diameter and five or more feet long set as posts to a depth of three feet.

Mast—The mast may be 20 to 25 feet high. A stiff pole about six inches in diameter at the top should be selected. To erect, the foot of the mast is placed in a hole dug about one foot deep. The guy cables and pulleys are attached at the desired points and steps for climbing the mast are nailed to it, if desired. The top of the mast is then raised as high as conveniently possible, by hand. Power may then be used to raise it the remaining distance. In applying power, attach a cable to the mast at about two-thirds the distance from the bottom to the top, and pass this cable over an A frame set one-third of the distance from the bottom. The A frame serves to direct the horizontal force exerted by the team or tractor into an upward pull on the mast. As



in triangle for direct pull operation.

the mast is raised, the guy wires are snubbed around the anchor post to control it in raising. They are securely fastened to the anchors when the mast is vertical.

In setting anchors in marl, a post or series of posts may be used. It will be necessary to twist these into the marl. Setting the side anchor after the cable is threaded makes it possible to select this point with reference to the length of the cable, thereby avoiding cutting the cable.

Rigging Cable—In rigging cable, care should be taken to thread it through the blocks in the proper order. It is not necessary to cut the cable, even if too long. The side anchor should be set last, as before mentioned, to accommodate the length of cable used. The free ends of the cable are attached to the bucket. The trip block is attached to the cable at the unloading point. The hitch for the team or tractor consists of a short piece of chain clamped to the main cable with not less than four cable clamps. Pully blocks, easily suspended with short chains, should be hung free to align with the cable in operation.

Removing Overburden—It is sometimes possible to remove overburden with a plow and slip scraper. Where the surface is too soft or wet, the bucket must be used. Side cutters may be attached to assist in cutting sod. When an opening is made at the outer end of the trench, it is usually possible to dig under the sod with the bucket working toward the mast. The overburden should be piled separately, generally close to the mast, this being controlled by setting the trip block at the desired point.

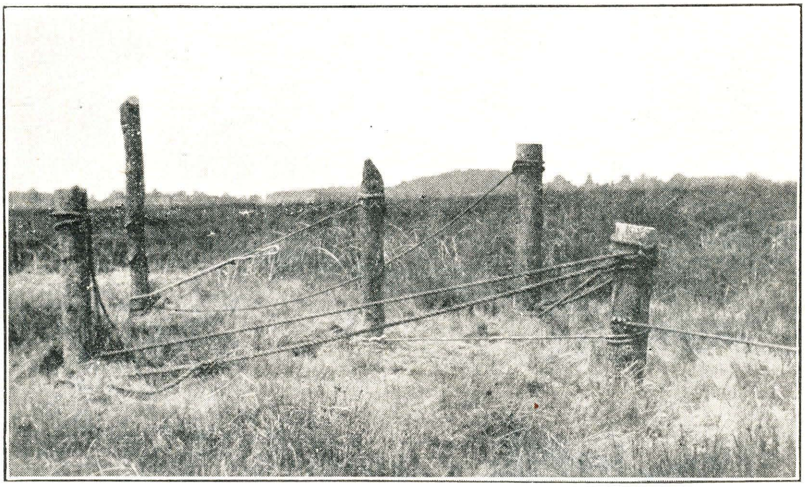


Fig. 12.—A cableway anchorage in marl. The trolley cable is attached to post at the right. The tops of the posts are held by lines to the bottom of other posts.

Operating—No explicit directions can be given for operating. The adjustments must be found for each particular condition by trials. There are three principal adjustments to the equipment:

1. Elevation of cableway by means of a double block and tackle.
2. Angle of cutter by means of height of front hitch.
3. Depth of cut and size of load by means of the depth gauge.

In general, if the cutter does not "bite" either lowering the cable and raising the front hitch, will improve the cutting effect. If the cutter "bites" but the bucket does not fill, the depth gauge should be set to cut a thicker slice. If the bucket tends to overload, or the marl goes back over the bucket, the depth gauge should be set farther back and for a thinner slice. Since conditions are constantly changing, frequent adjustments may be necessary. One adjustment should be made at a time so that its effect may be noted. In general, it is also advisable to begin cutting a minimum amount near the mast, working farther out as found necessary and as familiarity with the outfit is developed.

Cost of Marl and Limestone—A basis of cost comparison between lime and marl is the cost of a single application, using sufficient amount of each to secure equally good results. In practice, two cubic yards of marl is often used to equal one ton of limestone. The cost of one application of either includes the cost of material, the cost of transportation, and the cost of spreading. For a one-ton application of lime at $3.00 per ton f.o.b. the local freight depot, five miles from the farm, allowing 25c per ton mile for hauling and 50c a ton for spreading, the total cost of a single application would be:

Material—1 ton @ $3.00	$3.00
Handling and hauling—transportation 5 miles @ 25c. . . .	1.25
Spreading—1 ton @ 50c	.50
Total per acre	$4.75

An estimate of cost for a two cubic yard application of marl follows: The cost of marl is taken at 75c per cubic yard at the pile two miles from the farm, haulage costs at 25c per ton mile, and spreading at 50c per cubic yard. With marl at 1,500 pounds per cubic yard the weight of two cubic yards would be 1½ tons. The total cost for a single application would then be:

Material—2 tons @ 75c	$1.50
Handling and hauling—transportation 1½ @ 2 x 25c	.75
Spreading—2 tons @ 50c	1.00
Total, per acre	$3.25

It will be noted in the example given that transportation costs are high on lime due to distance while spreading costs are high on marl due to bulk. If the lime were hauled two miles and the marl five miles the costs of lime would show a lower figure than marl being $4.00 per application per acre as compared with $4.37 per application per acre for marl.

While the above figures are approximately correct, they are used as examples only. Perhaps the surest way to determine costs is to follow the method shown and make a trial of sufficient length to determine the three important factors of cost for the particular conditions. Handling and transportation costs are quite likely to be the deciding factors.

Drying and Spreading Marl—It is possible to spread marl directly from the deposit. Because much water must be handled by this method, it is preferable to allow the marl to air-dry for a period of two weeks or more, which allows time for the free water to drain off. Since marl dries very slowly, it is impractical to dry it to a point where it can be crushed to powder form. Artificial drying has been tried, but the added cost of heat, handling, and overhead cost generally makes this impractical.

In spreading air-dried marl, the manure spreader is used in the larger majority of cases. Where hauled a considerable distance, straw is used to cover the bottom to prevent the marl from working through. Since the manure spreader spreading rate is somewhat high for marl, the spreader is loaded from one-half to two-thirds full. Because the manure spreader is not satisfactory for hauling long distances, many prefer to spread by hand from piles placed in the field when the marl is hauled. End gate spreaders of the rotating disc type will spread most grades of marl satisfactorily direct from a wagon, if not too wet.

Cooperative Ownership of Digging Equipment—The purpose of a cooperative plan is to lower costs by spreading overhead costs over the greater yardage which may be dug with one machine. The organiza-

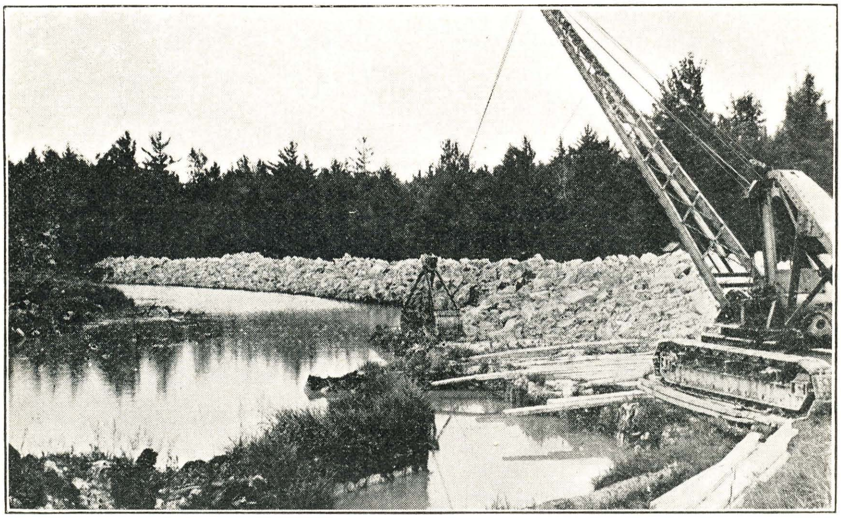


Fig. 13.—Marl for many acres in Osceola County, dug with a clam shell bucket. Crawler type treads and planking permit moving over marsh.

tion should be carried out with this in view. To make the cooperative plan of owning digging equipment successful, it is necessary to have a complete agreement, preferably written, covering points which might posibly be misunderstood. In working out a cooperative plan for excavating marl, a definite organization should be formed with its officers, including a manager or operator, to execute the work. Each member should assume his share of the costs and responsibility. A uniform sale price is agreed upon and a working plan is adapted outlining in general how and when the work is to be done. Profits or losses from the use of the outfit are divided in proportion to ownership after deducting all items of expense including overhead. An elaborate organization is not required, but to be successful the program must be planned and carried out in a business-like way.

Another way for cooperators to assist in financing equipment is to contract for a stated amount of marl in advance of the purchase of equipment. If this is done by means of written orders, little difficulty will be experienced under ordinary conditions in securing money for the purchase of equipment on loan. In purchasing marl in this manner, a price must be paid which will give assurance that the contract can be carried out by the operator. The venture should offer sufficient inducement financially to insure continuation of operation and a permanent supply of marl for the community. While several may interest themselves in the installation and operation of equipment, the possibilities of the use of marl are more often seen by the individual who may wish to install equipment to supply his own needs as well as those in the immediate vicinity. In this case, the confidence of neighbors in the value of marl can be tested by getting orders for stated amounts.

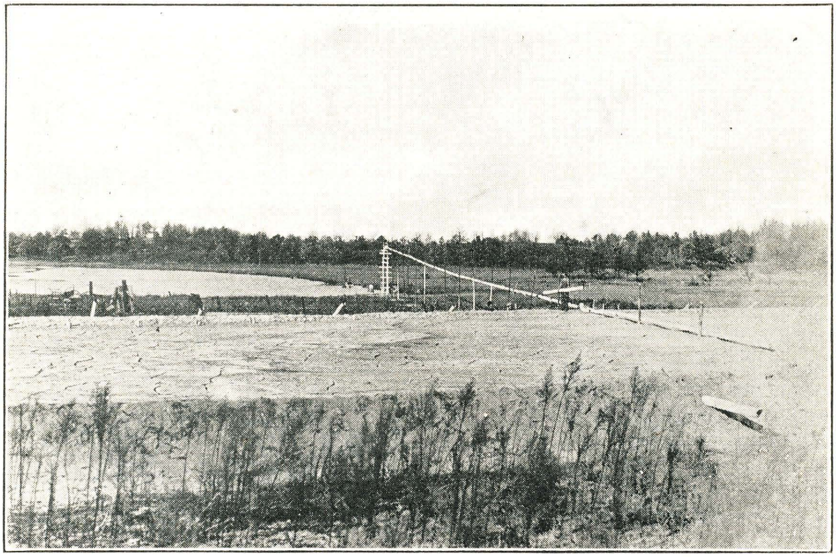


Fig. 14.—This marl excavated by pumping contained about 1,300 yards. The long pipe conveyed marl and water from the pump. The short pipe drained water from the surface after the marl had settled. Shrinkage cracks show on the surface.

If there is any doubt as to the success of the venture financially or of the full cooperation of the community, it is probably best to defer action; unless, of course, the needs of the home farm are sufficient to warrant the full expense of installing equipment.

Where publicly owned equipment or larger installations of machinery are to be employed, the procedure is about the same. Assurance should be had in the form of orders for a sufficient amount of marl to make the project successful. To this end, many must pledge support. Some one must also take an active part in carrying out the project. This type of work may be carried out in cooperation with the county agricultural agent who may be in position to assist in organizing and encouraging the venture.

Excavating Data—Marl has demonstrated its value in the leguminous crop program and is being used at an increasing rate. A survey of its use in the state for 1931 show about 1,500 deposits in 43 counties, marl being dug from about one-half of them. Two-thirds of the total have been classed as wet deposits, one-half of the remaining one-third being in the dry deposit class on account of abnormally dry years. These figures indicate a considerable field for power excavating equipment in normal years. In 43 counties included in the survey, the marl used is estimated at 129,479 cubic yards, which indicates a total of approximately 200,000 cubic yards for the state in 1931.

UTILIZATION OF MARL FOR AGRICULTURAL PURPOSES

C. E. MILLAR

Marl is Used to Supply Calcium

Water dissolves calcium and similar neutralizing or sweetening elements from the soil minerals as it passes through the soil. Crops also use these elements in their growth and when harvested leave the soil poorer in them. As a result of this continual removal of calcium and similar elements, soils in humid climates ultimately become deficient in basic or sweetening substances and the acid or sour constituents predominate. When this condition is reached, the soil is said to be sour, acid, or deficient in lime; and the condition must be corrected before satisfactory stands of alfalfa, clover, or sweet clover can be grown. Most other crops commonly produced in Michigan also grow better on soils containing adequate quantities of lime.

Marl contains calcium and is used for sweetening or correcting the acid condition of sour soils just as ground limestone and hydrated lime are used. The term "lime" is used to designate any compound containing calcium or calcium and magnesium in a form that will correct or neutralize acid. It is just as correct therefore to refer to marl as lime as it to speak of ground limestone, hydrated lime, and quick lime as lime. The calcium in marl exists in the same chemical condition as it does in ground limestone, that is in the carbonate form, and so the value or purity of marl is expressed in percentage of calcium carbonate or lime carbonate as it is frequently called. Marl sometimes contains small percentages of magnesium, phosphorus, nitrogen, and other elements of importance in plant growth, but the quantity present is usually too small to be of practical significance. In applying marl, it should be remembered that the purpose is to correct the acid condition or calcium deficiency and that the marl does not take the place of barnyard manure or commercial fertilizer.

Impurities in Marl

Samples designated as marl have been found to contain from approximately 100 to very small percentages of lime carbonate. The opinion is sometimes expressed that samples which are very white are of correspondingly high purity. Such is not always the case, as many samples contain white sand which greatly reduces the purity without affecting the color. In fact, occasionally samples are received of a soft white substance which resembles marl very closely but in reality is sour or acid in reaction. Unless one has had much experience, it is difficult to detect the presence of fine white sand and especially to estimate the quantity by rubbing the marl between the thumb and fingers.

Organic matter or humus is another impurity commonly occurring in marl. At times, the quantity present is sufficient to produce a dark gray color and to materially reduce the percentage of lime carbonate. In some cases, a jelly-like humus is present which does not make the color very dark but decreases the purity and when dry glues the marl together into hard lumps, making application to the soil virtually im-

Fig. 15.—Close up of a marl pile shortly after excavating.

possible. Though it is safe to conclude that a marl containing sufficient organic matter to give a dark gray color is of low purity, it is not safe to consider a light gray marl of high purity. An application of marl which is of low grade because of its content of organic matter will increase the humus content of the soil to a slight extent. The presence of considerable black, muck-like organic matter, therefore, is not objectionable aside from the fact that it lowers the purity of the marl and hence makes necessary a heavier application.

A comparatively small percentage of clay may not discolor the marl greatly but makes it sticky when wet and hard when dry. As a result, it is very difficult to apply a marl containing much clay in either the wet or dry condition. Clay is one of the most objectionable of the impurities occurring in marl.

Some marls are composed very largely of shells; but, in others, no shells are discernible. The presence of many shells does not necessarily indicate a high-test marl as shells may occur abundantly in marl containing considerable quantities of organic matter or of sand.

High-test marls from swamps and from some high land beds are soft and powder easily between the fingers when dry. However, marl from some of the high land deposits are rather hard and may occur in more or less rock-like pieces even though the purity be very high.

Experience has shown that the purity of marl cannot be reliably estimated by its color, by the "feel" when rubbed between the fingers, by the presence of shells, or by the fact that the marl is soft, crushing easily between the fingers. A general idea of the purity of marl may be obtained by dissolving a teaspoonful in one-half tumbler of dilute muriatic acid made by adding one part of strong acid to four parts of water. Muriatic acid is the same acid used to make "zinc cut" for soldering. The acid should attack the marl vigorously, usually filling the tumbler with froth. In a very short time, the action should be completed. In case the action of the acid is prolonged, especially if streams of bubbles continue for some time to rise from various places on the fragments of marl, it is probable that the marl contains clay or organic matter in sufficient quantity materially to reduce the purity. The acid dissolves the lime leaving the impurities that were in the marl. When the action of the acid is over therefore the quantity and nature of the residue gives a clue to the purity of the marl. The tumbler should be rotated in order to make the liquid swirl around thus bringing the undissolved material into a pile on the bottom of the tumbler. An appreciable quantity of sand means a low test because sand is very heavy. A considerable quantity of black muck-like organic matter indicates a low purity. A large number of light-colored, organic particles floating in the liquid would suggest the presence of an organic cementing material which would cause the marl to harden when dry. A heavily clouded or milky appearance of the liquid shows the presence of clay, and a piece of the marl should be dried to determine if it gets too hard to spread easily or to crumble and mix through the soil thoroughly by dragging after application. In fact, regardless of the nature of the impurities, it is a good idea to allow some of the marl to become completely dry and note whether it gets hard or crumbles easily.

Though the simple acid test described will give a general idea of the quality of the marl and the nature of the impurities, before excavation is begun, a more accurate test should be obtained by taking a sample to the county agent or by sending one to the Soils Department of the college. When drawing marls directly from the bed or excavating into a stock pile, it is a good plan to make a test occasionally to determine if the marl is running of uniform purity.

Taking Samples for Testing

Marl from different portions of a deposit may vary considerably in purity as may also material taken from different depths at the same location. To obtain a representative sample, it is necessary to take a small quantity of marl from a number of different places over the bed and mix them thoroughly. In case the bed is of considerable thickness, portions should be taken from both near the top and near the bottom. If the deposit is thin or of only moderate thickness, samples taken near the center, vertically, perhaps will suffice. Large deposits may better be represented by several samples, each composed of small quantities of marl taken from several places in that portion of the bed. A pint is an amply large sample if properly taken so as to represent accurately the bed or a given portion of the bed.

Marl is Measured Not Weighed

Though there are a few beds containing dry marl, in the majority it is saturated with water. When the marl is excavated and piled on dry land, considerable water drains away; nevertheless, the material always remains wet, the quantity of water retained varying with the impurities in the marl, climatic conditions, and other factors. It is evident that a material of this type so variable in water content cannot be measured satisfactorily by weight; it is customary to measure marl by the cubic yard. The following table indicates the total weight of dry material and the pounds of lime carbonate in a cubic yard of marls of different degrees of purity, as the marl occurs in the bed. When marl is dug and thrown in piles on high ground or is loaded directly onto wagons or trucks it is not so compact as it is in the bed and hence will settle. The shrinkage resulting from this settling amounts to about 25 per cent.

Sample Number	Per cent of carbonates	Per cent of water on dry basis	Per cent of water on wet basis	Weight of cu. yd. dry marl in lbs.	Weight of cu. yd. wet marl in lbs.	Weight of lime carbonate in 1 cu. yd. dry marl	Weight of lime carbonate in 1 cu. yd. wet marl
1...............	75	46.7	32	1652	2430	1239	1239
2...............	85	45.5	31.3	1665	2424	1415	1415
3...............	88	38.9	28	1670	2319	1470	1470
4...............	95	35.1	26	1731	2339	1644	1644

Deterioration of Marl in Storage

Marl is frequently excavated in considerable quantities and stored in large piles on high land for future use. When allowed to stand in such piles for a considerable time, much water will drain out of the marl and the repeated wetting and drying and freezing and thawing tends to break up the lumps and increase the ease of application. When stored in such piles, even for long periods, the marl will lose none of its value. In fact, poisonous substances which occasionally occur in marl from beds covered with water, will decompose or escape during storage in well-drained piles.

Quantity and Method of Application

Because of the moisture content most marls cannot be applied through any of the usual types of lime spreaders. The manure spreader is the most convenient implement for applying marl. A few inches of manure of straw or of muck may be placed in the bottom of the spreader before loading the marl, although this is not done in the majority of cases. However, it serves to force the marl over the beaters. The spreader should be set to operate as slowly as possible.

A convenient method of handling marl is to place it in piles in the barnyard, along the farm lane or in the field and then when manure is being drawn to put on half a load of manure and fill out the load with marl.

Farmers in some sections of the State follow the practice of dumping the marl in piles of a few bushels in a checkerboard pattern over the field during the winter. In the spring, the marl is spread from the small piles by hand using a six-tine manure fork with a piece of sheet metal wired over the upper two-thirds of the tines.

Fig. 16.—An application of marl on this strongly acid sandy loam soil in Ingham county made possible the growth of sweet clover seen on the right.

With any spreading device now in use, it is impossible to apply marl as uniformly over the soil as crushed limestone may be distributed. To compensate for this lack of evenness of distribution, it is advisable to use from one-third to one-half more marl than is equivalent in neutralizing power to an application of crushed limestone. It is difficult to cover an acre with less than four yards of marl. As a result it is customary to use about four or five cubic yards of good marl to the acre for soils which are moderately to strongly acid. In case the marl is of low purity or the soil extremely acid, the quantity applied should be increased proportionately. Cultipack, float, or roll after applying to break any lumps present.

No general answer can be given to the frequent questions, "how pure must marl be to make its use practical" and "is it cheaper to use marl or ground limestone?" The conditions on each individual farm influence the problem to such an extent that each farm operator must arrive at the answer by calculating the relative cost of the two materials **applied to his land.** In each case, he must take into consideration the charge for the material, the distance it must be drawn, the cost of applying, and the time he has available for such work. Frequently, the problem is simplified by certain limestone companies quoting a price for their product distributed on the soil. If the marl is to be drawn a considerable distance, it must be of high grade to warrant the expense unless the farm management program is such that there are periods when regular work is slack. During these intervals, teams and time may well be employed in drawing marl of even mediocre grade for a rather long distance. If a bed of marl exists on a particular farm or within a very short distance, it may be economically used even if of low grade, since it may be drawn and applied at odd times.

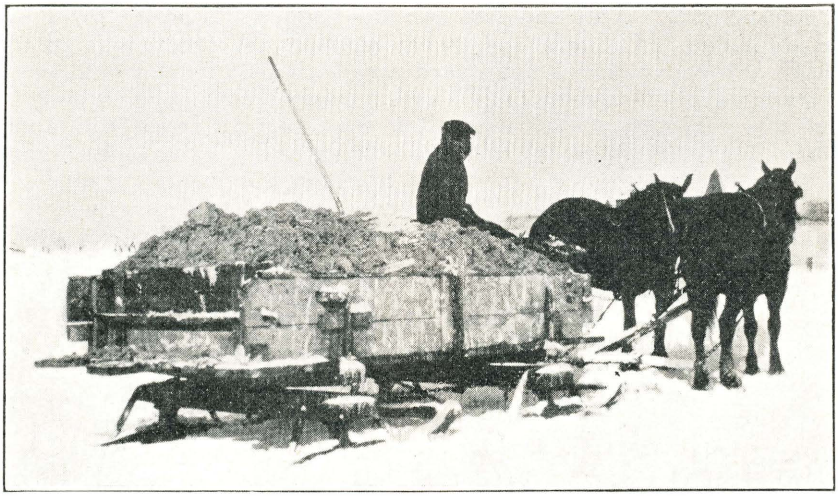


Fig. 17.—When other work is not requiring all of a farmers' time he can draw marl and lime his sour land at a low cost.

Time of Application

The time for applying marl is not so important as is its thorough incorporation in the soil. Marl may be applied on stubble or sod and plowed under, providing a year or more is to elapse before seeding a legume. Land that is being fitted for wheat in which a legume is to be seeded may have an application of marl worked into the surface soil by means of the disk or spring-tooth harrow. In case the legume is to be seeded in oats or barley, it is not a good practice to attempt to apply the marl in the spring while the ground is being fitted. Not enough time is allowed by this method for the marl to become thoroughly mixed with the soil and for the correction of the acid condition.

On the lighter soils where it is considered advisable to seed alfalfa without a companion crop, the marl may be applied in the early spring in preparation for a summer seeding. It would be just as well or even better, however, if the marl could be applied the previous year or two years in advance.

Some marls from beds usually covered with water or a thick layer of muck contain substances which are poisonous to plants. Damage may result if a crop is planted shortly after applying marl of this character. It is advisable, therefore, to apply marl from such deposits a considerable time before planting or to allow the marl to stand in a storage pile for several months before applying.

How Long Will an Application of Marl Last

The length of time that a given quantity of marl will satisfy the lime requirement of a soil varies with the characteristics of the soil. A sandy loam soil on one of the experimental fields of the Soils Department in southwestern Michigan received about two and one-half yards of marl in 1917. This soil still contains sufficient lime to grow satisfactory stands of alfalfa and sweet clover. On other soils, there is reason to believe that a four yard application of marl would need to be repeated in the course of five or six years if alfalfa is to be grown. The only safe way to tell when it is necessary to repeat the application of marl or lime is to test the soil carefully. Since the quantity of marl usually applied represents a greater neutralizing equivalent than if limestone or hydrated lime were used, it is safe to conclude that the marl will last as long or longer than the usual application of these materials.

Comparative Value of Marl, Crushed Limestone, and Hydrated Lime

Marl contains its calcium in the same chemical form as does limestone. It is evident therefore that one ton of pure dry marl will correct as much acidity as one ton of pure dry limestone. The particles of limestone are hard and compact while the individual particles of marl are very small and usually soft. It would seem, therefore, that marl would react in the soil, correcting the acid condition, at a more rapid rate than would the limestone. Undoubtedly, this would be true if in each case the particles could be separated from each other and mixed uniformly through the soil. As previously stated, however, the marl is usually damp and must be applied in lumps and, hence, does not become uniformly mixed through the soil except after repeated tillage probably covering a period of several years. The limestone on the other hand can be applied much more evenly. It is safe to assume, therefore, that marl cannot be depended upon for a more rapid correction of soil acidity than can limestone of suitable fineness.

Hydrated lime is made from limestone. One ton of pure calcium limestone will make 1,480 pounds of pure hydrated lime which will neutralize just as much acidity as the one ton of limestone and the hydrated lime is said to have a neutralizing value of 135. In some cases, hydrated lime has a neutralizing value of 150 or even of 170. Hydrated lime should be used in proportion to its neutralizing value which figure is always printed on the package. Thus, if a soil requires 4,000 pounds of limestone and it is desired to use hydrated lime with a neutralizing value of 150, the proper quantity of hydrated lime to apply may be calculated as follows:

$$\frac{4000}{150} = 2666 \text{ pounds hydrated lime.}$$

Hydrated lime is very fine and is more soluble than ground limestone or marl. It is to be supposed, therefore, that hydrated lime would react with the soil more rapidly than will limestone and marl. Though this is probably theoretically correct, practical experience shows that, under general farm conditions, limestone meal containing 30 to 40 per cent of particles that will pass a 100-mesh screen or a high grade marl will give as satisfactory immediate results as will hydrated lime.

Fig. 18.—Clover from equal areas of sandy soil in Ingham County. Left, no lime. Right, limed with marl.

The Relation of Marl to Soil Fertility

Marl has several beneficial effects on the soil aside from supplying calcium to correct the acid condition. The bacteria and other organisms which transform the soil nitrogen into an available state by decomposing humus, work more efficiently in the presence of adequate lime. As a result, one may expect an increased availability of soil nitrogen to follow an application of marl to sour soil.

Experience has shown that commercial fertilizers, especially those rich in phosphoric acid, usually give greater returns in crop production on soils well supplied with lime than on soils which are deficient in this constituent.

By increasing crop growth and yields, there is more straw, stover, or other roughage which can be returned to the soil directly or in manure, thus adding to the humus supply. The ability to grow leguminous hays as a result of sweetening sour soils with marl greatly increases the number of livestock which may be kept on the farm, thereby not only increasing the farm income but providing more manure for soil building.

Leguminous crops are the only ones which can make use of nitrogen from the air. By putting acid soil into condition to grow legumes, one may draw on the limitless supply of air nitrogen and thus supply this most costly of plant food elements to his soil. It must be borne in mind, however, that alfalfa, clover, and sweet clover do not obtain all their nitrogen from the air and that to enrich the soil with nitrogen by growing them some of the top portion of the crop must be plowed under or else fed to livestock and the manure must be cared for to prevent loss and then be returned to the land.

There are types of bacteria which fix nitrogen from the air without living in the nodules on the roots of legumes. The most active of these organisms do not thrive in soils which are strongly acid. By correcting the acid condition in the soil through an application of marl, these nitrogen-fixing bacteria may be set to work collecting nitrogen from the air and storing it in their bodies where it will become available later to crops.

Use More Marl

There is much more marl applied to the sour soils of Michigan than the average observer might estimate. Though it is impossible to determine accurately the quantity of marl that is being used, the figures available make it safe to conclude that the acreage sweetened annually by means of marl is greater than the acreage sweetened with commercial lime.

In the preceding pages, an effort has been made to point out some of the characteristics of marl which influence its use for correcting soil acidity and some of the precautions which should be observed in making use of it. Those who have used marl correctly report satisfactory results with very few exceptions. The large quantity used and the wide distribution of its use in the state testify to the satisfaction it has given. In many communities, it is by far the cheapest source of lime available. It is to be hoped that the farmers of Michigan will make a much more extensive use of the marl deposits in their neighborhoods.