

ACKNOWLEDGMENTS.

There has been less written on the subject of the lime industry than almost any other branch of chemical technology of equal importance. This fact has made the preparation of this Bulletin, especially chapters five and six, less a work of compilation and more of personal observation than is usually the case. But no personal observation or experience of the representatives of the Survey could possibly have brought to light this mass of important facts in the short time available, had it not been for the coöperation of those already skilled in the business itself.

It is a source of much pleasure to be able to testify to the beautiful spirit shown by the lime manufacturers of Ohio in this connection. They have met the Survey with open arms, have hailed with the greatest interest and enthusiasm the efforts of the Survey to clear up the technology of their problems, and have contributed with an almost unexampled freedom from their records, books and experience.

If this discussion of the technology of the lime industry proves of value, the credit must be given in a large measure to the lime manufacturers who so willingly contributed the results of their years of experience. While each of them responded readily, there were a few among them who had access to plants with special equipment, or who had unusual experience in certain fields, who were thus in a position to furnish more information and make better criticisms than others.

We feel under special obligations to Mr. Chas. Warner, of the Cedar Hollow Lime Co., Wilmington, Delaware. Mr. Warner is not a citizen of Ohio, and could not be appealed to on the grounds of state pride in the work of this Survey, but his interest is broader than state boundaries, and his criticisms and suggestions on all phases of this work have been most helpful.

Mr. Warner's knowledge of the lime industry has been built up by actual contact with the problems involved at his own plants, as well as observation of results at many others. His engineering education has made an admirable foundation for the systematic work which he has done when any new experiment was to be tried.

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INTRODUCTION.

THE LIMESTONES AND LIME INDUSTRY OF OHIO.

BY EDWARD ORTON, JR.

The lowest element, stratigraphically considered, in the rock floor of Ohio, consists of a great bed of calcareous rock, called the Trenton limestone. Though this deeply buried stratum comes up to daylight in but one point in the state, at Point Pleasant, Clermont county, it has been nevertheless proven to underlie most of the state, by the countless drill holes which have been put down, especially in the western half. Hundreds of these holes have penetrated to or into this well-known bed, which in some portions of the state has been made famous the world over on account of its wonderful resources in natural gas and petroleum. The thickness of the Trenton limestone is a point not yet well established, though it is thought that it has been perforated by the drill in at least one point near Columbus.

Resting on this massive foundation, there follows an orderly series of beds of rock, succeeding each other with a persistent uniformity seldom surpassed in similar areas elsewhere. The gross thickness of these strata is about 3,000 feet, though nowhere in the state is more than 600 feet of it exposed in any natural section. These rocks consist chiefly of limestones in the lower third, though they are intercalated with some thin calcareous shales. In the middle third of the series the limestones give way quite abruptly to alternating beds of shale and sandstones or conglomerates, which occupy about a thousand feet in thickness. In these beds the limestones are practically absent.

The upper third of the rock beds of the state are much less strikingly differentiated from the middle beds than the middle from the lower. The upper third consists of sandstones and shales as the chief lithological factors, but differs from the middle third in the fact that it is interstratified with thin beds of coal, fire clay, iron ore, and limestones, which, though not of much bulk, are of great economic importance. The limestones are not a large element in their upper beds, probably not exceeding 100 or 150 feet in collective thickness of all of the separate strata. They differ greatly from the thick, massive, crystalline light-colored stones which compose the lower third, being dark-colored blue or gray usually, amorphous, and in thin strata of a few feet each.

In these three great divisions, approximately 1,000 feet is known to consist of limestone. This material composes therefore almost a

third of the fixed resources upon which the present and future mineral industries of Ohio will depend. In view of these facts, it seems eminently proper to bestow upon the limestones and their products a more searching examination than they have so far received.

Before taking up this discussion mention must be made of the work which has preceded in the earlier organizations of the Survey. The work done consists of three principal contributions.

First: The untangling of the stratigraphical order and geological equivalence of the limestone beds.

Second: The uses of the limestones for the manufacture of quicklime.

Third: The uses of the limestone for the manufacture of hydraulic cements.

The first of these tasks has been done on a scale completely surpassing the two latter. The limestones have not only been classified and studied, for themselves, but also have served, especially in the upper strata of the state, as the most serviceable guides to the unraveling of other problems. This task was largely completed during the work of the Second Geological Survey, but owing to the greater minuteness to which correlation is now carried, and to the great advances in stratigraphical geology which have been made in surrounding states, it has become necessary to repeat this work. The present classification and nomenclature of the Ohio formations is set forth in Bulletin VII.

The article in Volume VI of the Survey by Dr. Edward Orton, discussing the limestones of Ohio from the economic standpoint, especially as regards the manufacture of quicklime, presented the subject as well as the means at hand permitted at that time. As was clearly stated by the author, no laboratory investigations other than chemical analyses were made or attempted, and the data on the technology of lime manufacture were only such as could be gotten from practical men in the business. The literature of the subject, scanty as it now is, was then more scanty and, being almost wholly confined to the German, was not consulted to any extent. The need of revising this work is therefore apparent, especially in view of the numerous improvements and changes which have been brought about in the process of manufacture of quicklime, and in the uses to which lime is now put.

In addition to the ordinary uses of quicklime, a new industry has recently sprung up in the manufacture of bricks from sand and quicklime. The importance of this new structural material has yet to be proved commercially—it is beyond all doubt feasible from the technical standpoint to make it. It has been made the subject of a separate report, as Bulletin V of this series, by Mr. S. V. Peppel, B.Sc. It really falls midway between a quicklime industry and a cement industry, as it uses quicklime as a raw material, but perfects a hydrous silicate bond in the finished product in the process of manufacture.

The third article, on cement, was prepared by Professor N. W. Lord and published in Volume VI. The reasons for again opening up this topic are set forth in full in Bulletins 2 and 3 of the Fourth series, where the work of twenty-four pages of 1888 has been amplified and extended to cover six hundred and forty pages.

The present Bulletin originally had for its object the consideration of the limestone resources of Ohio from the standpoint of the cement industry. It was then thought that the report of 1888 on the quicklime industry was not in urgent need of revision, but that the growth of the cement industry in our midst necessitated a fresh consideration of the lime resources from the new standpoint.

The sampling of the state was largely done with this plan in view. Samples were often so taken as to include shaly strata between limestone beds, which would have been rejected by any lime burner, but which the cement maker would need. Also, samples were taken in general only in districts where it was thought the fitness of the material for cement manufacture was not definitely established, either for or against. The notes made at the time of sampling also were taken chiefly from the same point of fitness for cement.

But as the work progressed, contact with lime manufacturers and dealers made it clear that the scope of the inquiry should be broadened to include the whole subject of lime manufacture. The excellent work of 1888 on the chemical character of the limestones used for quicklime made it seem unnecessary to re-analyze these materials, except in occasional points missed in the former work. But in the technology of the industry, progress had been rapid and in this respect revision was needed.

The work as completed therefore seeks to do three things.

First: To make known the limestone resources of Ohio, from the standpoint of cement manufacture.

Second: To compile and systematize the known facts concerning the limestone resources of Ohio from the standpoint of quicklime manufacture and other uses, and to some small extent to add to this compilation by new studies.

Third: To present as fully as now possible, the present status of the technology of the lime industry.