largely against this later deposit, instead of the till itself, and would find comparatively little material from which to construct a gravel beach. For this reason we find more gravel in the Belmore, less in the Arkona, and still less in the Warren beaches.

From the distribution of the sand over the region to the west of the Forest and Grassmere beaches it is to be inferred that the prevailing and heaviest winds during this stage were from the east, northeast, or southeast. As the beach ridge of sand was formed by the action of the waves, its loose particles after drying would be seized by these winds and gradually moved landward, until the belt of sand was from three to seven miles broad. It is just this action that now occurs along the eastern shore of Lake Michigan owing to the prevailing northwest winds, while the western shore is comparatively free from such sand accumulation. The sand from the Warren beaches was thus spread over thousands of acres of land, impoverishing the soil and those unfortunates who are compelled to get their living from it. Low cabins, puny barns, bony stock, poorly clad and half starved children; all are because the prevailing direction of the wind, a few thousand years ago, was easterly. At present the prevailing direction of the wind is from the opposite point of the compass and the Lake Erie sands are not encroaching upon the fertile soils adjoining. To summarize then, the sand and gravel of the county were derived originally from the crystalline rocks to the north and east, washed out of the till by wave action around the margins of the lakes and still further distributed by the wind.

(b). Clay. While the action just described was in progress in the littoral region of the lakes, the finer particles of sand and alumina were taken in suspension and carried lakeward by the waves and currents. This material would settle very slowly into the deeper and quieter portions of the water and form the clay deposit previously referred to as covering the bottom of the lake. This would fill up all irregularities of the till surface and slope very gradually and evenly toward the southeast. The particles were so nearly homogeneous in size and distribution that no distinct stratification is visible. The vegetable growth upon the lake bottom became embedded in the clay and gave it a dark color. This deposit would necessarily be thinner in the western and thicker in the eastern part of the county, where it covers the surface boulders. That which was originally deposited over the central portions of the



county was very largely removed, as the waters receded, and was carried further eastward. This clay is very sticky when wet, consists of alumina and silica in finely divided particles, contains enough iron to burn red and was derived from the till. Small streams entering the lake from Lenawee and Washtenaw counties would contribute some sand and clay to the Monroe deposits, but they were derived from the surface till of these regions.

(c). Loam. This term is applied to a mixture of sand and clay, which either owing to the proportions of the ingredient, or to the size of the constituent particles, is looser and less compact than clay itself. When wet it is not so sticky, and upon drying does not bake and crack. As the proportions of clay and sand differ, varieties are distinguished which graduate into one another, and into other types of soil. When the plant food products are present it forms an ideal soil, because of the ease with which it can be worked and of its ability to conserve just the proper amount of moisture for plant growth. Owing to the presence of organic matter it is very commonly of a dark color. Narrow strips of this soil occur along the margins of the clay and sand belts where the two have become mechanically mixed through the action of wind and water.

(d). Silt. Along the margins of all the streams, constituting their flood plains, is a deposit very similar in its physical properties to loam. It usually differs from it, however, in having a much greater variety of material present, since it represents the surface wash from all the regions drained by each particular stream. It is distinctly stratified and contains the shells of both water and land snails and other molluscs. Owing to its great fertility it supports an abundant vegetation which gives it a dark color. The larger streams furnish the broader areas of this type of soil, and in some regions dikes have been constructed around the fields to shut out the streams completely at times of flood. In composition the typical river silt consists of 50 to 70% of sand, about 10% each of alumina and organic matter, with varying quantities of iron, calcium, magnesium, potash, soda and phosphorus. Their general nature is shown by the two analyses* given below from the bottom lands of the Raisin just over the western boundary of the county, at Deerfield. The first analysis is of silt which had been under cultivation for 40 years, without manuring, the second represents the "virgin soil." The timber in both cases is ash, basswood, hickory, walnut and oak.

*"Michigan Soils." Bulletin 99 of the Michigan Agricultural College, page 6.

| | Cultivated. | Uncultivated. |
|---|---|---|
| Sand and silicates | 58.17 | 62.42 |
| Alumina | 6.48 | 10.64 |
| Oxide of iron | 7.62 | 3.42 |
| Lime | 1.92 | 2 10 |
| Magnesia | 1.43 | 1.59 |
| Potash | 1.84 | 2 05 |
| Soda | 1.20 | 1.19 |
| Sulphuric acid | .32 | .24 |
| Phosphoric acid | .40 | .41 |
| Organic matter | *10.97 | †9.39 |
| Water | 9.45 | 6.08 |

*Nitrogen =.42
†Nitrogen =.37.

(e). Muck. One characteristic of a glaciated region is the presence of innumerable basin like depressions, in which spring and surface water may accumulate, but from which it cannot readily escape, except by evaporation. Many such spots are found in the sand belts, where the sand is thin and underlain by clay. Small lakes are here formed in which plants, drawing their sustenance from the water and air, get a foothold and eventually add their remains to the soil of the bottom and margin. Coarse varieties of moss presently start, which dying beneath and growing above prepare a bed for the rushes, the water lilies, and the water-loving shrubs. Through the agency of water fowl animal life might be introduced, the decay of which would furnish other ingredients to the soil accumulation upon the bottom. Some clay and sand would be washed in from the surrounding region, so that through all these agencies the lake would be slowly filled and converted into a marsh. New types of plant life would now find suitable conditions, the filling process would continue and a meadow finally result, capable of cultivation. The black, spongy, carbonaceous mass, resulting from the alteration and partial preservation of the organic matter, is called *peat* when practically pure. Usually it is mixed with clay and sand and is then known as *muck*. It is rich in nitrogen and phosphorus, but does not contain sufficient body to serve as a soil for most plants. The total amount of such soil in the county is not great although small areas are numerous in certain regions. A cranberry marsh covering 112 acres is located in the S. E. ¼, Sec 24 of Summerfield township, belonging to Clayton Everett, of Toledo. This is flooded in the spring as shown in Fig. 6 but is drained and later irrigated by numerous wells, from which the water is pumped by windmills. An extensive peat bed occurs in Sec. 9 of London



township, 60 acres of which belong to the Ilgenfritz Nursery Co., of Monroe. A crop of *Sphagnum*, the moss concerned mainly in the production of peat, is harvested from it each season and used in packing about the roots of nursery stock for shipment. It holds moisture well, is light and does not "heat." In 1838 Hubbard reported a soil of fibrous peat one to two feet thick as covering 18 sections in Ida, 9 in Summerfield and 5 in Whiteford.

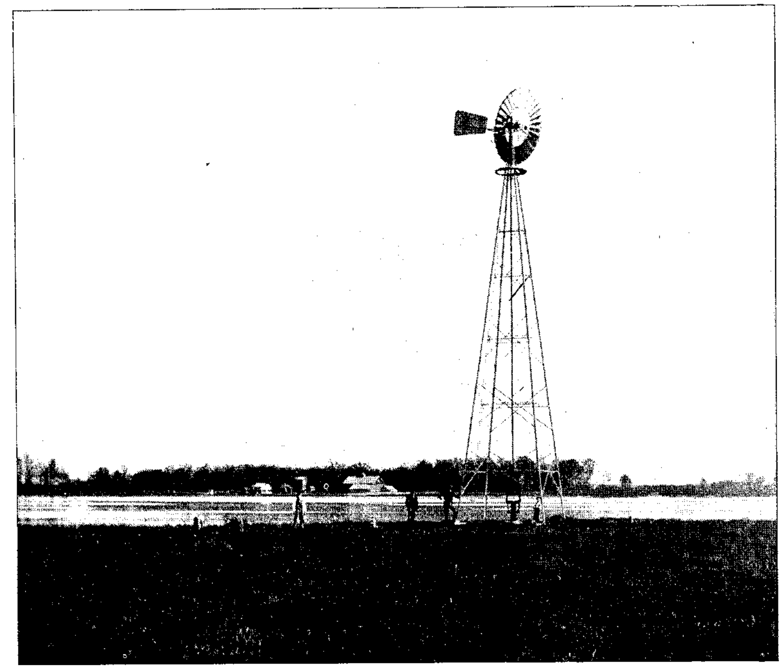


Fig. 6. View of extensive cranberry marsh when flooded in the spring. Sec. 24, Summerfield Township.

### B. *Relation of Soils to Vegetation.*

§ 4. Fertility.

The bulk of all tissue found in the higher plants consists of carbon and water in chemical combination. The carbon is derived from the carbon dioxide of the atmosphere, being separated from its oxygen by the green coloring matter, known as chlorophyll, with the energy of sunlight. The water is derived from the soil mainly through the agency of roots. By combining chemically this carbon and water in certain proportion starch is made. From this starch, without the addition of any other kind of material, the plant produces sugar, gum, cellulose, lignin, oil, etc. The production of these substances, which so largely enter into the composition of all plants, constitutes no drain upon the soil. There are further needed, however, relatively small but important quantities of mineral substances, which can be derived only from the soil. These consist chiefly of potassium, sodium, calcium, magnesium, iron, phosphorus, silica and chlorine; all of which must enter the plant in chemical combination rather than as free elements. When the plant is burned this mineral matter constitutes the ash, while the carbon is united with oxygen again to form carbon dioxide and this with the water is restored to the atmosphere, to be used again in the same manner. When complete decay takes place the same changes occur but extend over a much longer period. It is self evident that a soil must be ready to supply, in available form, all mineral substances demanded for the complete development of those crops assigned to it. Table IX from the appendix of Johnson's "How Plants Grow," gives in convenient form analyses which were published some years ago by Prof. Emil Wolff, of the Royal Academy of Agriculture, Würtemburg. The various substances analyzed were in the condition in which they are handled by the farmer, that is, air-dried. The calculation of the amount of any mineral ingredient required for a given weight of each substance is very simple, since the figures represent the percentage composition. To illustrate, a ton of wheat would withdraw from the soil .55% of 2,000 lbs. or 11 lbs. of potash. A ton of red clover requires 1.95% of 2.000 lbs., or 39 lbs. of the same substance.

The failure of a soil to produce certain crops is not due necessarily to the absence of essential constituents in available form, but may be due to some physical disability. Some harmful ingredient may be present in disastrous amount, as an acid in the case of muck. Scarcely better advice can be offered the farmer now than was given sixty years ago by Bela Hubbard in the Second Report of the State Geologist (page 110); that he carry on experiments upon a small scale to determine the agricultural value of his various soils and inductively discover methods for improving them. It is now known that a mere chemical analysis cannot be implicitly relied upon to determine the character of the crop which the soil is capable of producing. Its fertility is in great measure dependent upon its texture, the mere size of its component particles. The finer the



TABLE IX.—PERCENTAGE COMPOSITION OF AIR-DRY FARM PRODUCTS. (WOLFF.)

| Substance. | Water. | Ash. | Potash. | Soda. | Magnesia. | Lime. | Phosphoric acid. | Sulphuric acid. | Silica. | Chlorine. | Sulphur. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wheat, grain | 14.3 | 1.77 | .55 | .06 | .22 | .06 | .82 | .04 | .03 | ........ | .15 |
| Wheat, straw | 14.1 | 4.26 | .49 | .12 | .11 | .26 | .23 | .12 | 2.82 | ........ | .16 |
| Oats, grain | 14.0 | 2.64 | .42 | .10 | .18 | .10 | .55 | .04 | 1.23 | ........ | .17 |
| Oats, straw | 14.1 | 4.40 | .97 | .23 | .18 | .36 | .18 | .15 | 2.12 | ........ | .17 |
| Barley, grain | 14.5 | 2.18 | .48 | .06 | .18 | .05 | .72 | .05 | .59 | ........ | .14 |
| Barley, straw | 14.0 | 4.39 | .93 | .20 | .11 | .33 | .19 | .16 | 2.36 | ........ | .13 |
| Rye, grain | 14.9 | 1.73 | 54 | .03 | .19 | .05 | .82 | .04 | .03 | ........ | .17 |
| Rye, straw | 15.4 | 4.07 | .76 | .13 | .13 | .31 | .19 | .08 | 2.37 | ........ | .09 |
| Corn, grain | 13.6 | 1.23 | .33 | .02 | .18 | .03 | .55 | .01 | .03 | ........ | .12 |
| Corn, stalks | 14.0 | 4.72 | 1.66 | .05 | .26 | .50 | .38 | .25 | 1.79 | ........ | .39 |
| Buckwheat, grains | 14.1 | .92 | .21 | .06 | .12 | .03 | .44 | .02 | ........ | .02 | ........ |
| Peas, seeds | 13.8 | 2.42 | .98 | .09 | .19 | .12 | .88 | .08 | .02 | .06 | .24 |
| Peas, vines | 14.3 | 4.92 | 1.07 | .26 | .38 | 1.86 | .38 | .28 | .28 | .30 | .07 |
| Beans, seeds | 14.1 | 2.96 | 1.20 | .04 | .20 | .15 | 1.16 | .15 | .04 | .08 | .23 |
| Beans, plants | 18.0 | 5.84 | 2.59 | .22 | .46 | 1.35 | .41 | .01 | .31 | .81 | .22 |
| Potatoes, tubers | 75.0 | .94 | .56 | .01 | .04 | .02 | .18 | .06 | .02 | .03 | .02 |
| Turnips | 90.9 | .75 | .30 | .08 | .03 | .08 | .10 | .11 | .02 | .03 | .04 |
| Sugar-beets | 81.6 | .80 | .40 | .08 | .07 | .05 | .11 | .04 | .03 | .02 | ........ |
| Sugar-beet tops | 89.7 | 1.80 | .40 | .30 | .33 | .36 | .13 | .14 | .06 | .10 | ........ |
| Red clover hay | 16.0 | 5.65 | 1.95 | .09 | .69 | 1.92 | .56 | .17 | .15 | .21 | .21 |
| White clover hay | 16.0 | 6.03 | 1.06 | .47 | .60 | 1.94 | .85 | .53 | .27 | .19 | .27 |

degree of comminution the greater is the total surface available for retaining moisture by what is known as capillary attraction. This moisture is spread out as a delicate film over the soil particles, so that the finer these particles are the greater is their combined surface, the more water are they capable of holding, and the more tenaciously is it retained for plant use. A cubic foot of compact limestone has 6 square feet of surface, or 864 square inches, but if sawed into 8 equal cubes, 6 inches upon a side, it possesses 1,728 square inches of surface. If cut into one inch cubes the total surface would be 10,368 square inches, or twelve times as great as the original surface of the cube. Similar treatment of each one inch cube would enormously increase the total surface, and the principle would be the same if the particles were of irregular shape, as is true in the case of soil. It has been estimated that a gram of soil contains from 2,000,000 to 15,000,000 individual granules, depending upon whether we consider a sandy or a clayey soil and the combined surface must be astonishingly great. An estimate made by Whitney gives a cubic foot of soil a surface of 50,000 square feet. If the soil is too loose and open, as in the case of sand, moisture is not properly conserved. Upon the other hand if the soil particles are too fine, as in a very compact clay, too much water is retained for the proper aeration of the roots and the perfect development of the plant. It must now be apparent why the loams and silts are the best soils, for it comes both from the standpoint of texture and the greater variety of material which they contain.

§ 5. Fruit culture.

The clay soils of Monroe county are rich in calcium carbonate owing to the prevalence of limestone in the county and to the north. With the favorable climatic conditions the grape grows luxuriantly in such soil and attains a high degree of richness. So abundant was this fruit along the river from Monroe to Dundee that the *Namet Cybi* of the Indians became *La Riviere aux Raisins* of the early French settlers. In a paper read before the Pioneer Society in June, 1883, Judge I. P. Christiancy thus describes the remarkable growth of the wild grape. The river, he says, was so called "from the immense quantities of wild grapes along its banks, which as late as 1843 and 1844 I saw growing on the Macon Reserve along this river and the Saline and Macon where the forest was still untouched, over the tops of the tallest forest trees; some of the vines being from six to eight inches through; which, after climbing to the tops of the trees, dropped branches to the ground, which again took root and made an inextricable mat of vines, such as I have never seen elsewhere except in the tropics."*

*Michigan Pioneer Collections, Vol. 6, 1883, pages 362-3.



With such a variety of soil and a favoring climate, conditions are found suitable for the growth of other fruit, besides the grape, but Monroe cannot be said to rank high in this regard, when it is compared with other counties of the state. The following table shows the number of bushels of fruit produced in the various townships during the season of 1898, as given in the Farm Statistics for 1898-9. Where no numbers are given the statistics are wanting.

TABLE X.—BUSHELS OF FRUIT PRODUCED IN 1898.

| Townships. | Apples. | Peaches. | Pears. | Plums. | Cherries. | Strawberries. | Blackberries. | Raspberries. |
|---|---|---|---|---|---|---|---|---|
| Ash | 1,039 | 141 | 116 | 4 | 16 | 15 | .......... | 8 |
| Bedford | 816 | 432 | 100 | .......... | .......... | 3,726 | 456 | 222 |
| Berlin | 1,264 | 30 | 150 | 66 | .......... | .......... | .......... | .......... |
| Erie | 4,078 | 5,065 | 1,682 | 5 | 190 | 1,489 | 181 | 811 |
| Exeter | 100 | 40 | 30 | .......... | .......... | .......... | .......... | .......... |
| Frenchtown | 225 | 170 | 25 | 30 | .......... | 150 | 100 | 275 |
| Ida | 1,417 | .......... | 33 | 5 | .......... | 80 | 68 | 25 |
| La Salle | 685 | .......... | 190 | .......... | .......... | .......... | .......... | .......... |
| London | 1,345 | 402 | 342 | 52 | 67 | 311 | 17 | 137 |
| Milan | 450 | 75 | 50 | 3 | .......... | 270 | 148 | 30 |
| Monroe | 947 | 1,460 | 741 | 27 | 12 | 289 | 127 | 525 |
| Raisinville | 1,203 | 521 | 321 | 53 | 27 | 85 | 4 | 51 |
| Summerfield | 405 | 480 | 75 | 100 | .......... | .......... | .......... | .......... |
| Whiteford | 2,026 | 427 | 1,156 | 92 | 279 | 477 | 41 | 103 |
| Totals | 16,000 | 9,243 | 5,011 | 437 | 591 | 6,892 | 1,142 | 2,187 |

An inspection of the table suggests that the best fruit producing townships are in the southern part of the county, including Erie, Bedford and Whiteford. This does not necessarily follow, however, although these townships have a slight climatic advantage over those farther north. It is probable that the nearness of the Toledo market stimulates the raising of fruit and that most of the other townships could make an equally good showing with an intelligent handling of the soils which nature has given them.

§ 6. Farm products.

In the production of the staple farm crops Monroe county ranks well both as to the number of bushels produced and the average yield per acre, the heavier soils being well adapted for the complete development of the cereals. Some localities are capable of

TABLE XI.—MONROE COUNTY FARM PRODUCTS FOR 1898.

| Township. | Soil. | Wheat. | | Corn. | | Oats. | | Rye, bu. | Potatoes, bushels. | Beans, bu. | Clover seed, bu. | Hay, tons. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Bushels. | Average. | Acres. | Bushels.* | Acres. | Bushels. | | | | | |
| Ash | Clay, sand | 50,072 | 20.16 | 2,239 | 78,805 | 1,996 | 64,947 | 162 | 10,299 | 83 | 61 | 2,944 |
| Bedford | Sand | 42,113 | 21.50 | 2,558 | 85,642 | 1,746 | 59,892 | 2,151 | 78,896 | 177 | | 2,447 |
| Berlin | Clay | 23,097 | 18.73 | 948 | 41,127 | 1,008 | 33,304 | 100 | 2,265 | | 43 | 2,047 |
| Dundee | Clay, sand, silt | 75,000 | 18.75 | 5,500 | 175,000 | 5,220 | 210,000 | 8,000 | 2,000 | | | 8,000 |
| Erie | Clay, sand | 56,641 | 24.09 | 1,733 | 78,201 | 1,273 | 50,633 | 121 | 14,352 | 13 | 207 | 3,514 |
| Exeter | Clay, sand | 51,936 | 18.84 | 2,923 | 77,363 | 2,215 | 63,430 | | 10,346 | 261 | | 2,755 |
| Frenchtown | Clay, sand | 64,621 | 19.89 | 3,085 | 110,832 | 2,714 | 84,675 | | 15,157 | | 84 | 3,760 |
| Ida | Sand, clay | 58,649 | 21.71 | 2,797 | 101,305 | 2,076 | 70,733 | 1,626 | 42,873 | 222 | 58 | 2,525 |
| La Salle | Clay, sand | 60,522 | 22.00 | 2,300 | 121,450 | 1,872 | 59,825 | | 15,703 | 18 | 163 | 2,773 |
| London | Sand | 33,656 | 19.94 | 1,906 | 64,136 | 1,472 | 48,256 | 2,461 | 22,029 | 493 | 26 | 2,278 |
| Milan | Clay | 54,159 | 22.34 | 2,359 | 110,600 | 1,651 | 67,715 | | 9,414 | 232 | 42 | 2,361 |
| Monroe | Clay, sand, silt | 32,923 | 22.04 | 1,311 | 51,425 | 1,063 | 34,988 | 50 | 8,449 | | 46 | 1,611 |
| Raisinville | Clay, sand, silt | 87,745 | 22.31 | 3,829 | 140,930 | 2,914 | 96,842 | 472 | 19,633 | 35 | 108 | 3,500 |
| Summerfield | Sand | 42,890 | 21.67 | 2,752 | 106,245 | 1,456 | 52,474 | 1,137 | 59,930 | 14 | 10 | 2,460 |
| Whiteford | Clay, sand | 59,133 | 21.97 | 3,479 | 135,825 | 2,370 | 92,627 | 1,546 | 60,656 | 195 | 64 | 4,120 |
| Totals | | 793,157 | 21.04 | 39,719 | 1,478,886 | 31,046 | 1,089,381 | 17,826 | 372,002 | 1,743 | 912 | 47,125 |

* Shelled.



yielding 30 to 40 bushels of wheat to the acre, but the average yield is but little over half this amount. For 1898 the average for the entire county was 21.04 bushels, Erie township leading with an average of 24.09 bushels to the acre. For 1897 the county average was 20.80 bushels which gave Monroe the rank of 6 when compared with the other 83 counties of the state. The county produces annually nearly a million bushels of wheat, over a million of oats and a million and a half of shelled corn. For the season of 1898 Table XI gives a summary of the yield by townships with the final total taken also from Farm Statistics of Michigan for 1898-9. The sand belts furnish desirable conditions for growing potatoes, beans and buckwheat. It would seem as though the sweet potatoes might also be grown with profit here, but the experiment has been tried only by a very few who report encouraging results. In Sec. 8 of Bedford township ¾ of an acre of heavy sand yielded 12 tons of Hubbard squash. The patches of muck, abundant in certain localities, are generally capable of producing good crops of cranberries, celery and peppermint. The analysis of three typical celery soils will show the composition required for such crops. There must not be over one per cent of iron sulphate present and the muck must not be "sour." ("Michigan Soils," Bulletin 99, Agricultural College.)

| | Kalamazoo. | Grand Haven. | Newberry. |
|---|---|---|---|
| Sand and silicates | 19.16 | 24.09 | 24.56 |
| Alumina | 1.40 | 1.71 | 2.21 |
| Oxide of Iron | 3.94 | 3.52 | 1.30 |
| Lime | 6.09 | 5.02 | 4.18 |
| Magnesia | .81 | .62 | .75 |
| Potash | .34 | .20 | .42 |
| Soda | .38 | .33 | .40 |
| Sulphuric acid | 1.31 | 1.04 | .67 |
| Phosphoric acid | .88 | .69 | .46 |
| Carbonic acid | 1.95 | 1.05 | 1.10 |
| Organic matter | 63.76 | 61.73 | 63.75 |
| Water | 6.51 | 10.85 | 7.31 |

The rapid development of the beet-sugar industry in Michigan has created a demand for a new crop for which Monroe county soil and climate will be found well adapted. The ideal belt for growing the sugar-beet, so far as temperature alone is concerned, is determined by the summer isotherm of 70° F. This isotherm cuts diagonally across the county, from Toledo northwestward, and the entire county lies between the summer isotherms of 69° and 71°. The season opens early and the rainfall during the period of growth is all that is required. There is but one unfavorable feature relating to the climate and this is the amount of precipitation in September and October, which at Toledo is 2.38 and 2.32 inches respectively. The result of this precipitation at this time is to produce a second growth in the beet, which occasions a certain loss in percentage of sugar. Trial only will demonstrate whether the difficulty is sufficiently serious to involve considerable loss. There are thousands of acres in Monroe county which are well adapted to beet raising so far as soil is concerned. This should be a light loam with a clay subsoil, level but well drained, either naturally or artificially. Thin soils with hard clay subsoils do not allow the tap roots proper development. Wiley, the American authority upon the subject, says, "In general any soil which will give good crops of the cereals and other farm products will produce good sugar-beets." According to the Land Commissioner French, during the season of 1898 Monroe county produced 215½ acres of beets. Previous experiments have demonstrated that the beets are of good quality. Estimates for the state place the amount received for each acre at $53, half of which represents profit. The following paragraph from "Progress of the Beet-Sugar Industry for 1898," by C. F. Saylor, is full of encouragement:

"Thirty-four samples were received from the State of Michigan, showing a fine average weight, a satisfactory content of sugar, and a high purity. The results of the experimental work in Michigan last year were of such an encouraging nature as to justify the establishment of a beet-sugar factory at Bay City. Other factories are now building, and Michigan gives promise of becoming a strong rival to California in beet-sugar production. Evidently all parts of the State are capable of producing high-grade beets, and the climatic and soil conditions are extremely favorable. The data of this and previous years show beyond question that Michigan is one of the best states of the Union for sugar-beet culture." (Page 151.)

§ 7. Forest growth.

The character and distribution of the timber is determined directly by the nature and distribution of the soils already described. Upon the heavy clay are found oak, ash, elm, beech, hickory, black-walnut, bass, maple, whitewood, and along the water courses, sycamore. A singular belt of hickory, about one mile wide by two to three in length, extended originally in a northeast and southwest direction through Secs. 5, 6, 7 and 8 of Milan township. This region furnishes also most of the beech found in the county. The regions of heaviest sand have but a scanty growth of timber, consisting mostly of yellow, white and burr oak which form the so called "oak openings." In the swampy regions "popple" and tamarack are abundant. North of the Raisin the chestnut is common on the sand belts and extends northward into Wayne county.



The farmers uniformly report this tree as absent south of the river upon the same sand areas, over which it is abundant to the north. It appears that the Raisin has thus far constituted a barrier to the southern progress of this tree. In a preliminary survey of the flora of southeastern Michigan, Prof. C. F. Wheeler of the Agricultural College, in 1890, noted the following 55 trees:

| | |
|---|---|
| Acer dasycarpum | Silver maple. |
| A. rubrum | Red maple. |
| A. saccharinum | Sugar maple. |
| A. saccharinum, var. nigrum | Black maple. |
| Aesculus glabra | Ohio buckeye. |
| Asimina triloba | Papaw. |
| Amelanchier Canadensis | Shad-bush. |
| Betula papyracea | Paper birch. |
| Carpinus Americana | Ironwood. |
| Carya alba | Shagbark hickory. |
| C. amara | Bitternut. |
| C. porcina | Pignut. |
| C. sulcata | Big shell bark hickory. |
| Castanea sativa, var. Americana | Chestnut. |
| Celtis occidentalis | Hackberry. |
| Cercis Canadensis | Red bud. |
| Cornus florida | Dogwood. |
| Cratœgus coccinea | Red haw. |
| C. coccinea, var. mollis | Red haw. |
| C. crus-galli | Cockspur thorn. |
| C. tomentosa | Black thorn. |
| Fagus ferruginea | Beech. |
| Fraxinus Americana | White ash. |
| F. sambucifolia | Black ash. |
| Gleditschia triacanthos | Honey locust. |
| Hamamelis Virginiana | Witch hazel. |
| Juglans cinerea | Butternut. |
| J. nigra | Walnut. |
| Liriodendron tulipifera | Whitewood. |
| Morus rubra | Red mulberry. |
| Negundo aceroides | Box elder. |
| Nysa multiflora | Sour gum. |
| Ostrya Virginica | Water beech. |
| Platanus occidentalis | Sycamore. |
| Populus balsamifera | Balsam poplar. |
| P. grandidentata | Large toothed aspen. |
| P. monilifera | Cottonwood. |
| P. tremuloides | Aspen. |
| Prunus Americana | Wild plum. |
| P. serotina | Wild black cherry. |
| P. Virginiana | Choke cherry. |
| Quercus alba | White oak. |
| Q. bicolor | Swamp white oak. |
| Q. coccinea var. tinctoria | Black oak. |
| Q. macrocarpa | Burr oak. |
| Q. palustris | Pin oak. |
| Q. rubra | Red oak. |
| Rhus glabra | Smooth sumach. |
| Salix amygdaloides | Western black willow. |
| S. nigra | Black willow. |
| Sassafras officinale | Sassafras. |
| Tilia Americana | Basswood. |
| Ulmus Americana | White elm. |
| U. fulva | Slippery elm. |
| U. racemosa | Corky white elm. |

## *C. Amelioration of Soils.*

§ 8. Importance of subject.

Until the unwelcome truth is forced upon their attention probably most farmers look upon their land as an inexhaustible source of wealth, requiring only so much sunshine and moisture and so many hours of physical labor. Their farms to them are like the mythical hen which laid golden eggs without having to be fed upon bullion. In a state of nature the materials drawn from the soil by vegetation, are sooner or later returned to it, with a high rate of interest in the form of organic matter. It is impossible for this to occur when the land is under cultivation, otherwise there would be no advantage in such cultivation. A drain upon the soil is at once started, the nature and amount of which depends upon the character of the crops harvested. Every load of grain marketed, every animal fattened upon the farm means a certain reduction in its resources. It is not sufficient to return the straw and manure in order to make good the loss. This could be done only by again scattering the grain over the fields and restoring to the soil the carcasses of the animals fattened at its expense. Most of the older farmers will recall that the shocks of wheat do not stand as closely now as in former years. It is folly for the farmer, and especially for one who has his fortune still to wrest from his land, to allow his soil to become depleted and barren as has happened in many sections of New England and Europe. Left entirely to itself, in the course of time, the fertility of the land is restored by natural agencies, which it may be well to briefly consider since they will suggest means of artificial amelioration. Some of these agencies have worked with extreme slowness and seem trival, but operating through a long period, their effects have been great and to their action is due the happy, prosperous condition today of many Monroe county homes.

§ 9. Natural amelioration.

(a). Inorganic agencies. The drifting of loose sand by the wind over adjoining clay areas, although frequently disastrous, has produced belts of loam in the county which are better suited to most crops than either the sand or the clay alone. A similar action has taken place about the knolls and ridges through the agency of surface water, the sand being washed down and spread over the adjoining clay areas. Under cultivation finely pulverized clays are frequently taken as dust into the air and spread over adjoining sand belts, giving them more body and supplying, to a greater or less extent, the variety of materials which they need in order to support the staple crops. These clay particles may be carried beneath the surface by percolating water and become a permanent acquisition of the sand. Rain brings to the soil yearly small quantities of nitrogen in ammonia and nitric acid. From observations extending over a number of years at various stations in Europe it is estimated



that the average amount of these two nitrogen compounds per acre is 10.23 lbs. a year, with a range from 1.86 lbs. to 20.91 lbs. This is estimated by King as sufficient to supply the nitrogen required for two bushels of wheat.* Similar observations show that sulphuric acid is also present in rain water, but in smaller quantities. For a rainfall about equal to that of Monroe county the estimated amount is 2¼ lbs. to the acre for each year. Springs may locally add desirable ingredients to the soil, although too great quantities are generally deposited while the spring is active. In case the spring dries up the excess may be removed through the agency of rainwater and the character of the original soil more or less improved.

If one examines a pile of field stone many will be found, which although firm and solid within, are covered with a soft mealy crust, soft enough to be easily removed with the finger-nail. This is particularly true of rocks rich in plagioclase feldspar, hornblende and mica, less so for those containing much orthoclase feldspar and not at all so for the quartzites. This phenomenon is known as a "weathering" and results from the absorption of moisture by the minerals and their chemical disintegration. Both soluble and insoluble compounds result from this action, the former being taken into solution by the rainwater and carried to the streams, while the latter material is added to the soil. Boulders of considerable size may sometimes be found in which this destructive change extends to the center, so that they readily crumble at the touch or may easily be pulled to pieces with the fingers. This decay of the crystalline rocks adds to the soil silica, alumina, calcium carbonate and valuable quantities of soda and potash. When iron is present, even in small quantity, its oxidation and hydration takes place, staining the weathered material brown to yellow. The lasting qualities of glacial soils are due, in part, to this continuous enrichment which they receive from the rock fragments contained. Shaler has attributed the ranker growth of vegetation about surface boulders to this action.† Since this phenomenon may be seen about objects incapable of yielding nutriment to the soil it may be questioned whether the effect is not due mainly to the conservation of moisture and heat by the object. The disintegration of rock masses is greatly facilitated in temperate regions by alternate freezing and thawing

*The Soil, pp. 119-120.
†Origin and Nature of Soils. Twelfth Annual Rep., U. S. Geol. Sur., part I, pages 237 and 288.

of the water which collects in its pores and crevices. It has been determined that even solid granite will absorb .4 of a pound of water for 100 pounds of the rock. Upon freezing this water exerts an enormous disruptive force, producing crevices where none existed and enlarging others already formed. The great Ida boulder shown in Fig. 1 furnishes an illustration at its smaller extremity, where a large fragment has been flaked off in the way described. These crevices allow the destructive atmospheric agencies to operate over a larger and larger surface, thus greatly facilitating complete disintegration. Cleopatra's Needle, which safely withstood centuries of Egyptian climate, has suffered severely from a quarter-century of New York's changes and, in order to be preserved, must be housed as are other exotics.

(b). Organic agencies. Plant and animal agencies have a very important share in the natural improvement of soils already formed, or forming, operating in a variety of ways. In the case of the Ida boulder above referred to, the crevice which has been formed by the frost is now filled with soil in which smaller plants grow every season. In the course of time the wind, or a bird, will leave there the seed of some tree or shrub, which in its growth may completely rend the rock asunder. The accumulation of leaves in such a place, combined with growth in place of lichens and mosses, will furnish carbon dioxide gas and organic acids after their decay. These compounds added to the rainwater will greatly increase its power to dissolve substances from the rocks. Even the refractory quartz yields readily to its power. Hayes has recently cited instances of the solution of pure quartz through the agency of humic acids.* and gives Thenard as authority for the statement that simple humic acid will dissolve .8% of silica. After absorbing nitrogen from the air, however, and becoming azohumic acid it is capable of combining with 7 to 24% of silica, depending upon the quantity of nitrogen used. Compounds are formed which are readily soluble in alkaline carbonate solutions. Where conditions are favorable for the growth of bacteria, compounds may be formed which have a similar effect upon rock masses, thus rendering available to plants a larger quantity of mineral matter. The rootlets of the coarser plants and particularly those of shrubs and trees penetrate the subsoil to considerable depths, forming channels through which surface water and atmospheric gases may enter, thus extending downward the

*Bull. Geol. Soc. of Amer., Vol. 8, 1897, pp. 218-219.



action of these agencies. The overturning of trees by tornadoes frequently results in a mixing of soil and subsoil on account of the quantities of earth adhering to the roots. The effect, however, is just as liable to be disastrous as beneficial. Not only indirectly, as just pointed out, but directly through its partial decay, is the soil enriched through various forms of vegetation. The mineral substances required for plant growth are derived from the soil and returned again after the decay or combustion of the material. The carbon, however, which is the basis of nearly all plant products and some nitrogen, in certain cases, are drawn directly from the air, as explained in § 4 of this chapter. The incorporation of vegetation into the soil thus adds to it materials which it did not originally possess and to this extent it is enriched. Not only plant food is thus introduced but the undecayed carbonaceous matter renders the compact soils more porous, less wet and heavy, while the lighter soils are better enabled to retain their moisture. The dark color imparted to the soil gives it the power to absorb more of the sun's heat.

In this work of soil amelioration the plants are assisted to a great extent by animals. Charles Darwin in his book entitled "The Formation of Vegetable Mould," first called attention to the important effect of earthworms in working over and loosening up the soil. They, however, work mostly in soil that is already rich and hence needs their help least. Here they are frequently present in surprising numbers but almost or quite absent from heavy clay and light sand. They have the habit of passing through their long alimentary tracts, as they burrow, quantities of earth upon which their digestive juices act. The soil particles are triturated, softened, partially dissolved and finally ejected upon the surface in relatively large quantities. Penetrating to a depth of six to eight feet they bring to the surface the subsoil, thus mixing and deepening the layer of true soil. Darwin estimated from his observations in England that every five years the equivalent of one inch of soil is thus worked over by these lowly creatures (page 171). Their burrows allow atmospheric gases and surface water to reach the lower strata. Further, the earthworm draws into its burrow at night, to a depth of two to three inches, quantities of leaves. Enlargements in its burrow are lined with small seeds and pebbles. The vegetable matter thus introduced in part decays and enriches the soil. When this action is continued for one or more centuries its importance can scarcely be over-estimated. Next in importance to the earthworm may be mentioned in this connection the ant. The former prefers a damp soil while the latter selects one somewhat drier. In excavating their galleries they bring fine particles to the surface, sometimes from a considerable depth, thus securing the desirable mixing of soil and subsoil. Shaler has found the soils of certain fields in Massachusetts entirely altered through the agency of ants, and estimates that one-fifth of an inch of material is annually brought to the surface (page 278). Both animal and vegetable matter is introduced into the soil through their agency and their burrows secure more or less aeration for it. In tropical regions the work of ants is far more extensive, immense quantities of earth being brought to the surface. Branner has very recently described a region in Brazil the surface of which is nearly covered with their mounds, varying in height from 3 to 14 feet and in diameter from 10 to 30 feet.* Their channels were observed to extend to a depth of 13 feet below the surface, and through them surface waters are introduced, hastening the decay of the underlying rock. The larvæ of many forms of insects burrow into the soil and bring about some of the above results, but to a less extent.

In the southern part of Summerfield township Mr. Ezra Lockwood informed the writer that his sandy soil had been very materially improved through the agency of crayfish. These creatures construct long subterranean passages, about an inch in diameter and many feet in length, finally terminating at the surface. Over this entrance they frequently build up a chimney of clay for which it is difficult to assign any particular use. Standing several inches above the low flats they look as though they might be intended to exclude surface water from the burrow, but the crayfish would scarcely object to such water. If it left the mouth of its burrow, in case of surprise the crayfish would have difficulty in retreating, and quite probably the clay which it is desirable to remove in enlarging the entrance is thus heaped up in order to avoid leaving the burrow. The beneficial result noted comes from the mixing of this clay subsoil with the surface sand. In certain places these burrows assist in draining a marshy area and rendering it more tillable. A large number of burrowing animals exercise a similar effect, slight in any particular case but important in the aggregate. There may be mentioned mice, gophers, wood-chucks, rabbits, muskrats, moles, birds, etc., which

*Jour. of Geol., Vol. VIII, No. 2, 1900, pp. 151 to 153.



excavate burrows, mix the soil and subsoil, and introduce beneath the surface more or less organic matter. In all these cases cited the animal forms themselves eventually die and their remains are added to the soil. Valuable mineral and organic compounds are thus introduced which are worked over into plant tissue and finally again into animal. If the bodies still remained of all animal life that has died upon a given area since the close of the Glacial Epoch it is quite probable that the ground would be seriously encumbered with their carcasses.

§ 10. Artificial amelioration.

Nature offers many suggestions to the farmer whereby he may improve the character of his soil which is gradually and surely being impoverished. He may simply imitate the least expensive and most effective of her processes. One of these is the simple mechanical mixing of clay, sand and muck in sufficient proportions to form a loose, dark loam. In many regions this may be done by deep plowing, these different soils frequently overlying one another in close proximity near the surface. Many fields on the outskirts of the Forest and Grassmere beaches contain surface patches of sand and muck surrounded by clay. By means of a cart and scoop in the course of a few seasons these could be mixed and a valuable soil produced. Waiting for nature to accomplish this will seriously postpone the resultant harvest, as she is too dilatory in her methods. What would be supplied to the soil in the course of years through the disintegration of rock masses must be furnished more lavishly when the soil is under cultivation. An inspection of Table IX, § 4, of this chapter, shows that plants draw from the soil potash, soda, magnesia, lime, phosphorus, sulphur, chlorine and silica. Nitrogen in general must also be so obtained, although exceptionally it may be secured from the atmosphere in the way described below. Iron is also a necessary soil ingredient for the complete development of crops, but this along with the chlorine and silica is sufficiently abundant in all soils. Marl, ground limestone and "plaster" will cheaply supply lime, magnesia and sulphur. The earlier geological surveys strongly called attention to the value and availability of marl as a fertilizer. The loss which the soil sustains in potash, soda, phosphorus and nitrogen is more difficult to make good, involving the use of manures and commercial fertilizers. Upon application the State Agricultural College will gladly supply to all their analyses of the fertilizers now upon the market, from which there may be obtained an idea of their relative value for certain soils and crops.

Patches of muck land, which might support crops of cranberries, celery and peppermint are frequently found barren because of an excess of free acid. Such muck smells sour and will turn blue litmus paper to a red color. This condition may be remedied by drainage, loosening of the muck so as to well expose it to the weather, and by neutralizing the acid with marl or wood ashes. In his Report of 1861 (page 194), Dr. Winchell discusses this subject in language well worth reprinting in this connection.

"Nature has placed it (the material for overcoming the acidity of the muck) in the form of marl, in immediate juxtaposition with the peat which needs its agency. Indeed the farmer can in many cases load his cart with the mixed deposits without even moving his team from their tracks. I hardly know a more striking adaptation of natural means for the accomplishment of a necessary object. The porous nature of our soils suffers their soluble constituents to be carried away to the lower levels where peat and marl are accumulating, and where the growths of ages unknown, have been adding a thousand fold to the nutritive elements brought down from the soils of the contiguous hill slopes. These depositories of agricultural force, a good economy will not fail to appreciate and apply to the recuperation of declining wheat lands."

A practical method of increasing the fertility of soil, through the addition of nitrogen, has long been known to the farmer although few can explain the steps in the process. The procedure is purely an empirical one. If a plant of clover be pulled up and the soil washed from its roots there will be found upon them small irregular lumps, "tubercles." If one of the tubercles be picked to pieces upon a strip of glass and examined with a high power microscope there will be found minute stick like bodies in enormous numbers. These are one-celled plant organisms known as "bacteria" and in some way, as yet unknown, they enable the clover plant to appropriate the free nitrogen of the air. Beans, peas, lupine, and leguminous plants in general are similarly aided by various species of these nitrifying bacteria. Other plants not so assisted are surrounded by a great atmosphere of this nitrogen of which they are unable to appropriate an atom. They may be compared to the wrecked mariner upon a desert island, who famishes for lack of water although surrounded by the great ocean. In addition to the mineral matter taken from the soil and the carbon from the atmosphere, the crop of clover stores up nitrogen derived from the air. The plowing under of such a crop then adds to the soil valuable plant food which it did not possess. If a soil is too poor to produce clover suitable fertilizer may be applied first and then the field sown with clover, preferably one of the coarser varieties. The nitrogen of the soil is in part free



and in part in the compounds ammonia, nitrous and nitric acid, nitrates of sodium, calcium, etc. The ammonia which is a valuable ingredient of barn yard manures, is converted into nitrous acid through the agency of bacteria and this is changed into nitric acid, in which form it may be utilized by plants. If the soil is too wet some of these compounds are broken up, the nitrogen returned to the air and the soil to this extent impoverished.

# CHAPTER VIII.

## ECONOMIC PRODUCTS.

§ 1. Building materials.

A detailed description of the geological features of the various quarries of the county and layers exposed has been given in Chapter IV. At nearly all these localities stone for curbing and rough masonry may be obtained in unlimited quantities. Along the anticlinal ridge in the eastern part of the county the rock is shattered in places and its value much diminished for construction work. The lower layers in the Navarre quarries on Plum Creek are, however, heavily bedded and masses two and a half feet in thickness are being removed. In all the quarries in southeastern Michigan it is found that the surface layers are shattered and thin bedded, probably from the enormous pressure of the ice sheet and subsequent action of the frost. The Monroe beds which lie between the Sylvania sandstone and the Dundee limestone furnish the best building stone in the county. About Ottawa Lake, however, the layers are too thin bedded and their color is not uniform, so that they are desirable only for rough work. Northeastward these beds improve in quality. At the Little Sink, Lulu and Ida quarries good building stone, but no massive blocks are obtained. The blue streaked dolomite previously described as occurring at the Lulu quarry has a thickness of 20 inches, is of a fine texture and would probably take a good polish. Upon exposure to weather the blue color would rust and the rock shows a tendency to check, but for indoor work it might prove of value.

The most massive blocks for building, curbing and flagging are obtained at Woolmith quarry (Chapter IV, § 4), from a very thick bed of silicious dolomite of a light brown color, sold in the market as a "sandstone." Plate II gives a view of some of the blocks of this bed that may be obtained by the use of steam channelers. Masses of almost any desired size may be secured and sawed into shape. Thin dark seams detract somewhat from its value for fronts. According to the Company its crushing strength as determined by Gen. Q. A. Gilmore and Col. Herman Kallman, of the U. S. Engineers' Office in Detroit, is 13,800 pounds per cubic inch. Much of this stone has been used in Detroit during the past five years. The Macon and Dundee quarries furnish some heavy blocks of very pure limestone two to three feet thick, suitable for bridge work. The rock is impregnated with oil which would render it objectionable for many uses. The oil near the surface is lost upon standing, after which the rock grows lighter in color and the oil still contained within would contribute to the preservation of the stone. The sills and cappings of the old court house at Monroe were of this stone and well stood the test of years. About 200 cords of this stone are taken out yearly from each of the two quarries.



§ 2. Quick lime.

Since the early occupation of this region by white settlers lime to supply the local demand has been burned wherever the rock was available. Small openings were made into the upper layers and in the vicinity of outcrops, loose fragments were collected from the surface. The kilns were constructed, whenever convenient, along hillsides so that the rock could be dumped in from above. Their remains are frequently met with along the line of the "Stony ridge" from Ottawa Lake to Stony Point. As early as 1838, according to Hubbard, three kilns were in operation on Plum Creek, burning 900 to 1,000 bushels annually, five at Ottawa Lake, producing 2,500 bushels, and eight kilns upon the Macon, yielding 6,000 to 8,000 bushels annually. At the time of the Winchell Survey in 1859 and 1860 the Macon kilns were turning out about 10,000 bushels annually, and those upon Plum Creek a much greater amount. The chief business, however, was carried on at Raisinville (Grape) where 13 kilns were in operation, each with a capacity of 8,540 bushels. Dr. Winchell estimated that about 295,000 bushels were being produced annually in the county with a value of $36,875. At present writing lime is being burned at but three points in the county. Upon Plum Creek a small kiln of a capacity of 500 bushels is operated by Hugh Gaffny but only enough lime is produced to supply the Gas Company, 1,000 bushels in 1899 and 3,000 bushels in 1898. The rock used is the local dolomite, giving a slow slacking lime. The increasing cost of fuel has seriously interfered with the business. With wood as fuel the time required for burning was 72 hours, but by using alternate layers of fine coal and dolomite this time is reduced to 50 hours. At

Grape S. A. Kring has been operating the quarry up to a recent date owned by Robinson and Taylor, of Detroit. The rock burned is a dolomite which showed upon analysis of magnesium carbonate 45.01%, calcium carbonate 51.69% and of silica 3.45%.* Small quantities of iron, alumina and gypsum occur also. This yields a lime which slakes slowly, does not develop much heat, increases relatively but little in volume and will not take as much sand. This type of lime sets slowly and is preferred by many builders. Mr. Kring operates a continuous, double kiln from which every eight hours 75 bushels of lime may be withdrawn. The industry is continued for eight months in the year with eight hands and three teams, by which the product is drawn to Maybee, Ida and Monroe for shipment. For the past two seasons there have been burned here 35,000 bushels of lime annually, which has retailed at the kiln at 18 to 20 cents a bushel and in car load lots sold for 14 or 15 cents.

An entirely different type of lime is that manufactured at the Macon quarry from the pure limestone. This is of a purer white color, slakes very rapidly, developing much heat and increasing greatly in volume. It is capable of binding together much sand and is consequently said to be "strong." Owing to its "lively" character it is difficult to confine it in barrels. There are four kilns here, but two of which are in repair. These yielded 6,000 bushels in 1898 and 1,000 in 1899. Ordinarily only the two upper beds are used, of which the upper yields the whiter lime, (Chapter IV, § 1). The third bed yields a "livelier" lime than the upper two. The conversion of such limestone ($CaCO_3$) into lime ($CaO$) is accomplished by driving off the carbon dioxide ($CO_2$) at a temperature of about 824° F. The markets for the Macon lime are mainly local, but it is regularly supplied to the Southern Chemical Company, manufacturers of wood alcohol at Yuma, Michigan. Considerable lime was at one time shipped to Ann Arbor and Detroit but lack of shipping facilities prevented competition with more favored localities. The Detroit and Lima Northern now passes within a few rods of the quarry and these facilities are in consequence much improved.

Lime has been burned at Woolmith and at Ottawa Lake but the quality at each place was found unsatisfactory. Excellent facilities for manufacturing and shipping a promising variety of magnesian, or dolomitic lime, are found at the Ida quarry. A large double kiln of the continuous type stands upon the edge of the quarry and but

*Some of these dolomites might be suitable for basic furnace linings. L.



a few feet from the Adrian-Monroe branch of the Lake Shore railroad. Lime was burned here up to the time of the last financial depression and has not been since resumed. The best grade is made from the upper six feet of the second bed (Chapter IV § 6). It slakes slowly but is said to be strong for this variety of lime. It hardens into a substance more nearly resembling cement than mortar, becomes fully as hard as limestone itself and well resists the weather. In a private letter from Homer Wilcox, a Jackson dealer in lime, cements, etc., the following estimate is given of this lime.

"The ordinary quick lime manufactured at Ida is not liked as well as some other limes because it slakes so slowly. When used, however, it furnishes a stronger bond and though slowly setting becomes ultimately harder than the quicklime from Ohio, around Fremont and Genoa, or the darker quicklime from the Marblehead territory. * * * Burned moderately it makes a white, slow-slaking, hard setting lime and though it works cool and sets slowly, when it does set is very strong and resists action of water almost equal to hydraulic cement." (Jan. 28th, 1897.)

From figures furnished to the U. S. Geological Survey at Washington the total value of the lime for this county was $4,520 in 1897, $5,163 in 1896 and $6,675 in 1899. These figures appear to be somewhat below the actual amount produced. It is certain that the amount of this product could be indefinitely increased and of each of the three varieties described.

§ 3. Soda ash limestone.

For the manufacture of sodium bi-carbonate ($Na\ H\ CO_3$) known ordinarily as "soda ash" now being produced in great quantity along the Detroit River, a high grade limestone is required. This should contain from 95 to 99% of calcium carbonate with only small percentages of silica and iron. The carbon dioxide of the stone is driven off by heat as in the ordinary manufacture of lime and is made to combine with the sodium of the salt made use of in the manufacture of the ash. At present most of the rock is supplied by the extensive Sibley quarry near Trenton from their remarkable "9-foot bed." The only formation in Monroe county capable of yielding stone of requisite purity is the Dundee (See Plate 1) and the only accessible locality is on the Macon, northeast of Dundee. It is probable that here are found the identical beds of the Sibley quarry, reduced in thickness and somewhat altered in character, but still exceptionally pure, (See descriptions and analyses Chapter IV, § 1). The limestone here is impregnated with oil which would render it objectionable for the manufacture of soda, but it would seem as though this might be either burned from the stone at a lower temperature than that at which the gas would escape or else washed from the gas in case the oil and gas were driven off together. In the Christiancy quarry the disposition of the water is a serious matter on account of the nearness of the Macon. In describing the quarry it was pointed out that this difficulty would become relatively less as the quarry was deepened and broadened. Another site for a quarry in which water would probably cause still less trouble may be found about 80 rods to the northwest upon land formerly belonging to James Brown, now owned by B. E. Bullock, of Toledo. The rock is said to come to within five to six feet of the surface which would not mean an excessive amount of stripping considering the thickness of the strata that could be worked for one purpose or another.

§ 4. Beet sugar limestone.

The wonderful development of the beet sugar industry in Michigan has still further stimulated the search for higher grade limestone. The specifications required are essentially the same as for the stone used in the manufacture of soda ash. If found at all within Monroe county it must be at the localities mentioned above, which fortunately are surrounded by favorable agricultural regions for the growth of the beets. The stone is burned in kilns and both the carbon dioxide gas which escapes and the lime left behind are utilized in the manufacture of the sugar. The limestone should be compact and hard and not in fine pieces, otherwise it will "bridge" in the kiln and give trouble. For this reason marl cannot be made use of for this purpose. The percentage of silica, silicates and alumina needs to be low, since these will cause fusion in the kilns, the compounds adhering to the sides and "bridging." Magnesia and gypsum are not objectionable in the kilns but they interfere with the filtering and evaporation of the juice. It is said that magnesia may be tolerated up to three per cent. One per cent of moisture in the stone is considered desirable but as much as five per cent is objectionable since it interferes with the burning. A good quality of coke is recommended as fuel rather than coal which may introduce impurities into the lime and gas. The table of analyses opposite is taken from Special Report on the Beet-Sugar Industry in the United States for 1897.

Numbers 1, 2 and 3 were found to be satisfactory, while 4, 5 and 6 are excellent. The analyses of the Macon limestone make a very good showing when compared with these, but it is not to be expected that all the beds will prove equally suitable. The oil will prove an objectionable ingredient unless it can be disposed of in the way



TABLE XII.—COMPOSITION OF LIMESTONE FOUND SUITABLE FOR BEET-SUGAR MANUFACTURE.

| Ingredients. | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| Moisture | 4.17 | 6.25 | 5.16 | .52 | 1.21 | .11 |
| Sand, clay and insoluble matter | 3.07 | 3.17 | 2.25 | 2.85 | .55 | .27 |
| Organic matter | .97 | 1.12 | .86 | .30 | .41 | .15 |
| Soluble silica | .98 | .64 | .56 | .06 | .20 | .03 |
| Oxides of iron and alumina | .19 | .15 | .20 | .32 | .23 | ........ |
| Calcium carbonate | 88.65 | 87.93 | 90.03 | 93.80 | 96.58 | 99.10 |
| Magnesium carbonate | .95 | .50 | .45 | 1.81 | .50 | ........ |
| Sodium and potassium ($Na_2O$, $K_2O$) | .01 | ........ | ........ | ........ | ........ | ........ |
| Undetermined | 1.00 | .24 | .39 | .34 | .32 | .34 |

suggested, or in some better manner. In the manufacture of the sugar the juice of the beet is treated with the lime either in powdered form or as "milk of lime." This lime unites mechanically and chemically with the impurities of the juice after which the carbon dioxide gas, driven from the limestone by heat, is allowed to bubble through the limed juice. A recombination takes place forming the calcium carbonate anew as a flaky precipitate which carries the impurities to the bottom. This calcium carbonate is separated from the juice containing the sugar by passing the latter through a cloth filter. This precipitate has value as a fertilizer and the farmer may bring his beets to the factory and take back a load of this material for enriching his soil. Lime is sometimes further used in recovering from the waste substance known as the "molasses" its final content of sugar. This sugar may equal 15 to 20% of that contained in the beet and is made to unite with lime forming tricalcium saccharate, which may be filtered out. In some of the European factories this sugar is recovered by the use of strontia, derived from the mineral strontianite, a mineral which occurs at several localities in Monroe county, but so far as we yet know only in limited quantities. The strontium is again carefully recovered in the form of the hydrate and after the process is started, simply the loss has to be made good. This loss as calculated by Prof. Wiley, in terms of strontianite would equal 6.25% of the weight of the molasses treated, rather more than the county could supply unless richer deposits are uncovered. For a factory using 300 tons of beets daily it is estimated that from 35 to 40 tons of limestone would be required daily, the exact amount depending upon the purity of the stone.

§ 5. Cement materials.

A widespread and deep seated impression has prevailed for a long time in and about the county that the dolomites of the Monroe beds possess hydraulic properties; that they are capable of producing a cement capable of hardening under water. This has resulted very probably because of their equivalency with the noted "waterlime" series of New York. In his report for 1840 Hubbard says that experiments upon the rock about Monroe had already demonstrated its value for such purpose. Winchell in 1861 suggests that further tests be made upon the rock with a view to determining just what hydraulic properties it does possess. Some little experimentation has been carried on by private parties but no complete or conclusive tests have been yet applied. Edward Vorster, formerly of Monroe, now of New York City, conducted some experiments upon the Monroe stone which proved unsatisfactory, he thought because of the absence of sufficient soluble silica and the presence of too much magnesia. Magnesia, however, is perfectly hydraulic and when properly calcined will set under water and form a stony mass. Homer Wilcox, of Jackson, in a letter quoted above in § 2, makes the following statement concerning his tests upon the Ida dolomite:

"From a series of experiments with rock from quarries one mile west of Ida Station, Monroe county, Michigan, I did not find the burned and ground rock a true hydraulic cement and yet it possessed properties different from any other rock I found in Monroe county, and I secured samples from, I think, all the quarries in that county. Ida limerock burned moderately hard, made a slow-slaking, slow setting lime when used as quicklime, but the same stone burned very hard lessened in bulk, became heavy and would not slake; but when ground into a flour and mixed with water set slower than the ordinary cements of the country (Akron or Louisville), and became ultimately harder than either Akron or Buffalo. I was, however, unable to calcine the rock hard enough in ordinary kilns to insure this result."

Hydraulic properties of perhaps a high order of excellence are suggested by these experiments. With specially constructed kilns and skilled labor in charge the rock might be made to produce a good quality of hydraulic cement.

The requirements for an hydraulic cement rock, according to Lord, are a limestone, magnesian or not, having intimately mixed with it 15 to 35 % of clay and a little potash or soda. Sand should not be present in the form of grit and the rock should dissolve in hot acid giving much muddy residue. Mr. Edward D. Boyer the Superintendent of the Hercules Cement Co. of Catasauqua, Pa., has kindly supplied the following average analysis of their rock, which, he says, is practically the same for the entire now famous Lehigh region.



| | |
|---|---|
| Calcium carbonate | 69.375 |
| Silica | 14.280 |
| Alumina | 9.000 |
| Iron | 2.810 |
| Magnesium carbonate | 2.353 |
| Potash salts, moisture | 2.182 |
| | 100.000 |

A table of American cement rocks was published in Vol. VI of the Ohio Geological Survey which may be of value in this connection for reference. The proportions of the various constituents are seen to vary greatly. These rocks are burned with a bright red heat in suitable furnaces and then ground in mills to an impalpable powder.

TABLE XII.—COMPOSITION OF AMERICAN CEMENT ROCKS.

| Locality. | Calcium carbonate. | Magnesium carbonate. | Silica. | Alumina. | Iron oxide. | Alkali. |
|---|---|---|---|---|---|---|
| Ulster Co., New York | 30 72 | 35.10 | 19.64 | 7.52 | 2.38 | 4.10 |
| Cumberland, Maryland | 41.80 | 8.60 | 24.74 | 16.74 | 6.30 | 6.18 |
| New Lisbon, Ohio | 69.00 | 3.40 | 15.65 | 6.80 | 2.50 | ........ |
| La Salle, Illinois | 42.25 | 31.98 | ........ | 22.18 | ........ | ........ |
| Bellaire, Ohio | 46.52 | 26.40 | 16.41 | 5.44 | 3.38 | ........ |

The composition of the rock has to be carefully watched in order to determine the amount of burning required and the grinding needs the same careful supervision. So far as analyses have been made of the Monroe rocks there are none of them which show a composition which would promise much in this direction. There is too much silica of the insoluble variety in many of the beds and in none of them does there seem to be sufficient alumina.

In the manufacture of Portland cement the proper proportions of clay and calcium carbonate are artifically united and burned at a temperature of 2,900° F. During this burning calcium silicate, and calcium aluminate are formed (the former below 1300° the latter above), which upon being ground and then wet, become hydrated, harden even out of contact with air and form insoluble masses. These cements do not slake as does lime and do not require any carbon dioxide gas from the air in order to harden. The celebrated English cements are made from the chalk beds and clay dug from the ancient bed of the Thames and Medway rivers. Analyses of these cements show the following range in composition, according to Heath.*

| | |
|---|---|
| Lime | 58 to 66% |
| Silica | 20 to 26% |
| Alumina | 2.5 to 10% |
| Potash | 1 to 3% |
| Soda | 0 to 2% |

A mixture that ordinarily suffices to secure the proper composition is 72 to 77% of calcium carbonate and 23 to 28% of clay. The carbonate may be in the form of limestone or of marl and should be quite free from magnesia and sand. The clay should be of an even grade and free from grit. When rubbed between the fingers it should have a smooth greasy feel and should not stain the fingers. Silica in combination with potash and soda is spoken of as *soluble* and must be present in the clay. Too much iron and gypsum are objectionable; of the latter from one to two per cent may be tolerated. Caustic magnesia (MgO) forms a hydrate and sets with great hardness. When it and caustic lime (CaO) are present in uncombined form in the cement, however, the lime sets first and the magnesia later thus causing injury if the percentage reaches 4 to 5 per cent. Magnesia may be made to combine with silica and alumina as in the case of the lime but the hydration of its compounds is also slower than those of calcium. In order to show the composition of some of the mixtures from which English Portlands are made the following table is reproduced from Redgrave.†

TABLE XIV.—COMPOSITION OF ENGLISH PORTLAND CEMENTS.

| Ingredients. | Folkestone, chalk and clay. | Forest of Dean, limestone and clay. | Barrow Lias, quarry mixture. |
|---|---|---|---|
| Sand | 2.50 | 5.57 | 2.58 |
| Silica | 11.83 | 9.61 | 11.41 |
| Ferric oxide | 1.97 | 2.42 | 2.34 |
| Alumina | 5.23 | 3.45 | 4.80 |
| Iron pyrite | Trace. | .............. | .43 |
| Calcium carbonate | 74.18 | 75.89 | 74.09 |
| Magnesium carbonate | 1.29 | 1.50 | 2.61 |
| Calcium sulphate | .18 | .16 | .21 |
| Potash | .90 | .88 | .93 |
| Soda | .31 | .39 | .46 |
| Water | 1.82 | .61 | .43 |
| | 100.21 | 100.48 | 100.29 |

*A Manual of Lime and Cement, 1893, p. 42.
†Calcareous Cements, their Nature and Uses, p. 45.



Mr. Homer Wilcox in his tests of Monroe rock added alumina to the Ida dolomite thus preparing a Portland type of cement. In his letter he gives the following statement of his results.

"I made mixtures of this Ida quarry rock in varying proportions with clay from various sections of Michigan and some from other states, but found no practical results, except in case of one particular kind of clay obtained from the coal mines of Jackson county, Michigan. I ground Ida quarry rock into flour without burning and mixed it with clay from the coal strata at Jackson, about ¼ clay and ¾ rock. Let it dry into soft bricks after mixing—then burned. It became very hard and slightly vitrified. This product I ground after burning and it was a pure hydraulic cement and the specimens from it superior in firmness, heft and hardness to any Portland cement I ever used, whether made in the United States, England or Germany. It cost too much, however, to manufacture for market and I abandoned the intention to place it on the market for that reason. I tried the same clay with limerock from other sections of Monroe county, but did not obtain the same results."

It is to be expected that the high percentage of magnesia in the dolomites of the Monroe series would prevent their use for such cements. In the quarries upon the Macon, however, as pointed out in preceding sections, limestone of sufficiently high grade occurs. The bed of marl south of Monroe (§ 11 of this chapter), is suitable also for this purpose but not enough of it is in sight. The clay deposits which constitute the till are too stony and sandy for use with the carbonate. The most promising deposits are in the southeastern parts of the county, Erie, La Salle and Monroe townships, where clay sediments from the glacial lakes occur most abundantly. These deposits are freest from pebbles and have a relatively small percentage of sand.

§ 6. Road metal.

The nature of the soils and the flat slopes conspire to give Monroe county exceptionally poor roads. In certain sections the roads are practically impassable for any kind of conveyance for several weeks of the year. Aside from the mere convenience and pleasure of the residents good roads are sadly needed in order that crops and farm supplies may be more economically transported. The economy arises from the saving in time, horseflesh, wagons and harness and the fact that crops may be marketed when the price is most advantageous, rather than simply when the highway permits. With a system of hard roads much of the necessary farm teaming may be done when the clay soils adjoining are not fit for cultivation and thus the time of the farmer, his hired help and team disposed to better advantage. Three tons may be drawn upon a good road with greater ease and less expense than one ton upon a poor road. Some 10,000 representative farmers from all parts of our country were called upon for estimates as to the cost per mile of hauling one ton of produce to market. The average cost for the entire country was 25 cents while in certain sections of New Jersey where the roads have been improved by a system of state aid the estimates averaged from seven to ten cents, making a saving of from 15 to 18 cents to the mile for each ton of produce.* In consequence of this saving there is at once an increased valuation in all property that secures the full benefit of improved roads. In the neighboring state of Indiana some 40 to 50 representative farmers who have lived under a system of poor and later of good roads have estimated that the increase in the market value of their land is $6.48 per acre, which is believed to be a very conservative estimate. But even this low estimate would mean an increase of $4,147.20 for each section of land. The total estimated annual loss from poor roads for a hundred acre farm is given by the U. S. Bureau of Agriculture† as $76.28, or a little less than $500 annually for each section. This loss alone in six years would construct and maintain an excellent stone road past every farm house in the county. In the Circular No. 28 above referred to, Director Roy Stone of the Office of Road Inquiry, quotes a Canandaigua farmer, whom he had questioned concerning his extra taxes as saying, "In this one week, by the advantage of having these stone roads and getting to market with my hay when it sells at a good price, my teams have earned $5.00 every day, while my neighbors' teams on the other roads are eating their heads off. We could not afford not to have these roads; we do not care anything about the taxation."

There are no available deposits of gravel in the county such as occur in Lenawee and Washtenaw counties, but Nature has given Monroe inexhaustible supplies of still better road metal and distributed it so that it is fairly accessible from all parts of the county. When the dolomites and limestones are crushed and spread over a road bed, which is properly drained, the surfaces of the stone become firmly welded and a very solid foundation results. It is not necessary to treat the entire road with crushed stone but simply one-half of it leaving a dirt road alongside, which at certain times is as satisfactory for driving as the compacted stone. This reduces the expense of construction and maintenance very considerably and is now being tried about Canandaigua, New York, with gratifying results. The stone used there are common field boulders which are drawn

*Circular No. 28, U. S. Dept. of Agriculture, Office of Road Inquiry.
†Circular No. 23.



from the land by the farmers at a good price per load, thus ridding the land of a serious incumbrance. Those of a single region are heaped together at a convenient spot and finally broken up by a portable crusher owned and operated by the township. The crushed stone are then distributed by local teams.

An excavation from 10 to 12 inches deep and 8 feet wide is made to receive the stone. Experiments, however, have shown that a six inch layer is satisfactory for ordinary roads, although 9 to 10 inches would probably be found more economical in the end. This thicker bed would require about 1300 cubic yards of crushed stone to the mile, which at the Monroe crusher would cost, at present prices, $780. The cost of transportation, preparation of the bed and spreading of the stone would have to be added. In some sections of the county the railroads are willing to carry road materials at the cost of transportation for the sake of encouraging improvements. In one sense every such road constructed is but an extension of the railroad to the farmers' residence. As the roads are ordinarily laid out it would be necessary for each section to become responsible only for two miles of road in order to completely cover the county. At first, however, only a few roads radiating from the main centers would suffice and these could be located with reference to the individual assistance that residents along the routes would be willing to render. Undoubtedly the expense of road construction could be very materially reduced by having each township, or adjoining townships, own and operate portable crushers. In 1896 such a crusher was worked by private parties in the eastern part of Whiteford township. A temporary tramway was laid and the stone were used in constructing one of the excellent roads leading out of Toledo. In only a few localities in the county are field stone abundant enough for such use. If the amount of time and labor that is ordinarily expended in improving (?) the roads could be more wisely directed great good would result.

Four permanent crushers have been constructed and operated in the county but two have ceased working. One of these was located alongside the Michigan Central just south of Newport Center and the other on Plum Creek at the quarry of the Detroit Stone and Supply Co. Those still in operation are at Woolmith and at the quarry of the Monroe Stone Co. north of Monroe. At Woolmith there are some beds capable of yielding a good quality of rock for macadamizing purposes, but the bulk of the rock possesses so much sand that it more readily crumbles and probably does not bind its fragments together so firmly. A more even type of dolomite is being crushed north of Monroe, the quarry having been operated almost continuously since Sept. 1, 1895. (See Plate IV.) The market is principally Detroit, but shipments are made to Saginaw, Bay City, Jackson, Adrian, Toledo, etc., the quarry being favorably located with reference to the Lake Shore, Michigan Central and Pere Marquette roads. During the season of 1899 this company shipped 55,706 tons at an average price of 60 cents per ton. Three grades of stone are supplied ranging from ½ to 2½ inches in diameter. The "Screenings" are used for cement sidewalks and are sold at twenty cents per ton.

As reported to the United States Geological Survey the total value of the limestones and dolomites marketed in Monroe county during the year 1897 was $29,812; for 1898 it equaled $23,779 and in 1899 was $43,183.

§ 7. Glass sand rock.

The bed of Sylvania sandstone has been described in considerable detail in Chapter III, § 6. It is so friable that it has no value for building purposes, although blocks firm enough for foundations have been taken from the Raisin bed. The chief use of this remarkably pure bed is the manufacture of glass, for which its fine even grain and purity well adapt it. It had been tested for this purpose before Michigan became a state and attention was especially called to the bed by Hubbard, Winchell and Rominger in their state reports. The outcrop was originally preëmpted from the government by Col. Thomas Caldwell, a British officer, and held by him and his heirs for many years. Charles Toll of Monroe has owned 60 acres of this land for over 40 years and for some time back has held sand and mineral rights on 150 acres adjoining. From 1860 until about 1873 or 4 the pits were operated by Toll, the sand being washed and sifted and shipped to Bridgeport, Bellaire and Benwood, Ohio; to Pittsburg, Wheeling, Rochester, Syracuse and Hamilton, Ontario. The sand was said to have been removed to a depth of twenty to twenty-five feet. The sand had to be teamed seven miles over a sand road and this so greatly increased the expense that it was finally unable to compete with beds more favorably located. The sand has been found to mix intimately with the fusible bases so that it melts rapidly and yields a glass free from color. Recently this land of Toll and his mineral rights have been leased by the Michigan White Sand Company, with headquarters at Maybee, Michigan. (W. H. Cowles, President and F. G. Strong, Secretary.) This company has put up a small experimental plant, in which the sand is heated to 400° F. without washing and then sifted, thus securing several grades of purity and fineness. A larger plant is contemplated which will have a capacity of 150 to 200 tons daily. The sand when washed gives no iron, traces only of calcium and magnesium carbonate and 99.59% of silica, thus showing very superior qualities for higher grades of glass. The whitest sand is said to be reached at a depth of two feet in the bed. By following the bed in the direction of the dip, as well as laterally the quantity is practically unlimited. Proceeding northwestward a capping of dolomite would soon be reached which would form a good roof in case it was desirable to mine the sand. The bed will be found to drop at about the rate of 25 feet to the mile.



The organic stain found in the upper part of the bed at the outcrop would be expected to disappear beneath the clay and dolomite. The course of the sandstone across the county is shown upon Plate I from which it is readily seen just where it is crossed by the various lines of railroads. A further examination of Plate XV will show the approximate thickness of the drift at each locality in case it might be desired to get to the sandstone by sinking a shaft through the drift. It should be noted that the full thickness of the bed would be obtained only by striking it on the western or northern edge of the belt. In case a test shaft happened to first strike the dolomite, the sand would be found just beneath and the dolomite would serve as a roof. As a rule the bed yields water in abundance and in mining the sand this water would have to be bargained with. It is not improbable that this water which it would be necessary to pump from any opening made into the bed would be quite sufficient for washing the sand. This sand has had several minor uses for which it is well adapted on account of its whiteness and sharp cutting edges. It makes a beautiful painters' sand, is very popular with the Diamond Match Company for use upon their match boxes and is unexcelled for scouring purposes, for which it is used locally. Soap charged with this sand would probably rival "Sapolio" for rough cleaning.

§ 8. Brick and tile.

The manufacture of brick upon a small scale was begun at a very early day to supply local demands. At the time of the Houghton Survey, Frenchtown had produced a total of 1,600,000. One kiln had been burned at Brest and about 100,000 at Newport. A trial had been made at Dundee and abandoned on account of the calcareous nature of the clay. Good brick were said to have been made in London township from clay obtained from the Saline valley. No statistics relating to the gradual development of the clay industry in the county are available. In 1896 the total value of the clay products was \$15,720 and for 1897, \$12,410. During the season of 1898 there were manufactured in the county, 2,112,100 brick, valued at \$10,535 and tile valued at \$12,470, making a total of \$23,005. For 1899 there were burned 1,625,000 brick and 1,165,000 tile, having an approximate total value of \$23,000. The position of the eight factories now in operation is shown on Plate XV. In 1896, at the time of the first inspection of the county for this report, two others were operating, one at Dundee and the other at Erie.

Notwithstanding the inexhaustible supplies of clay within the county, owing to its method of formation and accumulation, it is so charged with pebbles, many of them calcareous, as to be worthless for brick and tile. Upon burning, the fragments of carbonate are converted into lime, which will eventually slake and ruin the article containing them. Mechanically also they injure the soft brick and tile as they are forced through the die. This difficulty is in part obviated by running the clay first through a "crusher," which reduces the pebbles to coarse sand. From the till clays of various texture and purity could be obtained by a process of washing, but the time is not at hand when this would be profitable for ordinary use. Nature has, however, done considerable of this and deposited a washed product along the river valleys from which a good grade of brick and tile may be manufactured. Such clays usually contain sufficient sand to prevent warping and shrinkage in the process of burning. The sites of former lakes frequently contain clay of a very homogeneous character, which was washed in from the surrounding region. Such beds are generally only from one to three feet thick and in many cases underlie layers of muck and marl. This action took place upon a much larger scale in the case of the great glacial lakes described in Chapter VI, so that in the eastern, and particularly the southeastern corner of the county the superficial clays are to a greater or less extent utilizable. Whatever the color of the clay it burns in all cases to a cherry red, owing to the conversion of the iron compounds into the red oxide ($Fe_2O_3$).

The old method of moulding brick by hand has been discarded, but



a near approach to it is still found in the "soft mud process," used at Monroe. The clay is brought into a soft, pasty condition by the use of water and kneading machinery, and then forced into sets of moulds, similar to those formerly used in the hand process. These moulds are emptied and resanded by hand, the bricks being spread in the yard to dry, where they are liable to be injured by the weather. Such brick are open grained and porous, but do not show the cracks about the edges and corners which so frequently occur in brick forced through a die. In the "stiff mud process," which is the one very generally employed, the clay is moistened sufficiently to become plastic but is at all times stiff enough to hold its shape. There being less water to be gotten rid of the drying takes place under long sheds. The stiff clay is forced by means of an auger or plunger intermittently from the machine through the openings in a steel plate. These openings are of suitable size and shape to give the clay its desired form and it is then cut into proper lengths, during a period of halt, by a frame carrying tightly stretched wires. Bricks made by this process are more compact, have a smoother surface and are stronger, but quite generally show cracks along the edges and other imperfections, due to the action of the die and the imprisoned air. Most of the kilns used in burning the brick and the tile are of the "up-draft" pattern but there are a few "down-draft" kilns in operation. In this type of kiln the heated air is admitted at the top and is compelled to pass downward before it can escape, thus giving a much more even burning to the brick and tile. The following data relating to the factories were collected in September, 1899:

Milan Brick and Tile Manufactory, owned by the Farmers and Mechanics Bank of Milan, H. S. Knight, Manager. Located alongside of the Wabash railroad, N. E. ¼, S. W. ¼, Sec. 2, Milan township, within one-fifth mile of the Ann Arbor road. The clay for tile is of a bluish variety obtained from the Macon Creek in N. W. ¼, Sec. 14, place of Warren Lewis; from 6 to 10 inches of muck have to be removed. Six feet of clay may be worked before it becomes stony. The brick clay is obtained from the Saline, Sec. 1, Milan, place of O. W. Leonard, and is of a yellow color and sandy. Stiff mud process; Brewer machine, with a capacity of 20,000 brick and 8,000 tile daily. One double up-draft kiln. The engine used is 25 horse power and about 20 hands are employed. During the season of 1898 the company manufactured 100,000 brick and 120,000 tile; in 1899 about 280,000 brick and 125,000 tile. The markets are mostly local, but shipments are made along the railroads as far as Toledo and Detroit.

Meyers Bros., Azalia, Ann Arbor railroad. Clay is obtained from bed of the North Branch of the Macon and is a mixture of blue and yellow as worked. From four to six inches of muck are first removed, below which is 1½ feet of blue clay and still lower 3 to 6 feet of yellow before a bed of gravel is struck. The factory has been in operation 6 years, and employs about 14 hands. A Brewer machine is used, driven with a 35 horse-power engine, capacity 12,000 of 3 inch tile and 24,000 brick; down-draft kiln. Markets are local and shipments to various points in Monroe and Washtenaw Counties. Tile are made from 2½ to 8 inch. During 1898 there were put out 225,000 brick and 220,000 tile; during 1899 from 250,000 to 275,000 brick and about 250,000 tile.

Charles Jacobs, S. W. ¼. S. W. ¼. Sec. 34. Summerfield. The clay is a local deposit found just north of the factory. There are 6 to 7 inches of muck and loam, beneath which lies 2½ feet of streaked blue and yellow clay, before clay carrying pebbles is reached. This plant was operated for several years by Wadsworth and Harwick. The machine used is a Brewer with a capacity daily of 15,000 3 inch tile and 15,000 brick. Markets are entirely local as there are no shipping facilities. During the season of 1899 there were manufactured here about 45,000 brick and 300,000 tile. Down draft kiln.

Mrs. Katharine Stout, Ottawa Lake Charles Jewell, foreman. A streaked yellow clay is used obtained near at hand, carrying some pebbles. Stiff mud process; Adrian machine, No. 2; steam power. One down draft kiln in repair. Only tile are made here and mostly 3, 4 and 6 inch; but ranging from 2½ to 10 inches. Capacity of machine is 6,500 of 3 inch. During 1898 there were burned 200,000 tile and about 400,000 in 1899. The factory is near the Adrian-Toledo branch of the Lake Shore and shipments are made as far as Toledo.

August G. Matthes, Strasburg. Adrian-Monroe branch of the Lake Shore R. R. Clay used is a blue and yellow streaked bed three feet thick, beneath which is 6 to 8 feet of blue clay (till). Clay is somewhat stony but not sufficiently so to cause serious trouble. Machine is an Adrian, No. 2, stiff mud process. Capacity daily 14,000 brick and 13,000 3 inch tile. Employs 7 to 8 hands. One up draft kiln. Last season Mr. Matthes made 250,000 tile and 150,000 brick and in 1898 200,000 tile and 125,000 brick. Markets are entirely local. Brick sell for $4.50 to $6.00 per thousand in the yard. The following prices per thousand are secured for tile: 3 inch $9, 3½ inch $12, 4 inch $14, 5 inch $17, 6 inch $25, 7 inch $35, and 8 inch $40.

Robert C. Herkimer, N. E. ¼. S. E. ¼. Sec. 18, Exeter. Operated by Frederick Linenfelser. Clay used is of the yellow variety and obtained from the Saline flats. Brewer "6 A" machine; capacity 25,000 brick and 12,000 3 inch tile. Engine 25 horse-power; six hands; one up draft kiln. In 1898 there were burned here 150,-000 brick and 140,000 tile; in 1899 about 250,000 brick and 60,000 tile. The markets are purely local. Tile of the 3 to 4 inch size are mostly made, but range from 2½ to 8 inch. The prices are about the same as those above given for the Strasburg factory.

John Strong and Sons, South Rockwood, Michigan Central railroad. Clay obtained from surface near plant, bluish-yellow. The sod only is stripped off from the bed, five feet of which are usable. The pebbles present are first crushed. Adrian machine; stiff mud process for tile, soft mud process for brick. Engine 50 horse-power; daily capacity 30,000 brick and 10,000 to 12,000 3 inch tile. Two stacks for brick and two down draft kilns. 13 to 14 hands employed. During season of 1898 400,000 brick and 250,000 tile were made, but owing to overstocking none were burned in 1899. Markets are local, to points in Monroe and Wayne counties and north of Detroit. Tile from 2½ inch to 8 inch are made, but the demand is chiefly for 3 and 4 inch. The prices are for 2½ inch $8, 3 inch $9, 4 inch $13 and $6 for brick.

Charles G. Eaton, Monroe. Pere Marquette R. R. and Adrian-Toledo branch of the Lake Shore railroad. A yellow stony clay is used from a local deposit. A crusher removes the coarser pebbles and crushes the smaller. Soft mud process for brick. The bed of clay used is 3½ feet thick, from which only the surface has to be stripped. Sand has to be added to the clay. Brewer machine is used, with a 25 horse-power engine, capacity 30,000 brick daily. About 20 hands are employed. Up draft kiln for tile. Sizes range from 2½ to 8 inch, with most of 3 to 4 inch. In 1898 about 640,000 brick were burned and about 80,000 tile; in 1899 about the same amount of brick and about 65,000 tile. Markets local at about the same prices as above quoted.

## § 9. Natural gas and oil.

Covering the northwestern part of Monroe county as shown upon Plate XV there is an area over which there are strong surface indications of oil and natural combustible gas. This area covers Milan, London, Dundee, western Raisinville, nearly all of Summerfield and the northwestern corner of Ida townships. The oil impregnates the rocks and forms a scum over the water of ponds, streams and wells, giving it sometimes a very offensive odor. The gas bubbles up through the water, sometimes as a continuous stream, usually only as occasional bubbles. Still more of it escapes into the air without being noticed. Where especially abundant in wells it burns upon being ignited, giving a hot but only slightly luminous flame. It has comparatively little odor, by which it may easily be distinguished from the offensive, hydrogen sulphide gas ($H_2S$) which is found in



wells, imparting to the water the odor of "rotten eggs." From carbon dioxide gas which may also occur in wells and springs it is distinguished by its combustibility, since this former gas not only will not burn but will not support combustion. As pointed out in Chapter II this gas and oil are more directly associated with the St. Clair, Traverse and Dundee formations and are most abundant in Milan and London townships. This is known as surface or shale gas, can have no great volume and rarely ever any great pressure. It does not occur at definite horizons, is not associated with oil, salt water or any definite rock structure. The gas obtained from the drift deposits, in all probability, is derived from the underlying rock formations. The only practical use for this gas is for domestic purposes for which it has been but little utilized in the region. Piped into the house and used economically it would last for a number of years, when a new well could be sunk at but little expense and a new supply obtained. This should be looked upon as one of the resources of the farm and should be as carefully husbanded. The gas is not as valuable for illuminating as for heating purposes owing to its lack of luminosity. An Ohio man has discovered that if the fire brick of the grate are occasionally sprinkled with salt a more luminous flame may be secured.*

There is no necessary connection between this surface gas and oil and the deeper seated deposits so eagerly sought for by means of deep borings, since both may have been separately produced. At Findlay, Ohio, however, before the wonderful discovery was made such surface indications had been known for many years. At ten different places in the county deep wells have been drilled at heavy expense with the hope that some such deposits would be discovered as those which have made northwestern Ohio famous. Six of these wells have penetrated the Trenton limestone, the productive horizon in Ohio, but without adequate returns. (For records see Chapter III § 8). From data thus obtained it is apparent now why these wells have failed and there can be no justification for further expenditure to secure oil and gas from the Trenton within the limits of Monroe county. The gas and oil fields of Ohio and western Ontario are located along the crest of the great Cincinnati anticline, an uplift in the Trenton and overlying strata. This upheaval began in Silurian times, but was arrested, and the final folding as determined by

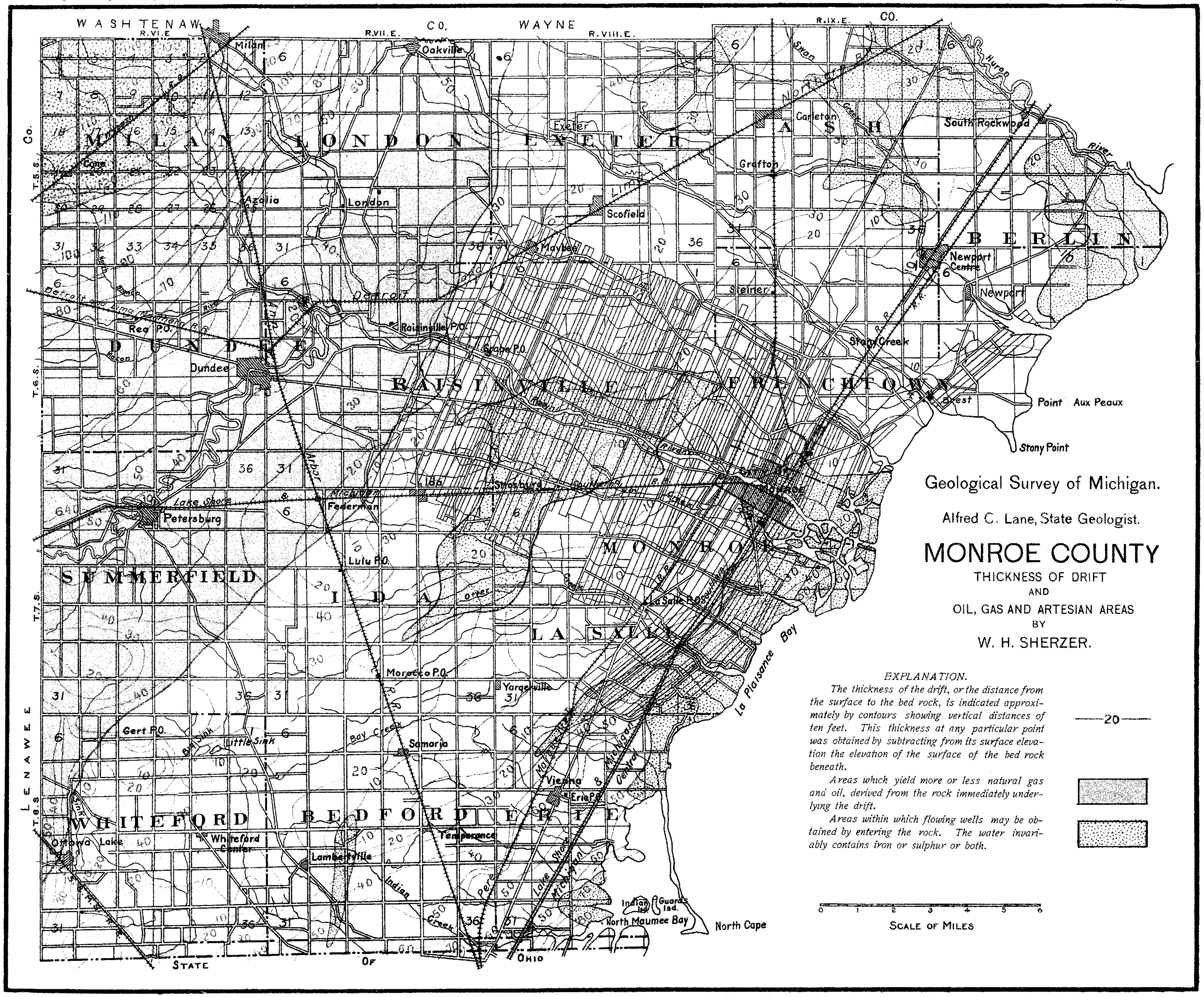
*In some districts of Ohio this "low pressure drift" gas has proved to be of commercial value. The use of Welsbach burners might remedy the lack of luminosity.

Foerste* took place in the late Devonian or early Carboniferous. As mapped by Orton† this anticline passes northward from Findlay to the east of Toledo, passing under Lake Erie and reappearing in Ontario. In a paper read in 1887 before the Royal Society of Canada.‡ Robert Bell says:

> "There seems to be no doubt that the occurrence of petroleum in Enniskillen is connected with the Cincinnati anticlinal, but the writer, after having done a considerable amount of geological work in Western Canada at various times since 1859, and having carefully studied the question, has come to the conclusion that this anticlinal, coming up from Ohio, does not run eastward, as Logan supposed, into Lake Ontario, but that it maintains its northward course, and runs into the southern extremity of Lake Huron." * * * "Northward of Lake Erie, an impartial study of what is actually known of the geographical structure, as well as of the distribution of the formations, indicates that its axis, after crossing the lake, continues on, as we would naturally expect it would, in the same general north-northeastward direction bearing through the counties of Essex, Bothwell and Lambton, from about Littles' Point on Lake Erie, to about Kettle Point on Lake Huron."

From this quotation and the figures given in Chapter III, § 9 concerning the drop in the Trenton towards the north and west it will be apparent that Monroe county is unfortunately placed upon the western slope of this productive anticlinal. The higher portions are to the east and south and towards these directions the oil and gas have been drained. The most promising part of the county for a test well was theoretically in the southeastern corner since this is nearest the crest of the anticline. Of all the ten deep wells the one nearest this region has proven most productive. This well was begun in November, 1898, and completed December 10th. It is owned by F. C. Potter in the N. W. ¼, N. W. ¼, Sec. 22, Erie township. The Trenton was struck at a depth of 1,555 feet, (see Chapter III, § 8), and entered 112 feet. The original gas pressure was 25 pounds to the square inch. It has been piped to the house and is used for lighting and cooking. The well contains oil and has been several times bailed out, some ten barrels having been thus secured in August, 1899. Most of the other wells have given some temporary showing, enough to raise the hopes of the stockholders, but none of them have done as well even as the Potter well. The three Monroe and the two Dundee wells have furnished decisive tests so far as the penetration of the Trenton is concerned. According to Orton, who followed very carefully the development in Ohio, the productive part of the Trenton is usually confined to the first 15 feet. In his report of 1888, § he says

*American Geologist, Vol. VII, 1891, pp. 97 to 109.
†Ohio Geological Survey, Vol. VI, pp. 46 to 55.
‡Trans. Roy. Soc. of Can., 1887, p. 105.
§Geological Survey of Ohio, Vol. VI, p. 118.



Geological Survey of Michigan.
Alfred C. Lane, State Geologist.
MONROE COUNTY
THICKNESS OF DRIFT
AND
OIL, GAS AND ARTESIAN AREAS
BY
W. H. SHERZER.
EXPLANATION.
The thickness of the drift, or the distance from the surface to the bed rock, is indicated approximately by contours showing vertical distances of ten feet. This thickness at any particular point was obtained by subtracting from its surface elevation the elevation of the surface of the bed rock beneath.
Areas which yield more or less natural gas and oil, derived from the rock immediately underlying the drift.
Areas within which flowing wells may be obtained by entering the rock. The water invariably contains iron or sulphur or both.
20
0 1 2 3 4 5 6
SCALE OF MILES
WASHTENAW CO.
WAYNE CO.
LENAWEE CO.
STATE OF OHIO
R.VI.E.
R.VII.E.
R.VIII.E.
R.IX.E.
T.5.S.
T.6.S.
T.7.S.
T.8.S.
MILAN
LONDON
EXETER
ASH
BERLIN
DUNDEE
RAISINVILLE
FRENCHTOWN
SUMMERFIELD
IDA
MONROE
LA SALLE
WHITEFORD
BEDFORD
ERIE
Milan
Oakville
Carleton
South Rockwood
Exeter
Grafton
Scofield
Azalia
London
Maybee
Newport Centre
Newport
Steiner
Stony Creek
Raisinville P.O.
Grape P.O.
Reg P.O.
Dundee
Point Aux Peaux
Stony Point
Ida
Strasburg
Monroe
Petersburg
Federman
Lulu P.O.
La Salle P.O.
Morocco P.O.
Yargerville
Gert P.O.
Little Sink
Samaria
Vienna
Erie P.O.
Ottawa Lake
Whiteford Center
Lambertville
Temperance
Indian Isd.
Guard Isd.
North Maumee Bay
North Cape
La Plaisance Bay
Huron River
Swan Creek
Bay Creek
Indian Creek
Lake Shore

"Thus far, unless some gas or oil is found in the uppermost sheets of the Trenton limestone, none is found below, and in but one case have valuable accessions to the supply been made more than fifty-five feet below the top of the rock. There are scores of instances now on record, all agreeing as to this point, and yet most of the wells that fail to find gas in the proper horizon are carried down 200, 300, 400 feet into the solid limestone before being finally abandoned. Such expenditures are a dead loss to the investors, and are generally of but little value to the drillers. The same perversity shows itself in multiplying wells after one or even after repeated failures in territory which must be counted on highly probable grounds as unproductive."

Gas and oil have had a common origin which is now generally believed to have been from the decomposition of organic matter, animal or vegetable, or both, which was originally deposited in the sedimentary rocks. There is a divergence of opinion as to whether the gas and oil were produced from the original partial decay of the organic matter at the time of its deposition, or later as a product of slow spontaneous distillation.* Probably the view that now receives widest acceptance is that these products have resulted from the decomposition of organic matter, at normal temperatures, either at the time the rocks were formed or later. The oil and gas may still be associated with the original beds in which it was formed or it may have escaped upward until its progress was arrested by impervious beds of suitable shape to confine it. In case no such beds existed it would escape to the surface and be lost. As might be expected from their method of formation limestones and shales would be the only beds with which any considerable amount of organic matter would be associated and in such beds oil and gas are believed to have originated. The organic matter of limestones was in the main of animal origin and gave rise to a dark heavy offensive oil containing a relatively large quantity of sulphur and nitrogen. It is oil of this nature that is found in Ohio and western Ontario. Oil derived from shale is in the main of vegetable origin and is lighter in color, contains less sulphur and nitrogen and has not the offensive odor of the limestone oils. Most of the oils of the Pennsylvania region are of this nature. Fissured limestones, sandstones and conglomerates serve as reservoirs for oil and gas, usually with an arched capping of shale. Where salt water, oil and gas all occur they are arranged in the order of their specific gravities; the gas would first be reached in the boring, would escape, give place to oil eventually and lastly to salt water. It is thus apparent why the crests of anticlines and of domes are so productive of oil and gas and why the slopes may prove barren, or yield a small quantity of oil or salt water only.

*See Geol. Sur. of Mich., Vol. V, Pt. II, pp. xix to xxiv.

§ 10. Artesian water and mineral springs.

Three belts of artesian water strike across the county in a northeast and southwest direction,—an eastern, a central and a western belt. Within these areas, when the rock is penetrated a short distance, the water generally rises to the surface and flows, thus saving the expense of windmills and the trouble of pumping for stock and for irrigation. This water is very generally charged with compounds of calcium, magnesium, iron and sulphur, derived from the limestone, dolomite and shale through which it has passed. The iron and sulphur are derived largely from the decomposition of the pyrite and marcasite, which are very commonly present in these rocks. Hydrogen sulphide gas is produced which is readily absorbed by the water, to which it imparts the odor of "rotten eggs." Upon exposure to the air this gas is decomposed and the sulphur is precipitated as a white mealy precipitate over troughs, stones and vegetation. When in quantity and after standing it begins to assume a slight sulphur yellow color. The iron is present in the water mostly as a carbonate and upon standing it is oxidized and deposited as a yellowish brown coating over objects, this being the hydrated oxide. This is insoluble in water and is readily distinguished by its color from the sulphur. When both iron and sulphur are present in the water in the form described a chemical combination takes place and iron sulphide results, giving the water an inky black color. A number of wells of this character were met with in the county, although the water of a region usually contains one or the other of these substances alone. In some instances artesian water is derived directly from sand and gravel layers in the drift and is reported as soft.

Continued drought makes no perceptible impression upon many of these wells, while with others the flow may be reduced and almost or quite stopped. The opening of new wells has been found to affect the flow of others in the neighborhood and the areas over which artesian water may be secured are becoming more contracted. Wells which formerly flowed in the southern part of Erie township, back three miles from the lake, have now ceased although the water rises to near the surface. The opening of the Woolmith quarry in Exeter township had a noticeable effect upon the water in the wells to the northeast. The deep well in the eastern part of the city of Monroe so seriously interfered with the action of the wells of that region that it had to be plugged. At the place of Nelson Richards, S. E. ¼ S. E. ¼, Sec. 1, Exeter, a flowing well ceased to act when another was started at Welsey Richards' place, one-half mile west, but by compelling the latter to rise four feet above the surface both wells flow. Meteorological conditions are found to affect the wells in several very noticeable respects, more or less puzzling to their owners. These effects may be thus summarized:



William Young, N. W. ¼, S. W. ¼, Sec. 6, Milan. Gives a muddy deposit before a storm.

J. R. Vescelius, S. E. ¼, N. W. ¼, Sec. 6, Milan. Becomes roily before a storm.

Charles Campbell, S. E. ¼, S. E. ¼, Sec. 27, Milan. Water becomes roily when wind is in the southwest.

Brightbill Bros., S. E. ¼, S. E. ¼, Sec. 3, Exeter. Three to four hours before a storm gives a black sediment.

William Laurie, S. W. ¼, N. W. ¼, Sec. 6, Ash. Water gives a black deposit 12 to 14 hours before a storm.

Scofield, Exeter. Level of water in well said to be raised three feet by an east wind.

T. M. Taft, S. W. ¼, N. E. ¼, Sec. 7, Summerfield. Water stands higher with an east wind, lower with a west.

G. W. Dauncey, S. E. ¼, N. W. ¼, Sec. 7, Berlin. Water flows faster before a storm, but is not roily.

Charles Todd, S. E. ¼, N. E. ¼, Sec. 7, Berlin. Flowing well had nearly ceased to flow on account of clogging with sand but once just before a storm it broke out afresh and gushed with such noise as to be heard some little distance, throwing out much sand.

These phenomena may all be simply explained by the meteorological conditions that prevail before and during times of storm. The density of the air at such a time is reduced over the surface of the earth, so that its pressure on the column of water in the well is less. Air enclosed in the subterranean passages of the rocks is temporarily more condensed than that over the surface and its pressure upon the underground water, added to the regular hydrostatic pressure, causes the water to rise to a higher level, or to flow with greater force than usual. If sediment of any kind has been deposited in the underground channels the increased velocity of the flow will cause this to be again taken into suspension and the water becomes roily. The only supposable connection between the east wind and the height of the water in the wells is that the wind in this quarter frequently presages a storm.

The most western artesian area covers nearly the northwestern half of Milan township to the west of the Arkona Beach. It is a portion of a belt which extends from Lenawee county northeastward into Washtenaw. The artesian water is derived from the rock and from layers of the drift, which varies in thickness from 100 to 150 feet. Throughout this entire area the water does not always flow, lacking nine feet of reaching the surface in Milan village. The water rises from a few inches above the surface to 14 feet at Thomas Welsh's. Here one well at the barn rises higher and yields softer and warmer water than another at the house, near at hand. At the place of John Dennison, S. E. ¼, N. E. ¼, Sec. 20, a flowing well can be readily obtained anywhere by penetrating a bed of coarse gravel at a depth of 30 feet. The amount of water supplied by these wells is never large, the best of them simply filling a one inch pipe. The heaviest flow of the region is obtained from the crest of the Belmore Beach, one mile over in Lenawee county at the residence of James Harmon. A strong flow was secured from a depth of 48 feet, rising 9 feet above the surface. A 1½ inch pipe is filled and the water is used in the dairy. At the barn a similar well was struck and plugged because of the difficulty in disposing of the water. This water is impregnated with iron.

The middle belt referred to consists of three detached patches extending in a northeast direction across the county. The most southerly is a narrow area about three miles long by one-half mile wide in Bedford township, just east of Lambertville. Some fairly strong flows are obtained in this region but they rise but little above the surface. In the central part of the county there is a large irregular area over which flowing wells may be ordinarily secured (see Plate XV). The water contains sulphur commonly when it comes from the rock but sometimes iron. The highest rise noted is 5 to 6 feet upon claim 472, South River Raisin.

The most northern area of this belt occurs in northwestern Exeter and northwestern Ash and continues as a narrow belt northeastward into Wayne county for a considerable distance. This region contains considerable sulphur at times in combination with iron. Some of the wells proved so offensive and so injurious to the soil that they were plugged. A rise of three feet above the surface is above the average.

The eastern artesian belt lies near the lake shore and consists of four detached areas, one small one in eastern Erie, a second about the mouth of the Raisin and extending southwestward into Erie, a third in eastern Berlin and a fourth irregular one in northwestern Berlin and eastern Ash. In Brownstown of Wayne county the two latter areas unite and continue towards Detroit along the Detroit River. As might be expected the flow of water is stronger in these regions and the rise above the surface is higher. At the Greening Brothers' nurseries south of Monroe the water reaches the surface with force enough to run sprinklers and when compelled to do so



will rise 12 feet. Eastward at Lake Erie at the Lotus House there are two flowing wells which will rise 20 feet above the surface or 25 feet above the lake. The water of the wells in this lake region is generally charged either with sulphur or iron, seldom containing both in such quantity as to become dark. The heaviest flow of

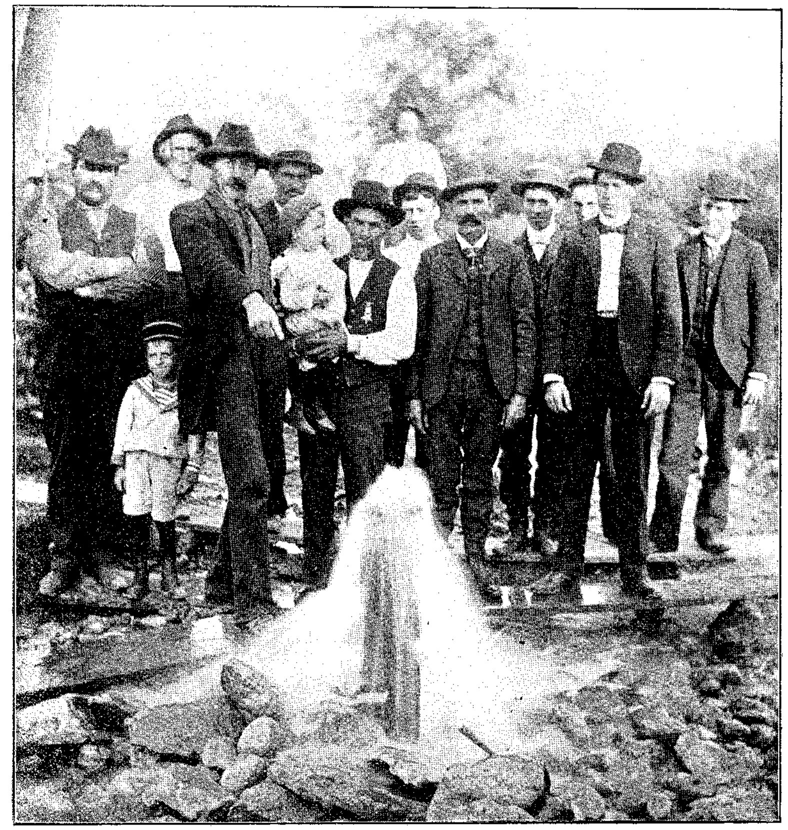
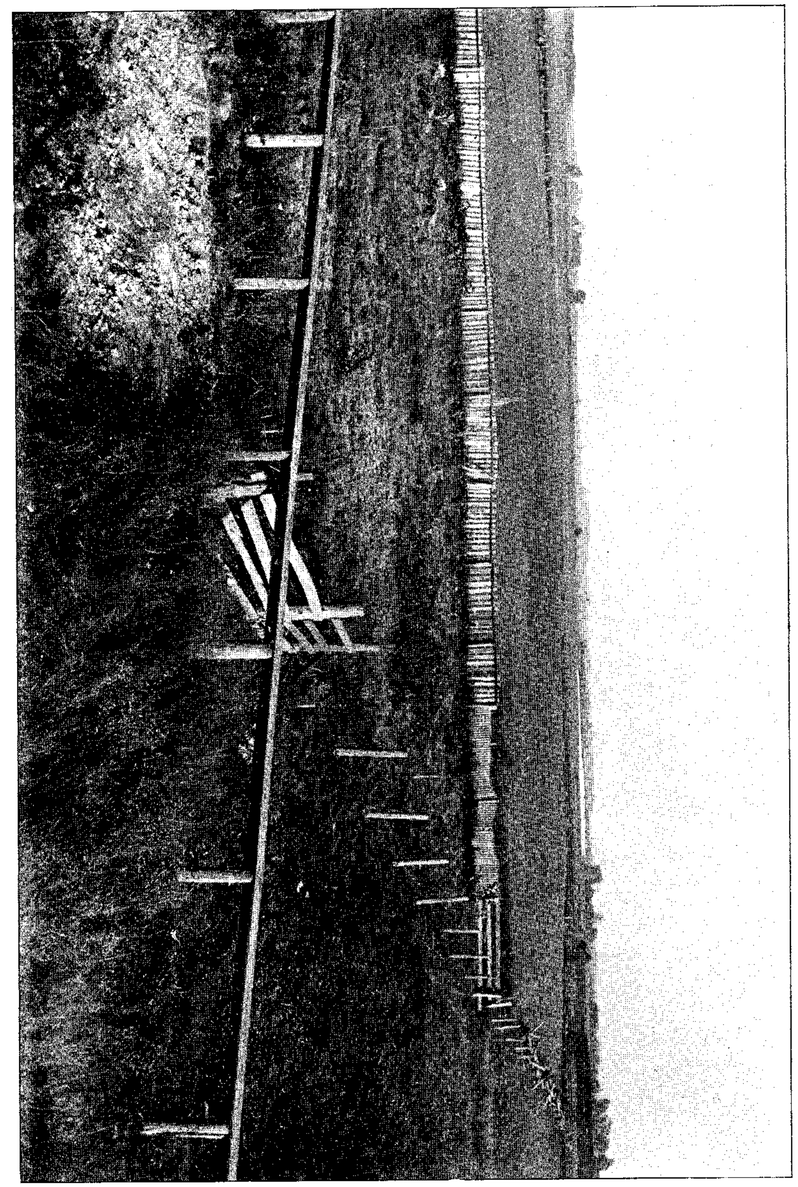


Fig. 7. Gushing well struck upon Otter Creek, September, 1899. Residence of Edward Sharkey, 2½ miles southeast of LaSalle.

artesian water known in this part of the state was struck in September, 1899, upon the south bank of Otter Creek, about 2½ miles southeast of La Salle, at the residence of Edward Sharkey. The well is 51 feet deep and 6 to 8 feet in the rock, having been drilled with a three inch drill. September 4th water was struck and began to flow, slowly at first and then with greater strength. A wooden pump-stock was driven into the hole and projected four feet above ground. Through this the water was thrown with force and to a considerable distance, latterly through 10 one and one-half inch holes bored in the side. Thus prevented from escaping freely the water began to rise through the clay around the mouth of the well and at a distance of 25 to 30 feet from it, forming a shallow lake about 100 feet across. By this time Mr. Sharkey became alarmed for the safety of his house and the pump-stock was withdrawn, an eight inch pipe being inserted in its place. At the time of the writer's visit a very rapid stream two feet broad and four inches deep was flowing from the well to Otter Creek. Fig. 7 shows the well as it appeared September 16, 1899, as taken by an amateur.

Within these artesian areas not infrequently natural openings have been made to the surface through which the water escapes and flows as a mineral spring. These are more common in the central and eastern part of the county, back from the river to a distance of two to three miles. Some of them sometimes occur outside of the artesian areas, for instance the sulphur springs near the foot of Ottawa Lake upon the farms of Harmon Branch and William Bell. A strong natural flow of sulphur water, with some iron, occurs at Christopher Nichols' claim 685, South River Raisin. This would fill a five inch pipe and is but slightly affected by drought, never drying up. Upon land belonging to Catherine Sorter, claim 673, South River Raisin, there is a strong sulphur spring which feeds Sulphur Creek. This has been known to stop flowing but twice, in 1875 and 1895. South of Monroe 1¾ miles is located the somewhat celebrated "Shawnee Spring," upon claim 160, South River Raisin, just east of the Michigan Central tracks. From 1860 to 1879 or 80 the place secured some note as a resort. The water is said to retain practically the same temperature throughout the year and to be unaffected by drought. An examination of the water was made in 1864 by Prof. S. H. Douglass, then of the University of Michigan, who reported that the water contained free carbonic acid, magnesia, and abundance of lime, chlorides and sulphates and that hydrogen sulphide would probably be found in the water at the spring. The spring has formed a large mound of sphagnum moss and calcareous tufa over 500 feet across and 8 to 10 feet high, through which the water escapes by numerous mouths. (See Plate XVI.) Quite large masses of this tufa are loose in the field and ledges of it occur in position. The





SITE OF SHAWNEE SPRING NEAR MONROE. MOUND IS POORLY SHOWN.

water tastes and smells of hydrogen sulphide and is depositing sulphur. Similar springs with mounds of tufa are found to the south, upon lands of Mrs. Adeline Q. Navarre and Joseph Asam.

A large sulphur spring occurs upon the place of Peter Cushino, Otter Creek, near the Sharkey well just described. This has an elliptical basin 45 by 90 feet, with a 10 foot margin richly covered with *Chara*. The stream from the spring is not rapid, is 2½ feet broad and 10 inches deep. A similar but much larger spring occurs in the Erie marsh near Vienna, N. E. ¼, Sec. 22. It is reached by boat by punting one-half mile through an artificial channel. At a

Fig. 8. Great sulphur spring in the lake marsh near Erie. The figure gives also a view of the inundated margin; cf. Fig. 5.

distance the site of the spring is marked by a spot of the most livid green contrasting strangely with the dark waters of the marsh. The general form of the spring is circular as shown in Fig. 8 and its diameter is about 160 feet. The bottom is funnel-shaped, a marginal strip of 25 to 40 feet shelving off slowly and then making a sudden drop. The bottom where visible through the clear water is covered with a mat of *Chara*, encrusted with a deposit of sulphur. The sounding line struck bottom at 30 to 33 feet, although it is quite probable that fissures occur leading to greater depths. The outlet from the spring is a small sized river having considerable velocity, a breadth of 33 feet and a depth of one to two feet. The current is so swift that there is some difficulty experienced in entering the spring with a boat. The channel soon becomes broader and proportionately more shallow, and over the bottom of it much sulphur has been deposited. Fragments of tufa are found about the margin of the spring showing that the water is probably rich in calcium carbonate. It is very probable that these springs and flowing wells are fed by the water which enters the rocks in the western part of the county.

§ 11. Marl.

No extensive beds of this substance, for which the Portland cement industry has created a demand, are known to occur in the county. The largest deposit known occurs upon the property of Joseph Asam, claim 422, north of Plaisance Creek. Over an area of 6 to 8 acres there is a layer of black spongy muck containing many dead shells of *Helix*. Beneath this is found a bed of marl varying in thickness from one to three feet. The marl is so free from grit that, after washing, it has been found to produce a good polishing powder for gold, silver, nickel, brass etc. It was boxed and sold for this purpose some twelve years ago under the name Paragon Polishing Powder, being prepared by the La Plaisance Manufacturing Co. The marl contains some shells but appears to have been in the main precipitated from the water of a small lake charged with lime carbonate. Such a deposit may now be seen in process of formation over the bottoms of the series of lakes through which the Huron River flows in Washtenaw county. Upon claim 161, about one mile west of the Asam deposit at the place of Eli P. Duval, there is said to be a black deposit with white clay. The latter is undoubtedly marl and a similar reference to a 10 inch layer of "whitish dirt" was obtained at W. J. Kelley's, claim 520, South Otter Creek, where it is overlain by 2½ feet of yellow sand and one foot of black sand. Beneath the sand layer is one foot of yellowish-white clay, 1½ inches of gravel and then common clay to the rock. Judging from these deposits we have here a former lake site. At the cranberry marsh belonging to Clayton Everett, of Toledo (S. E. ¼, Sec. 24, Summerfield, see p. 157), more or less marl occurs, but the maximum thickness is said to be but 6 to 8 inches. It is quite probable that thicker deposits occur towards the center of the marsh, possibly of considerable extent. In his early report Hubbard reported marl as occurring on Sec. 7 of Exeter and Sec. 9 of Ash townships.* A very extensive marsh occurs in Sec. 9 of London and probably contains marl beneath the surface. It might be possible to dredge out here both marl and a suitable variety of clay for Portland cement. The clay would be found beneath the marl if both occur. Such use is the main one for this loose variety of lime carbonate. Its value as a fertilizer and for neutralizing the acidity of muck has been referred to in the previous chapter, p. 172. In the early days it was sometimes converted into lime by heaping it up into a pile and keeping a wood fire going around and over it until the carbon dioxide gas was driven off sufficiently.

*Second Annual Report of State Geologist, 1839, H. R. No. 23, p. 410.



§ 12. Salt.

Springs along the Saline River furnished a weak brine for the use of the Indians and pioneers, but the main one was in Washtenaw county (T. 4 S., R. 5 E., Sec. 12). In 1823 this spring was described as being 16 feet deep, set about with a picket of logs from which the surface water was excluded by means of an embankment. Salt was manufactured here on a small scale, an analysis showing 113.8 grains of salt in 100 cubic inches of the water.* Dr. A. Winchell, in his report of 1860 (p. 59) refers to a salt spring in Ida township, 4½ miles south of the Raisinville quarries. No such surface springs could be located by the present survey, probably owing to the diminished flow from wells and springs. In Berlin township, S. E. ¼, N. W. ¼, Sec. 15, at the place of A. Bondie, the well water is reported as being occasionally salty to the taste. In Lenawee county, north of Deerfield, this phenomenon is more common. Such indications are of interest now only as they suggest the presence of more extensive saline deposits beneath the surface. Undoubtedly the waters obtained from the deep wells of the county are highly charged with salt but no study has been made of them. In but one of these deep wells was there recognized a stratum of solid rock salt (halite) and in this case the report lacks verification. According to a newspaper item, at a depth of about 1,200 feet, a 12 foot stratum of salt was penetrated in the Frey well, near South Rockwood (N. E. ¼, N. E. ¼, Sec. 33, T. 5 S., R. 10 E). This occurrence was not to be expected since the records of the six wells at the Church and Company's plant north of Trenton seem to indicate that the St. Clair and Detroit River beds of salt give out between the most northern and most southerly located wells of their group. Well No. 6 gives a stratum of 33 feet while Nos. 4 and 1 and 3 lying in this order to the east

*First Annual Report of the State Geologist, 1838, H. R. No. 14, p. 28.

give 30 feet, 26 feet and 25 feet respectively. Well No. 2 lies about 300 feet south of the above and shows but 2 feet of salt while in No. 5, some 800 feet south of the northern row, only a brine was secured with no solid salt. If the rumor in regard to the Rockwood well be founded in fact it will be necessary to assume that minor salt beds were deposited south of the main series after the inland sea had begun to break up into separate bodies of water (Chapter III, § 5).

# CHAPTER IX.

## MINERALS OF MONROE COUNTY.

§ 1. Introduction.

In this chapter it is desired to describe in simple language the native minerals so that they may be readily identified by those interested, even if they possess no previous scientific knowledge or training. After a mineral has been recognized the question of its formation and source becomes of more or less interest and importance, so that the history of the various mineral deposits will be briefly presented. There are excluded from the list all those minerals which were formed to the north and east and which were transported to the region under study by ice or other agency. This chapter will then be of little service in identifying the constituents of the drift boulders strewn over the surface or embedded in the soil. Almost any mineral known may occur in them. It will treat only of those mineral substances which were formed within the limits of the county, some of which are at the surface but most of which are contained in the rock strata and are now met with in the quarries and well drillings. A mineral has been defined as a natural, homogeneous, inorganic substance; but this definition, simple as it is, requires some explanation. It must have been formed entirely through the operation of natural agencies without the intervention of man. The substance itself must have practically the same chemical composition throughout, although it may have mixed with it more or less impurity. It must be of inorganic origin entirely, or if derived from plant or animal originally, its organic structure must have been practically destroyed.

### *A. Carbonates.*

§ 2. Calcite.

This is the most common and widely distributed mineral of the quarries. It is found filling seams and crevices in the limestones and dolomites and forming beautiful sparry lining to fissures and cavities. The calcite may occur as a compact granular mass or in separate, well formed crystals. The crystals are commonly sharply pointed, each point being formed by three pairs of triangular faces, making what is known technically as a scalenohedron.* Such crystallization is known popularly as "dog-tooth spar," because of the resemblance of the crystals to canine teeth. Hubbard, in his early report, refers twice to the "hog-tooth spar" and it is not now certain whether this is simply a misprint or whether he intended to characterize a coarser variety of crystal. Another common form of crystal is the rhombohedron, looking like an oblique prism. Whatever the original crystal, upon being broken the calcite breaks with remarkably perfect cleavage planes parallel to the faces of the rhombohedron. The luster is more or less glassy and the color is various from impurities. The usual color is snow-white to a cream-yellow, but it is sometimes tinged with a variety of color. Clear transparent varieties are known as "Iceland spar," but in general, the mineral is simply translucent. It cannot be scratched with the finger-nail, but is readily scratched with a pin or knife, giving a white powder, the "streak." Its specific gravity is the average for rocks, 2.7. Its composition is calcium carbonate ($Ca\ CO_3$), and it contains by weight, 44% of carbon dioxide ($CO_2$), and 56% of lime (CaO). This gas may be readily driven off by the application of cold dilute hydrochloric acid to the solid crystal, causing brisk effervescence, so called. The acid of standard strength is prepared by taking four parts of pure water to one part of the acid, giving a 20% mixture. The Monroe calcite crystals have been deposited from percolating water holding calcium bicarbonate $CaH_2(CO_3)_2$ in solution. This form of the carbonate is easily converted into the common variety ($CaCO_3$) which crystallizes where conditions are favorable. Such conditions are commonly found in rock fissures and cavities where there is little agitation of the water which is charged with the carbonate. The finest crystals of calcite in the county are found at the Woolmith quarry, although some good specimens can be procured in the dolomites about Monroe.

§ 3. Aragonite.

This mineral was not identified by the writer amongst his collections but is said to have been found about Monroe.† It has the same composition as calcite, but has less perfect cleavage and is perceptibly heavier and harder. It does not show the familiar forms of the calcite crystals, the scalenohedron and rhombohedron. Its crystals may be either simple or compound, or may occur in radiating groups of acicular crystals. The latter is the common crystallization of strontianite (§ 6 of this chapter), and it is quite possible that this mineral may have been taken for aragonite. With the dilute acid calcite and aragonite behave similarly, so that they are liable to be confused with one another, unless crystallization and cleavage can be well made out. Upon being heated as with the blow-pipe, they each whiten and glow, but the aragonite crumbles to powder while the calcite does not. The aragonite is liable to contain some strontia, which imparts an intense red color to the flame, making its separation from strontianite more difficult. The lime carbonate of many shells is in the form of aragonite as those of mussels and snails. Some corals and polyzoa form this same substance for their hard structures.

*See Vol. VI, Part I, appendix, for report on crystallization of calcite.
†Dana's system of Mineralogy, 1892, p. 1086.



§ 4. Tufa.

This is a cryptocrystalline form of lime carbonate deposited over moss, twigs, leaves, etc., by spring water. The underground water carries the calcium bicarbonate in solution as explained in § 2. Upon having its pressure relieved and being exposed to the air some of the carbon dioxide escapes from the unstable bicarbonate, the monocarbonate results and this is so slightly soluble that it must be precipitated. Deposited thus quite rapidly over the surface of meadows there results an imperfectly crystalline, lumpy mass, more or less porous and open, showing the imprints and moulds of the organisms covered by the water. This is known as calcareous tufa, but where the structure is compact, one layer superimposed directly upon another, it is termed travertine. Iron is generally present in the water, the oxidation of which gives the tufa a yellow to brown stain. The structure of this material, its lightness and occurrence about existing or former springs are sufficient for its identification. A drop of cold dilute acid causes at once a vigorous effervescence, as in the case of calcite. The most extensive deposits of this substance are found to the south of Monroe, near the lake shore (Chapter VIII, §10). Where abundant it is sometimes burned into lime and occasionally used for building purposes. The writer has seen a very pretty country church near Rochester, N. Y., constructed of this tufa.

§ 5. Dolomite.

Just as calcite results from the solution and crystallization of pure limestone, so the mineral dolomite represents the re-crystallized magnesian limestone. Through the agency of percolating water, charged with carbon dioxide gas, this limestone is taken into solution. Little is known definitely in regard to just how it is held, but is probable that the calcium and magnesium carbonates, of which the dolomite is composed, are separate and each in the form of the bicarbonate, $CaH_2(CO_3)_2$ and $MgH_2(CO_3)_2$. Under certain conditions these bicarbonates are converted into the monocarbonates, the normal forms, and crystallize together so as to form crystalline dolomite in seams, fissures and cavities. Such occurrences of this mineral, however, are rare although microscopic rhombohedrons make up the granules of oölite and cover the grains of the Sylvania sandstone. The spring waters from beds of dolomite deposit calcium carbonate in the form of tufa but no corresponding deposits of magnesium carbonate (magnesite) were observed. The crystals of dolomite very commonly show curved faces, instead of planes, have a pearly luster and give perfect cleavage. The color is white or pink generally, but may vary from the presence of impurities. The mineral is brittle and has a white streak. It is slightly harder and slightly heavier than calcite, but is distinguished from it most certainly by use of the dilute acid. When a drop of such cold acid is applied to the solid crystal there is almost no action, but if the acid is heated or the dolomite is powdered the effervescence is brisk. This mineral is a double carbonate of calcium and magnesium, having the chemical formula $(Ca\ Mg)\ CO_3$. It contains carbon dioxide ($CO_2$) 47.8%, of lime (CaO) 30.4% and of magnesia (MgO) 21.7%. Expressed differently it has of calcium carbonate 54.35% and of magnesium carbonate 45.65%.

§ 6. Strontianite.

This is the last of the four minerals from which effervescence may be obtained by the use of dilute acid. A drop of cold acid upon the solid substance causes vigorous effervescence as in the case of calcite and tufa. As found in this county it is of a snow white color forming irregular masses in the cavities and fissures of the dolomitic limestone. Usually it has a loose open structure, composed of globular masses, which show a radially fibrous structure upon being broken. Over their surface and dipping down into the cavities is a layer of fine pyramidal points, producing a fuzzy, frosted appearance.



When the crystals are broken they show both perfect cleavage and uneven fracture faces. The mineral is brittle, gives a white streak, has a glassy to resinous luster and is sub-translucent. The color although usually a pure white may be altered by impurities. The hardness is about that of dolomite (3.5 to 4), so that it may be easily scratched with a knife. Aside from the structure above described, which is quite characteristic, strontianite is easily distinguished from the preceding carbonates by its relatively high specific gravity (3.7), surprising one at once with its weight. If a fragment is moistened with hydrochloric acid and held in the flame of a lamp, candle or gas, or even a burning match, an intense red color is imparted to the flame. This is the familiar "red fire" of the Fourth of July, or campaign celebration and is due to the element strontium, from which the mineral derives its name. The mineral occurs at Stony Point, Point Aux Peaux and Brest, and in the Plum Creek quarries near Monroe, also in the Ida and Little Sink quarries. At the last locality the finest specimens may be obtained in lumps of snowy whiteness the size of the fist and upwards, having been formed in the cavities of the dolomite. At the Ida quarry small masses occur in cavities but some of the upper dolomitic layers are partially converted into strontianite, over the surface of which is spread a layer of slender orthorhombic crystals. This occurrence gives a clue to the origin of the mineral, suggesting that it has resulted from the action of strontium salts in solution acting upon the carbonates of calcium and magnesium. The composition is represented by the formula $Sr\ CO_3$, of which 29.9% by weight is carbon dioxide ($CO_2$) and 70.1% strontia (SrO). The "tremolite" reported by Houghton in his first report as occuring at Brest was probably this strontianite. Larger quantities than are now in sight would give this mineral a high commercial value since it may be used in recovering beet-sugar from the waste "molasses" (Chapter VIII, § 4). After the process is once started the strontium is recovered and the only loss is that occasioned by the actual sugar loss. According to Prof. Wiley this loss of the mineral strontianite would amount to about 6¼% of the weight of the molasses treated. In the market this strontian carbonate is worth five to six cents a pound.

*B. Sulphates.*

§ 7. Celestite.

This is another compound of strontium, of much interest and beauty which is more abundant than the above. It is found in the fissures and cavities of the dolomites at Point aux Peaux and Stony Point, about Monroe and in the Raisinville and Woolmith quarries. The finest crystallizations are found at the last mentioned locality, where the mineral is intimately associated with calcite and native sulphur. These crystals are of the flat, tabular variety, with beveled ends and edges and attain a size of 5 to 6 inches in length, by 3 to 4 in breadth and have a thickness of one inch. Typically the color is a beautiful celestial blue from which the mineral derives its name. Some of the masses, however, are perfectly transparent and free from color while others are a pure white, or a deep chocolate brown. The crystals are brittle and break with distinct to perfect cleavage faces, the luster is glassy and the streak is white. The mineral is easily scratched with a knife-point (Hardness = 3 to 3.5), being, generally, a little harder than calcite. A very characteristic property is the high specific gravity (4), it being even heavier than strontianite. From the preceding five carbonates described celestite may be readily distinguished by the action of hydrochloric acid, with which it cannot be made to give an effervescence. Chemically the mineral is strontium sulphate with the formula $SrSO_4$, containing of strontia 56.4% (SrO) and of sulphur trioxide ($SO_3$) 43.6%. Under the blow-pipe is readily fuses giving the intense red color to the flame. The occurrence of celestite in closed cavities in the dolomite, and its practical insolubility in water and acids, shows that its ingredients must have been introduced through the agency of percolating water and the mineral formed in place. A saturated solution of calcium sulphate (gypsum) would react upon the soluble salts of strontium so as to produce the celestite. The carbonate of strontium was not observed at the Woolmith quarry in association with the sulphate, there appearing to have been sufficient gypsum present to convert all of the original strontium salt into the more stable sulphate. At the Ida and Little Sink quarries only the carbonate was formed, while on the Lake Erie shore both the carbonate and sulphate are associated, indicating that the supply of dissolved gypsum was insufficient.



In the Plum Creek quarries, near Monroe, celestite may be observed undergoing alteration into strontianite, a rather unexpected change, the sulphate being regarded usually as the more stable form. However, a similar change may be produced in the laboratory by boiling the powdered sulphate with solutions of the alkaline carbonates; sodium, potassium or ammonium. It seems very probable that cold water, charged with one or more of the alkaline carbonates might, in the course of time, convert the outer portions of the crystallized sulphate into the carbonate.

§ 8. Gypsum.

Just referred to as probably having been active in the production of celestite is this calcium sulphate, which, although related to it in composition, is still readily distinguished from it by simple physical properties. Either in the form of gypsum ($CaSO_4+2H_2O$), or as the anhydrous variety (anhydrite, $CaSO_4$) this calcium sulphate is widely distributed through the Monroe beds of the county. As given in Chapter III, § 5, this sulphate was deposited directly from the waters of an inland sea, along with the calcium and magnesium carbonates which constitute the beds of dolomite. It would be formed anew wherever free sulphuric acid, derived from the decomposition of pyrite or marcasite, came into contact with calcium carbonate in solution. Calcium sulphate dissolves in 400 parts of water so that surface water, percolating through the dolomites containing gypsum or anhydrite, would take more or less of it into solution. Upon standing quietly in rock cavities and fissures, crystals of gypsum known as selenite, might form. Such crystals occur sparingly at the Woolmith quarry, but were not observed elsewhere. These are perfectly transparent flat crystals, without color and having a glassy to pearly luster. They split readily into thin plates, which may be easily bent without completely separating, but the thin plates are not elastic, as in the case of mica.

The cleavage in this one direction is very perfect. The streak is white and the specific gravity below the average, being 2.3. It is distinguished from all the minerals thus far described by its inferior hardness, since it is readily scratched with the finger-nail. No effervescence can be secured from it by the use of acid. Fine granular to compact masses of gypsum, variously colored from impurities, are known as "plaster" and are valuable for fertilizing purposes. When heated to a temperature of about 392°F. the water in chemical combination is driven off, the mineral crumbles to a white powder and is known as "plaster of Paris." By weight this water ($H_2O$) comprises 20.9% of the mineral, combined with 32.5% of lime ($CaO$) and 46.6% of sulphur trioxide ($SO_3$).

§ 9. Anhydrite.

In the preparation of the plaster of Paris if the gypsum is brought to a temperature of 400° to 650°F. not only is the water of crystallization driven off, but the calcium sulphate practically loses its power to again unite with it and "set." It has closely approached the condition of the anhydrous variety ($CaSO_4$), which is of common occurrence in nature and is known as anhydrite. As generally seen this is a compact or very fine granular translucent mass, of a pure white color and breaking with an uneven fracture. It is brittle and heavier and harder than gypsum. It cannot be scratched with the finger-nail, but is readily scratched with a knife point, giving a white powder. In well drillings it is frequently called "marble," but is easily distinguished from it by the action of the dilute acid. Anhydrite will slowly dissolve in hydrochloric acid, but gives no effervescence, while a small fragment of marble effervesces vigorously as it dissolves. This form of calcium sulphate contains 41.2% of lime and 58.8% of sulphur trioxide. It is less soluble in water than is the gypsum. The presence of anhydrite, or gypsum, in drillings, or dolomites, may be detected by boiling the powder for a short time in hydrochloric acid contained in a test-tube and then allowing the acid to cool. If calcium sulphate was present a mass of very slender needle like crystals will make their appearance. It is not definitely known why the sulphate should have been deposited from the evaporating inland sea in the anhyrous form. Ochsenius has explained it as due to the fact that when the hydrous sulphate (gypsum) is in solution in concentrated sea water with certain salts of potassium it exchanges part of its water for sulphate of potassium, forming polyhalite ($KCl$) and other salts which remain in solution in the bittern while anhydrite is deposited.*

§ 10. Epsomite.

When the free sulphuric acid of waters percolating through a bed of dolomite acts upon the dissolved calcium carbonate there is formed calcium sulphate as described in § 8 of this chapter. As might be expected this same acid would react similarly upon the magnesium carbonate of the dolomite and give rise to magnesium sulphate ($MgSo_4 + 7\ H_2O$), or epsomite. This is so very soluble that ordinarily we should not expect it to be deposited, but it is a common ingredient of mineral waters. Sometimes it occurs as a delicate efflorescence over the surface of rocks in dry fissures, the galleries of mines and caves. In the Ida well (see Chapter III, § 8) a 100 foot layer of this substance was reported and a sample saved. The sample proved to be epsomite, but it is believed to have come from a cavity or fissure and not to represent the entire bed which was probably a dolomite rich in anhydrite. Epsomite is now on the market at 2½ cts. per pound by the barrel. It contains by weight 16.3% of magnesia ($MgO$), 32.5% of sulphur trioxide ($SO_3$) and 51.2% of water ($H_2O$). It occurs usually in elongated slender orthorhombic crystals, white in color, with a glassy to earthy luster, breaking with perfect to imperfect cleavage. It can be scratched with the finger-nail, (Hardness = 2¼), giving a white powder. Its specific gravity is but 1.75 so that it appears very light. On account of its easy solubility it has a pronounced taste, which is salty to bitter. Upon being heated it gives off much acid water in which it liquefies.

*Quoted from Mich. Geol. Sur., Vol. V, Pt. II, p. xvii.



### C. *Chlorides.*

§ 11. Halite.

Owing to the possibility of the occurrence of rock salt ($NaCl$) in the northeastern part of the county (see Ch. VIII, § 12), a description of this mineral is here inserted. The common form of crystal is the cube, parallel to the faces of which it breaks readily with very perfect cleavage. When pure it is colorless and transparent but it is frequently rendered translucent and of a variety of colors from impurities. It can be scratched with the finger-nail, with some difficulty, giving a white powder. When pure its specific gravity is 2.1, so that it appears light. The most characteristic property is its familiar saline taste, being readily dissolved in water. It gives no effervescence with the acid. In the blow-pipe flame it fuses and imparts an intense yellow color, owing to its sodium, which makes up 60.6% of the mineral, while the remaining 39.4% is chlorine. It occurs in solid beds in the earth only where the subterranean waters have not had free access to it. It is believed to have been formed through the concentration of the waters of an inland sea.*

*See Chapter III, 5; also Geol. Sur. of Mich., Vol. V, Part II, pp. ix to xix.

## *D. Sulphur and Sulphides.*

§ 12. Sulphur.

Closely associated with the celestite and calcite crystals at the Woolmith quarry are beautiful crystalline masses of brilliant yellow sulphur, contrasting gorgeously with the blue of the celestite and the creamy white calcite. Attention was first called to this occurence of native sulphur by the writer in 1895.*

The sulphur is confined mainly to the ellipsoidal cavities in a soft, open bed of dark brown dolomite from one to three feet thick. These cavities vary in size from a fraction of an inch to three feet in their greatest horizontal diameter. Some of these cavities are completely filled with the sulphur, which at times shows crystal faces, but generally the sulphur shows only the rough conchoidal fracture characteristic of such crystalline masses. More frequently the cavity has a lining of celestite and calcite and only the central portion contains the sulphur, showing that its deposition began later than that of these two minerals. It was estimated by the foreman at the time of the survey, four years ago, that between 400 and 500 barrels had been removed, most of which was carried away by visitors. The present market value of such sulphur is 2½ cents per pound. This mineral is very easily distinguished from all others by its brilliant yellow, its resinous luster and conchoidal fracture. It is quite brittle, can be scratched with the finger-nail, has a specific gravity of but 2 and is translucent. It melts readily and burns with a blue flame emitting irritating odors of sulphuric dioxide ($SO_2$). It is insoluble in water and is not affected by acids. When the deposits were first examined by the writer in 1895 there entered the quarry from the "sulphur bed" a stream of water charged with hydrogen sulphide gas ($H_2S$). As the water trickled down the face of the quarry wall and flowed over the bottom there was deposited a mealy white precipitate of sulphur, resulting from the decomposition of this gas. Where this deposit was longest exposed it showed a slight yellow color. From the cavities of the dolomite specimens of whitish yellow sulphur were collected, having the same mealy appearance, but containing throughout small irregular masses in the crystalline condition. There is no room for doubt then that the sulphur has resulted from the decomposition

*American Journal of Science, Vol. L, Third Series, pp. 246-248; also in a paper presented to the Michigan Academy of Science, Lansing, December, 1895.



of hydrogen sulphide gas, introduced through the agency of percolating water, and that it has gradually passed from the mealy to the crystalline condition. The gas has been formed in the rocks through the decomposition of the next two minerals to be described.

§ 13. Pyrite and marcasite.

These are two minerals which have the same chemical composition ($FeS_2$), being compounds of iron and sulphur. They contain by weight 53.4% of sulphur and 46.6% of iron. They are not often seen at the surface, but are abundant enough in the rock strata to give character to the spring and well water and to be indirectly responsible for the formation of a number of the minerals described in this chapter. They each have a brassy luster and color, a specific gravity approaching 5 and are hard enough to make a scratch upon glass. They are brittle, break with an uneven fracture, are opaque and have a black streak. When heated sufficiently they are decomposed, the sulphur burns with its characteristic blue flame and leaves behind a dark mass which is now magnetic, owing to the free iron. The pyrite is generally found in beautifully perfect cubes of various sizes, having a golden color and luster, which causes it frequently to be mistaken for gold. In the dolomite of the Plum Creek quarries seams and incrustations of crystallized pyrite occur, in tarnished condition. The crystals are very small, giving the mineral a fine granular appearance, and are mainly octahedrons. This is the only locality at which pyrite was found. The marcasite is of a whiter yellow, does not occur in cubes, but usually in flattened concretions showing radially fibrous structure, and is more subject to decomposition than the pyrite. The formation of these two minerals through the agency of organic matter and oxide of iron was explained in Chapter II, § 11. When either of these minerals is in contact with water for a sufficient length of time, double decomposition takes place. The sulphur unites with hydrogen of the water to form hydrogen sulphide gas ($H_2S$), which is readily held in solution by the underground water and gives rise to "sulphur" springs and wells. The iron of the pyrite, or marcasite, is readily oxidized and if carbon dioxide be present will be converted into iron carbonate ($FeCO_3$), taken into solution and will impregnate the water with iron, forming "chalybeate springs or wells" (chapter VIII, § 10). The hydrogen sulphide itself may unite with oxygen to form sulphuric acid ($H_2SO_4$), which may unite with iron, calcium or magnesium to form the series of sulphates found in the natural waters. Pyrite and marcasite are very undesirable ingredients of building stone because of their tendency to decompose, whereby the stone itself is disintegrated and discolored through the oxidation of the iron left behind.

### *E. Oxides.*

§ 14. Bog iron ore (limonite).

Before the rich deposits of iron ore were located in the Lake Superior region and Missouri this impure form of iron oxide was eagerly sought. Hubbard in his original survey of the county located deposits in Secs. 19 and 25, of Summerfield township and called attention to indications in Sec. 3 (T. 9 S., R. 7 E.) of Bedford, and also in London.*

During the present survey other records were obtained of similar deposits. In section 23 of Milan (N. W. ¼, S. E. ¼) N. D. Baird struck bog ore at a depth of five feet while ditching. It is said to occur also one mile south of Petersburg upon the place of Enos Plomodore (S. W. ¼, N. W. ¼, Sec. 10). In the N. W. ¼, N. W. ¼, Sec. 26 of Bedford, bog ore occurs along a ditch for a distance of ten rods. This mineral occurs in marshes, where it is now forming, and in the beds of former swamps now drained and under cultivation, in beds of varying thickness. Irregular rusty lumps are found in the soil, having a dull earthy luster and without crystalline structure. Their high specific gravity (3.6 to 4) at once distinguishes them from irregular lumps of tufa or clay. The mineral breaks with an irregular fracture, is opaque, can be scratched with difficulty with a knife-point and gives a yellowish brown powder. It is an oxide of iron in combination with water, its formula being $2Fe_2O_3+3H_2O$. When pure it contains 59.8% of iron, 25.7% of oxygen, and 14.5% of water. When mixed with considerable clay it is known as "yellow ochre" and has been used as a paint. Upon the application of sufficient heat the water of crystallization is driven off and the oxide is converted into the red oxide known as hematite ($Fe_2O_3$). This also exists in a soft earthy form known as "red ochre," a bed of which three rods square, and one to two feet thick, was located in Sec. 21 of Bedford township, by Hubbard.†

*Second Annual Report State Geologist, 1839, H. R. No. 23, page 112.

†The first volume of the American Journal of Science in 1819 announced the "Discovery of American Cinnabar and Native Lead." (pp. 433-4.) A portion of a letter from J. L. Comstock, of Hartford, Connecticut, was published by the editor, which contained an extract from a letter written by B. F. Stickney, Indian Agent at Fort Wayne. The latter says, "I have found a black and garnet colored sand, in great abundance on the shore of Lakes Erie and Michigan, this is sulphuret of mercury, and yields about sixty per cent. It is so easy to be obtained, and is so convenient a form for distillation, that it must become an important article of commerce." In the second volume of the same journal (p. 170) the editor publishes a letter direct from Mr. Stickney, dated "Port Lawrence, Michigan Territory, Mouth of the Miami of the Lakes, June 17th, 1819," in which he says, "From the mouth of the Vermillion, round the whole shore of the western end of Lake Erie, on the shores of the Detroit river, Lakes St. Clair, Huron, and Michigan, the banks are streaked with small reefs of this black and red sand of cinnabar. The whole body of the soil is interspersed with this sand through the whole of this extensive district of country." The editor announced that a sample of the sand, enclosed in a letter had been lost. In his Catalogue of American Minerals, published in Boston, 1825, by Dr. Samuel Robinson this occurrence of cinnabar is noted (page 239). The red and black sand referred to must have consisted of oxides of iron.



When clay of a brown or yellow color from the presence of the hydrous oxide is burned, as in the manufacture of brick and tile, the conversion to the red oxide takes place in the furnace and a total change in color results. The iron for the formation of beds of bog ore is derived from the soil of the area which is drained into the marsh. It is introduced into the soil from the iron bearing minerals which have contributed to its formation, as hornblende, pyroxene, black mica, pyrite, siderite, etc., of the crystalline rocks. Upon the decomposition of these and other minerals iron is liberated which soon unites with the oxygen of the air forming generally the yellow hydrous oxide. In this form it is abundant in the soil and is insoluble, but must be transported before any beds can be formed. This is accomplished through the agency of decaying organic matter in the soil. The carbon of this organic matter has a stronger affinity for oxygen than has the iron, and some of the oxygen is torn from the iron oxide forming ferrous oxide ($FeO$). The carbon dioxide ($CO_2$) formed in consequence may unite with the ferrous oxide and form ferrous carbonate ($FeCO_3$). This carbonate is somewhat soluble in water containing carbon dioxide and is leached from the soils and transported by the streams to the swamps. Upon standing the carbon dioxide of the carbonate is exchanged for oxygen of the air with the formation of the oxide and the liberation of the $CO_2$. The oxide being insoluble must be precipitated and usually goes down as the hydrous form, that is, the bog ore variety. Beds rarely exceed one to two feet in thickness. From this method of formation it is apparent that the ore will be mixed with sand, clay and other impurities. For this reason and the manner of occurrence this ore has no commercial value at present. Shaler has suggested that as top dressing this ore adds binding qualities to limestone used in the construction of stone roads.

§ 15. Crystallized quartz.

The Sylvania sandstone has been described as consisting of countless millions of quartz crystals, each a hexagonal prism terminated by one or two hexagonal pyramids. The formation of these crystals through the secondary enlargement of rounded sand grains has been presented in Chapter III, § 6.

Water saturated with silica ($SiO_2$) and standing quietly in fissures and cavities sometimes forms an incrustation of quartz crystals. If no impurities are present the crystals are transparent and without color being known as "rock crystal." Limited quantities of this occur at the Navarre quarries on Plum Creek. When colored purple the quartz is called "amethyst" and this variety was observed at Brest by Dr. Winchell and is reported by Dana as occurring here and at Point aux Peaux and Stony Point. Quartz is readily distinguished from all the other minerals described by its simple physical properties. The form of the crystal is entirely characteristic when this can be made out, the hexagonal prism terminated with the hexagonal pyramid. It has a glassy luster and has no plane cleavage faces, but a conchoidal fracture. Its specific gravity is 2 2-3. It cannot be scratched with a knife or file and scratches glass very easily. It is insoluble in pure water, is unaffected by the ordinary acids and is infusible before the blowpipe. Heated with soda, however, it readily melts and forms glass. It consists, when pure, of 46.7% of silicon and 53.3% of oxygen.

§ 16. Chert.

This is a variety of uncrystallized or rather cryptocrystalline quartz ($SiO_2$) commonly known as "flint." It is, however, too impure for flint, since it contains a considerable percentage of calcium carbonate. From its resemblance to horn it has been called "hornstone," and owing to its abundance in our Dundee formation gave to it the name of Corniferous (*cornu*, a horn). As found in Monroe county its color is drab to brown, with a dull to subresinous luster. It is opaque to sub-translucent and is very brittle, breaking with a coarse conchoidal fracture and giving sharp edges. It readily strikes fire with steel and scratches glass with about the same ease as crystallized quartz. Its specific gravity is not perceptibly different. It occurs in the Monroe beds and the Dundee formation in seams and crevices, in irregular nodules, and as thin beds between the strata of the dolomite and limestone as previously described. In the quarries most of it is seen on the Macon and at Dundee, where it forms thin beds. It frequently encloses fossils in silicified condition, in the cavities of which the silica has sometimes crystallized, giving a thin layer of minute crystals suggestive of frost and known as "drusy quartz." The formation of this chert and the origin of its silica have been discussed in Chapter II, § 22. It is too impure for the manufacture of glass, for which flint is used, and its brittleness and lack of binding qualities unfit it for macadamizing purposes. Its hardness, manner of breaking and inertness to the weather made of it a most useful mineral for primitive man. From it he made his spear and arrow-points with which to capture game, the implement with which to prepare, and the spark of fire with which to cook such game. Quarries of a good grade of chert were of more value to him than the richest gold mines of the Klondike or the diamond fields of Kimberly.



### *F. Phosphates.*

§ 17. Apatite.

This is a mineral reported by Winchell and Dana as occurring at Brest, Point aux Peaux and Stony Point, but a careful search failed to reveal any of it at the present time. It is a phosphate of calcium, with the formula ($CaF$) $Ca_4$ $P_3$ $O_{12}$, occurring sometimes in limestones, but more commonly in the crystalline rocks. It contains of $P_2O_5$ 42.3%, of lime ($CaO$) 55.5%, and of fluorine 3.8 %. When properly prepared it is valuable for fertilizing purposes since it supplies the soil with both lime and phosphorus. Its common mode of occurrence is in the form of elongated hexagonal prisms, of a brown or green color. Its luster varies from glassy to resinous, the mineral looking as though it were slightly oily. It is subtranslucent to opaque, is quite brittle and shows only imperfect cleavage across the prisms. Its specific gravity is a little above the average of rocks (3.2), while its hardness permits of its being scratched, with some difficulty, with a knife-point. It gives no effervescence with the acids. This assemblage of characters readily distinguishes apatite from any other mineral encountered in the county.

### *G. Hydrocarbons.*

§ 18. Asphaltum.

Black, amorphous carbonaceous matter has been mentioned as occurring at various quarries, filling seams and crevices in the dolomites and limestones. Thin layers, more or less continuous, frequently occur between the beds, rarely attaining a thickness of one-quarter inch. Certain beds at the Woolmith quarry are impregnated with this substance to such an extent that the stone is considerably darkened by it and Mr. G. F. Smith has suggested its use for asphalt pavements, believing that by grinding and heating there would be found sufficient asphaltum to bind together the fragments. As seen in the county, both at the quarries and in the well drillings, the substance is always very impure. If held in a flame it burns for a short time, giving a bright yellow flame and oily odor, but does not perceptibly diminish in bulk. There is usually not sufficient carbonaceous matter present to continue the combustion after the fragment is withdrawn from the flame. When pure, asphaltum is very brittle, of a jet black color and pitchy luster, breaking with a coarse conchoidal fracture. It is soft and very light, its specific gravity ranging from 1 to 1.8. It readily melts and burns with a bright yellow, smoky flame. It is more or less soluble in turpentine, ether and alcohol, but not in water. It has formed where now found by the accumulation of rock oil, which has gradually lost its more fluid constituents and hardened. It is thus of organic origin, has no definite composition, consisting mainly of carbon, hydrogen and oxygen, and cannot be regarded as a true mineral.

### *H. Key to Minerals.*

§ 19.

The following simple key will enable those interested to readily determine the minerals of the county which are encountered in the quarries and well drillings. It will be of no service in identifying the ingredients of the common field boulders. The acid referred to is hydrochloric acid and is prepared by taking a small quantity of commercial strength and adding four times its volume of pure water. In using this a drop of the cold acid is first applied to the solid mineral. If the action is not vigorous the mineral may be reduced to powder at one place and the acid applied, or a fragment may be placed in acid in a test-tube and then heated. After the mineral has been traced, its description, as given in this chapter, should be carefully reviewed for the purpose of verification.



TABLE XIV.—KEY TO THE MINERALS OF MONROE COUNTY.

| | | | | | |
|---|---|---|---|---|---|
| Effervesces with dilute acid. | Incoherent. | | | White and mealy looking, associated with muck. Action with acid vigorous. | Marl. |
| | Coherent, in lumps or crystals. | Heavy. | | Occurs in irregular lumps, covered with fine crystal points. Action with acid is vigorous; colors flame an intense red. | Strontianite. |
| | | Medium. Acid action on solid mineral is | Vigorous. | Occurs in sharp pointed crystals, or breaks into rhombohedrons. Does not crumble on being intensely heated. | Calcite. |
| | | | | Occurs in six-sided prisms, or radiating groups of needle-like crystals. Crumbles on being heated. | Aragonite. |
| | | | Slight. | Action is increased by powdering the mineral. | Dolomite. |
| | | Light. | | Irregular brownish lumps of a loose, open structure. Action with acid vigorous. | Tufa. |
| Does not effervesce with dilute acid. Scratched with finger-nail. | Easily. | Not crystalline. Occurs in irregular, earthy masses. | | Rusty yellow to brown. | Yellow ochre. |
| | | | | Cherry red. | Red ochre. |
| | | Crystalline. | | Flat transparent crystals, separable into thin, flexible plates. | Selenite. |
| | With some difficulty. | Soluble in water, will not burn. | | Small white needle crystals, bitter taste. | Epsomite. |
| | | | | Breaks into cubes, salty taste. | Halite. |
| | | Insoluble in water, will burn. | | Color yellow, burns with blue flame. | Sulphur. |
| | | | | Color black, burns with yellow flame. | Asphaltum. |
| Does not effervesce with dilute acid. Not scratched with finger-nail. | Luster glassy. | Will not scratch glass. | | Very heavy, perfect cleavage, flat tabular crystals. | Celestite. |
| | | | | Moderately heavy, imperfect cleavage, six-sided prisms. | Apatite. |
| | | Will scratch glass easily. | | Average specific gravity, no cleavage, conchoidal fracture. Occurs in six-sided prisms with pyramids. | Quartz. |
| | Luster metallic. | | | Granular or in isolated cubes or octahedra, golden yellow color, slightly tarnished. | Pyrite. |
| | | | | Flattened concretions, radially fibrous structure, silvery yellow, tarnished. | Marcasite. |
| | Luster dull. | Very heavy. | | Rusty irregular lumps, generally loose in the soil. | Bog iron ore. |
| | | Medium weight. | | Drab or brown, conchoidal fracture, scratches glass easily. | Chert. |
| | | | | Pure white, uneven fracture, will not scratch glass. | Anhydrite. |

# CHAPTER X.

## FOSSILS OF MONROE COUNTY.

§ 1. General nature of fossils.

Embedded in the rocks which have been described, and imprinted upon the surfaces of the strata are the remains of former plant and animal life. From their resemblance to forms still in existence we know that they lived in the waters of an ocean charged with salt. From a study of the deposits which have been superposed, here and elsewhere, upon these strata we are forced to the conclusion that this ocean existed in Michigan so long ago that the time can be estimated only in millions of years. Nowhere in the county. or adjoining regions, have there been found embedded in the rocks any trace of forms higher than the lowest order of fishes. When we consider the advance which has been made biologically since that time we are still better able to grant to these fossils the respect which is accorded great age. When such objects first began to attract attention during the 15th and 16th centuries they were regarded as "sports of nature," as though produced through Nature's effort at self amusement. By some writers they were thought to be due to the "influence of the stars," and by others to have resulted from the fermentation of certain fatty matter in the earth through the agency of heat. Early in the 16th century Fracastoro and Leonardo da Vinci declared that they represented the remains of organisms which had once lived where they are now found, a view that was savagely combatted for 200 years. As this simple truth finally prevailed over prejudice and superstition the question arose as to the time of their destruction, it being assumed that their death was simultaneous and produced by some widespread natural catastrophe. For a long time and by many the Noachian deluge was regarded as the cause of this universal destruction of life, of marine forms as well as those which lived upon the land. During the 18th century the discussions covered the method of extinction and entombment, the formation and displacement of the



rocks containing them, the succession of forms and their relation to living species. By the middle of the century it had been shown by Marsilli, Spada and Schiavo that fossils are not scattered at random through the rocks, but that there is an orderly succession. By the close of the century this truth had borne fruit. William Smith, an English engineer, suggested their use in recognizing and correlating strata, since beds of the same age should contain the same assemblage of fossils. During the century just closing thousands of forms have been described and figured, their groupings in the strata investigated, and the solution of the problems of development undertaken. From such study beds of economic importance may be located in the geological series and the physical and biological history of the earth deciphered.

By Lyell a fossil was defined as any body, or the traces of the existence of any body, whether animal or vegetable, which has been buried in the earth by natural causes. The cast or mould of any organism whatever, the imprint of a leaf or the foot print of an animal would thus come within the definition. So also would the body of a sheep buried by yesterday's land slide, but probably would not have been regarded as a fossil by Lyell himself. It is now generally understood that the form, in order to be considered a true fossil, must have lived during a previous geological epoch.

§ 2. Conditions of preservation.

With reference to their manner of preservation fossils may be separated into four classes. First, those in which the organic matter itself has been preserved as in the case of some of the plant remains to be described. Here the carbonaceous matter of the tissue is still in existence and makes up the fossil, although it has been mineralized. Rock oil represents such preserved organic matter which has become separated from the organisms of which it at one time constituted a part. In this same class should be placed bones, shells, corals, etc., which still retain the matter of which they were originally formed. In a second class of fossils this original matter has been replaced, particle by particle, by other mineral matter giving rise to a "petrifaction." The replacing mineral is most commonly calcite or silica, but may be pyrite, sulphur, iron oxide, etc. Very frequently, as in the case of silicified wood, the minute details of even the microscopic structure are most perfectly reproduced. In still a third class of fossils the organism itself, or some part of it, has left its impress upon a soft mass capable of retaining the form. After hardening there is thus produced a mould of the original object. Such moulds of shells are quite common in the dolomites and occasionally a coral, or crustacean, is similarly preserved. Imprints of leaves, burrows and channels, footprints, etc., belong to this class. Finally, upon the withdrawal of the organism, or its removal by decay or solution, soft mineral matter may settle into the mould and form a cast. The most common form of cast is that of the entire exterior, but internal casts of shells are also not uncommon in the county. These are produced by the fine sedimentary material working its way into the internal cavity and there hardening. When the shell is dissolved away by percolating water a space is left between the mould and the internal cast. This occasionally becomes filled with sediment, sometimes with crystalline material and a cast of the shell itself is formed, which very much resembles a true petrifaction, but differs from it in not showing any of the real shell structure.

§ 3. Fossils of the Monroe beds.

The beds of dolomite are in general quite poor in fossils, but at certain horizons and in certain localities moulds and casts of brachiopods and gasteropods are abundant, crinoids, corals and bryozoan remains are found occasionally and lamellibranchs rarely. Worms, cephalopods and crustaceans are the only other animal groups that are known to be represented in this series of beds. There is nothing here to indicate that fish had yet come into existence, not a tooth, scale, plate or spine having yet been found. In nearly all cases the shell substance has been dissolved and nothing has been deposited in its place, so that the identifications have to be made upon the moulds, imprints, external and internal casts. A large number of such fragments were collected which are unidentifiable, either because of their state of preservation or because they represent species not yet described. The writer feels reasonably certain of the list below enumerated. A study was made of the fossil contents of the Monroe beds by Rominger and reported upon in 1876.* From these same beds in western Ohio, Whitfield identified and described a number of forms in a paper read before the New York Academy of Science in 1890.†

*Michigan Geological Survey, Vol. III, Pt. I, pp. 31 to 34.

†Description of Fossils from the Palæozoic Rocks of Ohio. Ann. N. Y. Acad. of Science, 1890; pp. 505 to 622. Also Geol. Surv. of Ohio, Vol. VII, pp. 407 to 493. Plate V accompanying this paper is reproduced as plate XVII of this report through the kindness of Prof. Whitfied and the Ohio Survey, although it contains some forms not yet discovered in the county.



*SPIRIFER VANUXEMI*, Hall. Palæontology of New York, Vol. III, 1859; p. 198, plate VIII, figs. 17 to 23.

*Orthis plicata*, Vanuxem. Geol. Rep. Third District of New York, 1842; p. 112, fig. 1.

A few specimens of this species were found in the beds about Monroe, but they are not common. Adult forms of the type figured on plate XVII, figures 4 and 5, occur and also immature specimens similar to those drawn and described by Hall.

*MERISTELLA LÆVIS*, Vanuxem, sp.

*Atrypa lævis*, Vanuxem. Geol. Rep. Third District of New York, 1842; p. 120, fig. 2.

*Merista lævis*, Hall. Palæontology of New York, Vol. III, 1859; pp. 247-8, plate XXXIX, figs. 1 to 4.

*Meristella lævis*, Hall. Thirteenth Ann. Rep. of Regents on the N. Y. State Cabinet, 1860; p. 75.

Cf. *Whitfieldella lævis*?, Grabau. Bull. Geol. Soc., Am. 1900, Vol. XI, p. 369.

This is the most common and most widely distributed fossil in the county, being seen at nearly all the localities where the beds of dolomite are exposed. Its general form is shown in figures 6 and 7 of plate XVII.

*MERISTELLA BELLA*, Hall. Thirteenth Ann. Rep. of the Regents on the N. Y. State Cabinet, 1860; p. 75.

*Merista bella*, Hall. Palæontology of New York, Vol. III, 1859; p. 248, plate XL, fig. 1, a-p.

This form, which much resembles the preceding and is found in association with it, is figured on plate XVII, figures 8, 9, and 10. The general outline is seen to differ from *Meristella lævis*, and each valve possesses a sinus the meeting of which give a more emarginate character to the front.

*NUCLEOSPIRA ROTUNDATA*, Whitfield. Ann. N. Y. Academy of Science, 1882; p. 194.

Se plate XVII, figures 11 to 14. The best preserved specimens of this species were collected from the beds of the Woolmith quarry where they are associated with Meristella.

*RETZIA FORMOSA*. Hall, sp.

*Waldheimia formosa,* Hall. Tenth Ann. Rep. of the Regents on the New York State Cabinet, 1857; p. 88.

*Trematospira formosa,* Hall. Palæontology of New York, Vol. III, 1859; pp. 215-216, plate XXXVI, figs. 2, a-u.

*Rhynchospira formosa,* Hall. Palæontology of New York, Vol. III, 1859; p. 485, plate XCV A, figs. 7-11.

This beautiful little shell is shown on plate XVII, figures 15 and 16. Quite perfect moulds are sparingly found, apparently more frequently at the Little Sink and Little Lake quarries. These specimens agree with those described from Ohio in being smaller than those from New York, figured by Hall.

*PENTAMERUS GALEATUS*, Dalman, sp.

*Atrypa galeatus,* Dalman. Vet. Acad. Handl., 1827; p. 130.

*Pentamerus galeatus,* Hall. Palæontology of New York, Vol. III, 1859; pp. 257-9, plate XLVI, figs. 1, a-z; plate XLVII, figs. 1, a-m.

*Gypidula galeata.*

Fragments of this large brachiopod are found about Monroe, one quite complete ventral valve having been secured, from which the identification was made.

*PENTAMERUS PES-OVIS*, Whitfield. Ann. N. Y. Acad. Science, 1882; p. 195.

This form was named because of the resemblance of its internal casts to sheeps' feet. See plate XVII, figures 18-22. These casts are in the dolomite about Monroe.

*GONIOPHORA DUBIA*, Hall, sp.

*Modiolopsis dubius*, Hall. Palæontology of New York, Vol. III, 1859; p. 264, plate XLIX, figs. a-e.

*Goniophora dubia*, Whitfield. Geol. Sur. of Ohio, Vol. VII, 1893; pp. 415-16, plate I, figs. 24-26.

Specimens of lamellibranchs are very infrequently met with in the Monroe beds. A number of well preserved forms of this species, however, were collected from the Plum Creek quarries. They are shown on plate XVII, figures 24-26.



*PTERINEA AVICULOIDEA*, Hall, sp.

*Megambonia aviculoidea*, Hall. Palæontology of New York, Vol. III, 1859; pp. 274-5, plate XLIX, figs. 7 and 8; plate XLIX A, fig. 8.

*Pterinea aviculoidea*, Whitfield. Geol. Rep. of Wis., Vol. IV; p. 322, plate XXIV, figs. 6 and 7.

The internal cast of the left valve of a large specimen of this, or a closely related species, was found in Daniels' quarry at the head of Ottawa Lake. The species is reported from the county by Rominger and from the Ohio beds by Whitfield. See plate XVII, fig. 23.

*LEPERDITIA ALTA*, Conrad, sp.

*Cytherina alta*, Vanuxem. Geol. Report of the Third Dist. N. Y., 1842; p. 112, fig. 6.

*Leperditia alta*, Jones. Ann. and Mag. of Nat. Hist., Vol. XVII, second series, p. 88.

This peculiar crustacean is shown in side view on plate XVII, figure 27. It is especially characteristic of the Waterlime division of the Lower Helderberg. It is of rare occurrence in the county but was found around Little Lake, in Bedford township. There occurs in the same vicinity a minute Leperditia of the same general form as the above but with a length of only .05 to .06 of an inch. The prominence of the eye tubercles indicates that it is distinct from L. alta and no intermediate forms were observed.

*SPIRORBIS LAXUS*, Hall. Palæontology of New York, Vol. III, 1859; p. 349, plate LIV, figs. 18, a-e.

The coiled tubes of very small marine worms are abundant about Newport and Monroe and at the Little Sink and Little Lake quarries. They appear to be identical with Hall's forms from the Lower Helderberg of New York. The tubes are circular in cross section, show from $1\frac{1}{2}$ to 3 coils, with a diameter of .02 to .04 of an inch. Usually nothing but the minute cavity remains, but occasionally a cast is found which shows 11 to 12 annular ridges in the last half whorl. Sometimes a considerable part of the last whorl is free from the remainder of the coil and irregularly extended. The Little Sink specimens are coarser than those found about Monroe and may represent another variety. Associated with them are tortuous vertical channels, which represent the burrows or tubes of larger worms, to which the generic name *Scolithus* has been applied.

In addition to the above identifiable species a large number of fragments were collected which cannot be satisfactorily specifically determined. These include Conularia, Tentaculites, Strophodonta, Orthis, Spirifer, Conocardium, Platyceras and numerous other gasteropods, lamellibranchs, trilobites, crinoids, cyathophylloid and favositoid corals.

Several types of plant fossils occur within the limits of the county. From what was said concerning the formation of the oölite granules and the associated structure in Chapter III, § 7, it is evident that these must be regarded as fossils. Under the same head would come the vertical channels found in one of the silicious dolomites at the Woolmith quarry, Chapter IV, § 4. These are supposed to represent the casts of marine plant stems about which the sandy, dolomitic slime settled and partially hardened. Upon the upper surfaces of certain ledges at Newport, Plum Creek and Little Lake quarries carbonized plant remains occur in abundance. The stems of one form are straight, unbranched and flattened and appear to be longitudinally creased by about eight furrows. The diameter of the flattened stems change but little in an inch or two and equal .06 to .07 of an inch. There is evidence of irregular jointing. Associated with this form is a more delicate variety which branches dichotomously and has a breadth of but .01 of an inch. A still coarser and less flattened type of stem is seen about Newport, hava breadth of .10 to .13 of an inch. These all very probably are remains of marine algæ. Of these remains which Rominger found at Newport he says the following:*

"The vegetable remains are of various kinds. Some are band-like, compressed stems, which sometimes bifurcate, and are of a jointed structure. On certain portions of these stems, annular cicatrices are disposed in remote rows, in shape resembling the pores of the tube of Favosites. Another kind of stem is narrower, more remotely jointed, and each joint is surrounded by a verticil of long, narrow leaves."

§ 4. Fossils of the Dundee formation.

The limestones exposed in the Dundee and Macon quarries are exceedingly rich in fossils. Upon weathered surfaces, under the magnifier, they are seen to consist of one mass of minute fragments in which, here and there, entire forms are embedded. The same species occur here as in the Trenton quarries where the opportunities for collecting are far better. Therefore detailed description of this fauna may be left to the Wayne county report. Upon the other hand all the forms found at Trenton are liable to be encountered in the Monroe county exposures. An extensive collection was made from the Sibley quarry, just north of Trenton, but there has not been time for its study. The following species were collected from this locality by Dr. Rominger:

*Mich. Geol. Sur., Vol. III, part I, p. 32.



*Atrypa reticularis*, Linnæus, sp.
*Spirifer gregarius*, Clapp.
*Spirifer acuminatus*, Conrad.
*Orthis Livia*, Billings.
*Strophodonta concava*, Hall, sp.
*Strophodonta perplana*, Conrad, sp.
*Paracyclas elliptica*, Hall.
*Conocardium subtrigonale*, D'Orbiguy.
*Pleuronotus Decewi*, Billings, sp.
*Phacops bufo*, Green, sp.
*Proetus crassimarginatus*, Hall, sp.
*Dalmania selenurus*, Eaton, sp.
*Stromatopora textilis*, Rominger.
*Stictopora Gilberti*, Meek.
*Zaphrentis prolifica*, Billings.
*Zaphrentis gigantea*, Lesneur.
*Heliophyllum Halli*, Edwards and Haime.
*Heliophyllum corniculum*, Lesueur, sp.
*Favosites turbinatus*, Billings.
*Favosites hemisphericus*, Troosy, sp.

In addition to the above species the following genera were represented by unidentified species. Fenestella, Polypora, Orthoceras, Gomphoceras, Gyroceras and Nautilus. Spines, plates, bones and teeth of sharks are found, most of them belonging to Onychodus sigmoides (Newberry), of the Upper Helderberg of Ohio.

In regard to the correlation of the fauna of the upper and lower Helderberg, Dundee and Monroe beds, reference should be made to Schuchert's paper already cited.*

*Bull. Geol. Soc. of Amer. pp. 241 to 332. See also paper by A. W. Grabau in the same volume, pp. 347-376, on the Siluro-Devonian contact in Erie county, New York. It is only fair to Prof. Sherzer to say that the important papers by Clarke and Schuchert, Williams, and Grabau referred to, have appeared during the proof reading, and the foot notes referring to the same and some slight changes in the text have been made largely by myself. While Prof. Sherzer has had a chance to see most of them, they may not be such as his deliberate judgment would approve, and in any case he would doubtless give these papers more worthy and ample treatment did time permit. It will appear clear upon careful reading of them that Clarke and Schuchert have excluded from the (Lower) Helderberg the Tentaculite

It seems clear that the Dundee fauna corresponds to that of the upper Helderberg, the Becraft limestone (Upper Pentamerus) of Darton and Schuchert, and that the bulk of the Monroe beds, especially those below the Sylvania sandstone have a Silurian fauna akin to that of the Manlius limestone or Waterlime. So far as yet appears there is no reason for cutting off any of the Monroe beds faunally from their lithological representatives, and considering them Devonian.

or Manlius limestone, which was considered originally its lowest member. In the western part of New York, Ohio and Monroe county, Michigan, the beds just above are wanting, and the unconformity which Grabau has pointed out exists. Hence naturally the Manlius limestone fauna has come to be regarded as typical Lower Helderberg in the region of the Great Lakes. This is regarded by all as Silurian. Whether the balance of the Lower Helderberg should be so regarded we have no occasion to decide. It may be noted, however, that if Hunt is right as to the intercalation of Corniferous in the Salina (p. 52), we must either include all the Salina as Devonian, or give up the "Devonian facies" as a criterion.—L.

# GENERAL INDEX.

## A.



## B.

DESCRIPTION OF PLATE XVII.

Figs. 1–3. Streptorhynchus hydraulicum. Whitf.
" 4–5. Spirifera Vanuxemi. Hall.

" 6–7. Meristella lævis. Van.
" 8–10. " bella. Hall.

" 11–14. Nucleospira rotundata. Whitf.
" 15–16. Retzia formosa. Hall.

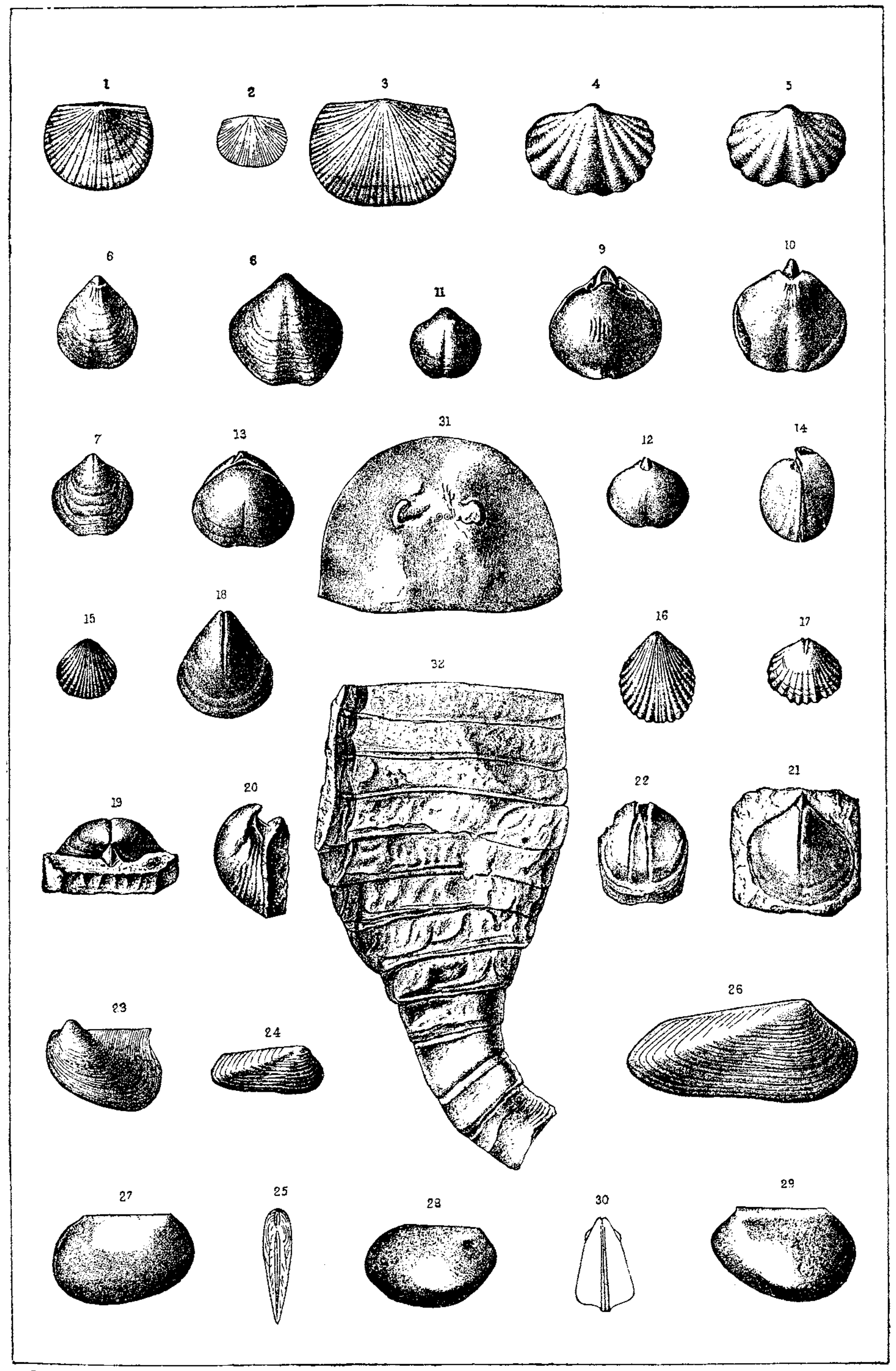
" 17. Rhynchonella hydraulica. Whitf.
" 18–22. Pentamerus pes-ovis. Whitf.

" 23. Pterinea aviculoidea. Hall.
" 24–26. Goniophora dubia. Hall.

" 27. Leperditia alta. Conrad.
" 28–30. " angulifera. Whitf.

" 31–2. Eurypterus eriensis. Whitf.
See pp. 223 to 225.






R. P. Whitfield Del

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