CHAPTER I.

THE OCCURRENCE, EXTENT AND ECONOMIC CLASSIFICATION OF THE LIMESTONES OF OHIO.

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The area and distribution of the older and principal limestone beds was worked out by the Survey many years ago. All of the geological maps of the older organizations have clearly delineated the chief areas of limestones, though it has been done as a matter of geology rather than economics.

The map shown on page 00, figure 1, has been copied in all of its essential features from these older maps, but the areas of the limestones of Carboniferous age has been added by the writers.

In many places, the areas of the different formations overlap each other, so that in ravines or in artificial excavations it is possible to open and work stone from two or more horizons at once. Where this situation exists, there is difficulty in the way of adequate rendering on a map. Also, the glacial drift, topographic features and other considerations come in to modify the situation, so that it can by no means be inferred that all places in the shaded or colored areas of the map are suitable for opening quarries, or for manufacturing of cement or lime. The map is meant merely to act as a general guide; to show the areas where each limestone is the topmost or surface formation; to point out the areas in which economic sites may be expected and sought for. The location of the actual site for an industry must take many other considerations into account, so that the occurrence of the stone itself in good quality and quantity is only the fundamental necessity of success. The other conditions will be the prominent ones in determining where, within the area, a plant shall be located.

As has previously been pointed out, the limestone wealth is found geologically in the lower and upper third of the rock system of the state, the vast bulk lying in one compact mass in the lower third, and a relatively small, but not unimportant, quantity being distributed through the upper third.

This division holds not only for geological age, but for geographical location, physical properties, chemical composition, and economic uses as well, so that economically considered, the classification may most easily be made along geographical lines into Eastern or Carboniferous limestones and Western or Pre-carboniferous.

Before discussing the stratigraphical divisions in detail, the use of stratigraphical names should be considered. The quarrymen, lime-burners and lime-users of Ohio are now habituated to the use of the geological names in use in the older surveys, and for that reason it has seemed wise to continue to refer to the formations frequently, if not invariably, by their older title.

On the other hand, the new stratigraphy is unquestionably more accurate, precise and authoritative than any which have preceded it, and it is desirable that it should come into trade use as soon as possible. For that reason, its names, where they differ from the old, are purposely inserted in many places in the text, often as synonyms, as a means of making their meaning known and beginning their use.

The following table, prepared by Professor Charles S. Prosser, and taken from Bulletin 7, will be found convenient in tracing the relationship of old and new names for the formations.

GEOLOGICAL SCALE IN OHIO.

Orton, Vol. vii, 1893.	Prosser, Bull. 7, 1905.
Glacial drift	Alluvium and Glacial.
Upper Barren Coal Measures.	Dunkard formation.
Upper Productive Coal Measures.	Monongahela formation.
Lower Barren Coal Measures.	Conemaugh formation.
Lower Productive Coal Measures.	Allegheny formation.
Conglomerate Group.	Pottsville formation.
Sub-carboniferous limestone.	Maxville limestone.
Logan Group.	Logan formation. Black Hand formation.
Cuyahoga shale.	Cuyahoga formation.
Berea shale.	Sunbury shale.
Berea grit.	Berea grit.
Bedford Shale.	Bedford shale.
Ohio shale. { Cleveland shale. Erie shale. Huron shale.	Ohio shale. { Cleveland shale. Chagrin formation. Huron shale.
Olentangy shale.	Olentangy shale.
Upper Helderberg or Corniferous limestone.	Delaware limestone. Columbus limestone.
Lower Helderberg limestone, or Water-lime.	Monroe formation. { Lucas limestone. Sylvania sandstone. Tymochtee member(?).

GEOLOGICAL SCALE OF OHIO—Concluded.

Orton, Vol. vii, 1893.	Prosser, Bull. 7, 1905.
Niagara Group. { Hillsboro sandstone. Guelph or Cedarville limestone. Niagara limestone. Niagara shale.	"Niagara Group." { Hillsboro sandstone. Cedarville limestone. Springfield limestone. West Union limestone. Osgood beds.
Clinton limestone.	Clinton limestone, Belfast bed.
Medina shale.	Saluda bed.
Hudson River Group.	Richmond formation. Lorraine formation. Eden shale.
Utica shale, not seen in outcrop.	
Trenton limestone.	Trenton limestone.

EASTERN GROUP.

The Eastern or Coal Measure groups until recently have received but little consideration from a commercial standpoint. The use in the arts of the limestones of the carboniferous period has been but local in its importance. This localization has been in a large measure due to the rugged topography of the country in which they occur, which retarded ready transportation, even from some of the most favorable localities. Another strong factor in retarding its development has been the nature of the deposits themselves. They are generally rather small in amount; that is, the vertical thickness as a rule is not great, and it is nearly always covered by a thick mass of superincumbent earth, which is cut through by erosion in valleys and ravines. In most cases, these also cut through the limestone as well, exposing it in their walls and sides. Thus the only way to win a large local output will in most places be by underground mining. With very few exceptions all that has been used so far has been exposed by nature; i. e., uncovered by erosion and the weathering agents.

The popular idea that these limestones are all impure and dirty has led most people to pass them by. However, the growth of the portland cement industry and the consequent demand for limestone low in magnesium carbonate, even if it be silicious or argillaceous, has brought about a more vigorous search by both capitalists and scientists, into the quality of all limestone occurring in quantities sufficient for economic winning, especially where located in close proximity to fuel. This search has been productive. It has brought the coal measures into

notice as a possible source of limestone. In southeastern Ohio, we find some of our best limestone for the manufacture of portland cement, in close proximity to beds of coal and clay.

These Carboniferous limestones are generally under ten feet in thickness, often only one or two feet being found. They are very hard, dense rocks, even in spite of their solubility in carbonated waters, lasting longer than the sandstones and shales, with which they are intercalated. They generally are blue or dark in color, conchoidal in fracture, fossiliferous, and exceedingly persistent or regular over large areas of country. On this account they have been of infinite service to the stratigraphical geologist, serving as the key to the rocks above and below them. In the largest portion of the coal measure areas, comprising roughly one-third of the state, there are from two to five separate limestone horizons represented in the same territory. These naturally overlap each other, so that an ascent of one hill will often bring three or four limestone horizons to view. But these beds are generally five feet or less in thickness, and as it is not economical to win limestone by underground workings with less than six or eight feet, these areas are excluded from any present importance.

In fact, it has been assumed that the least profitable workable thickness of stone is about eight feet, and only areas of this or greater thickness have been entered on the map, or sampled for analysis. It is not safe to say that the areas of thinner limestones in the coal measure areas will never be of economic value, for conditions change in ways no one can anticipate. These eastern stones are now becoming valuable, due to just such a shift in economic conditions, while heretofore they have been valueless. But the thinner stones, now rejected, apparently suffer from a more serious handicap from their small quantity and difficulty of mining than from either composition or properties or geographical location.

THE WESTERN DEPOSITS.

This division, embracing the greater part of the western half of the state, is a field of great activity, not only in the production of limestone for various purposes, but also for the manufacture of lime and its various by-products. It includes the now famous quarries at Marble Head and Kelley's Island, Marble Cliff and Columbus, Springfield and Greenfield. While the entire area is glaciated, a great deal of the stone lies almost at the surface, being covered by a thin coat of soil only. In many sections erosion has removed the greater portion of the drift originally left by glacial action, so that in almost any part of this area there are limestones at no great depths, making economic winning of the stone possible.

This territory, which has been leveled off by the glacial ice-sheet, whose hollows have been filled and whose hills have been degraded,

forms naturally a country suitable for a great population. It is the natural avenue for railroads, canals, and highways. The soil is fertile and well watered, and it has therefore become populous and rich. The imperative needs of this locality for building stone, lime and mortar, would of necessity develop the limestone beds here to a greater extent than in the eastern area, entirely irrespective of the quality of the materials or their extent.

But the advantages have been on the side of the western area, as here the stones are of enormous area, great thickness, easy access and most excellent quality. It is not strange, therefore, that the lime industry of Ohio has secured its first great development in this area.

These western deposits are generally massive, crystalline, light colored stones of remarkable purity. The clay or sand or iron coloring-matter falls below two per cent. in hundreds of places. The composition, however, is generally dolomitic; i. e., the stone is a mixture of carbonate of calcium and carbonate of magnesium, the proportions often becoming those of the mineral, dolomite, itself, which contains 56% of calcium carbonate to 44% of magnesium carbonate. Since dolomite makes a beautiful white lime on calcination, having physical properties similar to but less intense than pure calcium limes, this feature of its composition has not militated against its use in the trades, and, in fact, workmen have learned to prefer it, as it works slower and more mildly than pure calcium lime. Dolomite is as desirable for building material as pure limestone, so that there has been no drawback on this account. In fact, dolomite or dolomitic limestones are as valuable for most of the uses to which limestones may be put, as any other, and only become undesirable in metallurgical or chemical industries, where the base, calcium, is needed in its purest available form. Thus, for furnace flux, a rather low magnesia stone is generally used, while for Portland cement, the magnesia must be as low as possible and never exceed three or four per cent. For such accurate uses, the majority of western stones are at some disadvantages compared to the better quality of coal measure limestones.

It must not be supposed, however, that all of the western stones are dolomitic. Some very pure limestones occur in the Clinton, and low-magnesia stones are not uncommon elsewhere. The exact localities in which they occur will be given in Chapter III.