

High-Calcium Limestone and High-Magnesium Dolomite Resources of Indiana

BULLETIN 42-B



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DEPARTMENT OF NATURAL RESOURCES
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By LAWRENCE F. ROONEY

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High-Calcium Limestone and High-Magnesium Dolomite Resources of Indiana

By LAWRENCE F. ROONEY

Introduction

Limestone has many uses in addition to aggregate, dimension stone, and cement raw material, which are its principal uses in Indiana. Some uses, such as filtering, do not require stone of high chemical purity, but many uses do. Because the equipment necessary to quarry different grades of limestone is the same, a deposit that contains a large reserve of stone meeting the most stringent specifications is potentially more profitable than a similar deposit of stone that meets only minimum specifications. Stone suitable for such products as glass, for example, is equally suitable for agricultural and fluxing purposes, but most stone suitable for agriculture is not suitable for glass or fluxstone. This report therefore is devoted to high-calcium limestone and high-magnesium dolomite even though they may serve a broad spectrum of uses that do not require high chemical purity.

DEFINITIONS

In this report high-calcium limestone is defined as limestone composed of more than 95 percent CaCO_3 and high-magnesium dolomite as dolomite composed of more than 42 percent MgCO_3 . Ultra-high-calcium limestone is defined as more than 97 percent CaCO_3 and high-purity carbonate rock as more than 95 percent combined CaCO_3 and MgCO_3 . A thick unit of limestone or dolomite is defined as one that is more than 10 feet thick. Thick units of Indiana limestone and dolomite are as much as 99.2 percent CaCO_3 and 45.6 percent MgCO_3 . (Theoretically pure dolomite is 45.7 percent MgCO_3 .)

In tables 1-5 weighted average chemical analyses are given for rock units more than 10 feet thick. Weighted averages were obtained

by summing the products of the thicknesses of the rock units multiplied by their chemical analyses in percent and dividing the sum by the total thickness of the rock units. Only the thickest continuous sections in any one exposure or core averaging more than 95 percent CaCO_3 or 42 percent MgCO_3 are given in the tables. Units within those continuous sections may be much purer than the weighted average would indicate.

PREVIOUS WORK

Many of the early geologic reports contained either implicit or explicit references to high-calcium limestone in Indiana. For example, in the report of his reconnaissance of 1838, David D. Owen (1859, p. 58) wrote that the Ste. Genevieve oolitic limestone makes "...the whitest and most valuable lime of any rock at present observed in the West." In the 28th Annual Report (1904), W. S. Blatchley presented a comprehensive review of lime production in Indiana at that time. In the 39th Annual Report (1915), G. C. Mance published a valuable paper on the use of high-calcium limestone discarded as waste by Indiana's dimension limestone industry. In the "Handbook of Indiana Geology" (1922, p. 766-775), W. N. Logan described the lime production at that time and tabulated production statistics from 1904 to 1917. During the next 30 years, very little was published on industrial limestone in Indiana until John B. Patton's concise summary of the state's industrial limestone resources appeared in 1951 and his Ph. D. dissertation was submitted in 1953. A decade later, the only report specifically on high-calcium limestone in Indiana (McGregor, 1963) was published. It contained detailed chemical analyses of many measured sections summarized in this report.

A recent report on the Devonian and Silurian rocks in Indiana (French, 1967) contains many analyses of high-magnesium dolomite. These analyses are not weighted averages but are the analyses of samples from detailed measured stratigraphic sections. A study of the Blue River Group by Donald D. Carr is in progress. It will include more than 500 new analyses of Paoli, Ste. Genevieve, and St. Louis rocks and will also incorporate analyses previously published or on file.

This report, containing as it does only the weighted averages of thick units of high-calcium limestone and high-magnesium dolomite, will be most valuable when it is used in conjunction with French's and Carr's reports.

ACKNOWLEDGMENTS

The most useful parts of this report are the five tables of chemical analyses. The data therein were derived ultimately from memorandum reports on file in the Industrial Minerals Section of the Indiana Geological Survey. Most of the stratigraphic sections were measured and sampled between 1947 and 1952 by John B. Patton, Duncan J. McGregor, and other former members of the Industrial Minerals Section. More recent data on Mississippian rocks resulted from sampling by Donald D. Carr, Jack A. Sunderman, and me. Many data on the Devonian and Silurian rocks in this report were abstracted from the report by Robert R. French (1967).

The Geochemistry Section of the Indiana Geological Survey performed the chemical analyses. Peggy Palmer computed the weighted averages.

Uses of High-Calcium Limestone

Limestone and dolomite have more than a hundred uses. Lime, the product obtained by heating limestone or dolomite, has in itself almost as many uses. For a description of many uses of limestone, dolomite, and lime, the reader is directed to the following references: Bowles and Jensen (1947), Bowen (1957), Lamar (1961), and Boynton (1966). Agricultural limestone and burned lime deserve discussion here, however, because of the actual or potential size of their production in Indiana.

AGRICULTURAL LIMESTONE

Limestone fines are applied to soil principally as a neutralizer and as a mineral food for plants. The finer the limestone, the more rapidly it neutralizes acids and the more rapidly it is assimilated by plants. Most agricultural limestone used in Indiana is not quarried specifically for that purpose but is a by-product of the crushed stone industry.

Although any limestone or dolomite can be used as agricultural limestone, or "aglime" as it is generally called, the following minimum specifications (U.S. Department of Agriculture, 1966, p. 13) have been set by the U.S. Department of Agriculture for agricultural limestone purchased by farmers in Indiana who wish federal subsidy: (a) the calcium carbonate equivalent (C.C.E.) must exceed 80 percent; (b) 80 percent must pass an 8-mesh sieve; (c) 25 percent must pass a 60-mesh sieve; (d) the product of "a" multiplied by "b" above must equal or exceed 7200; and (e) all the fines resulting from the crushing must be included. The C.C.E. is a measure of acid-neutralizing power relative to the neutralizing power of calcium carbonate. For pure limestone, the C.C.E. is 100 percent; for pure dolomite, the C.C.E. is 108.6 percent.

Although plants use considerably more calcium than magnesium, most of the agricultural limestone applied to the soil is consumed in neutralizing soil acidity. Plants are able to obtain calcium and magnesium in proper proportion from soils that vary widely in calcium/magnesium ratios (Barber, 1964, p. 3). Therefore a high calcium/magnesium ratio in limestone is not essential to plant growth.

LIME

When limestone or dolomite is heated, carbon dioxide is driven off, and CaO or $\text{CaO}+\text{MgO}$, a product called quicklime because it reacts rapidly with water, including that moisture normally present in air, is left. A more stable compound, hydrated lime, can be prepared by combining quicklime and water under controlled conditions. The major specification for lime is that the noncarbonate impurities not exceed 2 percent, if possible. When limestone is burned, the percentage of nonvolatiles roughly doubles, so that limestone containing 2 percent SiO_2 burns to lime containing almost 4 percent SiO_2 .

Lime has many uses and is second only to sulfuric acid as an industrial chemical (Boynton and Gutschick, 1960, p. 498). Now its demand is experiencing a spectacular upswing. During the past decade, the steel industry has been developing rapidly a new process for making high-quality steel, generally referred to as the basic-

oxygen furnace (BOF) process and sometimes as the oxygen-lime powder (OLP) process, by which high-quality steel low in nitrogen, phosphorus, and sulfur can be produced more rapidly and cheaply than by the open-hearth process. The conversion of the American steel industry to the basic-oxygen process is proceeding at as rapid a pace as the tremendous investment will permit. The last new open-hearth furnace built in this country was built in 1953 (U.S. Bureau of Mines, 1967, p. 7). According to Boynton (1966, p. 345), most informed persons in the steel industry predict that no new open-hearth furnaces will ever be built.

The basic-oxygen process uses a large amount of lime as a flux, "as much as 12-fold per day over former processes" (Rock Products, 1963, p. 83). Boynton (1966, p. 345) reported that the basic-oxygen process uses an average of 130 pounds of lime per ton of steel compared with about 28 pounds of lime per ton of steel produced by previous processes. Because burning adds to the cost of the flux and reduces the weight of the limestone by about 50 percent, the cost of transportation is a much lower proportion of the total cost of lime flux than of the total cost of limestone flux delivered to the steel plant. Thus the high-quality limestone deposits in Indiana cannot be dismissed as potential sources of flux in spite of their distance from the steel centers. But the cheap transportation route of the Great Lakes and the established large-volume lime production of Missouri, Michigan, and Ohio will make it difficult for Indiana to obtain much of the lime-flux market.

Flux is only part of a large market for lime in which Indiana could share, but does not. Raw materials for both high-calcium and dolomitic lime are abundant in the state, and considerable lime was produced in Indiana during the 19th century and the early part of the 20th century. In the early 1920's, six lime plants were reported (Logan, 1922, p. 766-775) to be in operation at Huntington, Salem, Delphi (two plants), Mitchell, and Milltown (pl. 1). Before that time, plants had been in operation at many other places in the state. Although production in 1917 was 118,530 tons (Logan, 1922, p. 771), by 1935 it had shrunk to 71,993 tons (Fix, 1938, p. 7),

and in 1953 the last plant using Indiana limestone as its principal raw material closed down. For comparison, in 1966, lime "sold and used" was almost 4 million tons in Ohio and more than 1 million tons in both Missouri and Michigan (U.S. Bureau of Mines, 1967, p. 499). A new plant went into production in July 1966 near Gary, Lake County (pl. 1), with a capacity of about 350,000 tons per year (O'Brien, 1966, p. 132), but the limestone is imported from Michigan via the Great Lakes.

Indiana also has the raw materials for high-calcium limestone products having higher specifications and higher unit value than flux lime. Oolitic limestone of the Ste. Genevieve Limestone, for example, because of its purity and whiteness, would be acceptable for almost every special use. Parts of the Salem, North Vernon, and Jeffersonville Limestones and the Traverse and Detroit River Formations would also be suitable for most uses except those which demand extreme whiteness in the raw rock.

Uses of High-Magnesium Dolomite

High-magnesium dolomite has fewer uses than high-calcium limestone. It is used for high-magnesium lime, magnesium compounds, refractories, and dead-burned dolomite (Lamar, 1961). One of the largest uses is fluxstone, but for that use it need not be high-magnesium dolomite. The amount of noncarbonate impurities, however, must be small (Lamar, 1961, p. 16). In fact, many chemical uses of dolomite require only that the combined calcium and magnesium content be high and other constituents low. For example, glass manufacture requires limestone or dolomite low in iron, sulfur, phosphorus, and carbon. One specification for dolomite to be dead-burned and used as basic bottoms in open-hearth furnaces is that it should contain less than 1 percent SiO_2 , less than $1\frac{1}{2}$ percent total Al_2O_3 and Fe_2O_3 , and more than 35 percent MgCO_3 (Bowles, 1928, p. 100). Dolomite that meets most specifications is so abundant in Indiana that only high-magnesium dolomite is discussed in this report.

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Sources of High-Calcium and High-Carbonate Limestone

In order of importance, the Salem Limestone (middle Mississippian), the Ste. Geneveive Limestone (middle Mississippian), and middle Devonian limestone (specifically the Jeffersonville Limestone and to a lesser degree the North Vernon Limestone, the Detroit River Formation, and the Traverse Formation) have the greatest potential as sources of high-calcium limestone in Indiana. The bedrock distribution of these rocks is shown on plate 1. Other formations from Ordovician to Pennsylvanian in age contain high-calcium limestone units, but these high-calcium units are not known to attain a thickness greater than 20 feet or do not crop out. Ordovician rocks, however, are a potential source of high-carbonate limestone.

BLACK RIVER AND TRENTON LIMESTONES (ORDOVICIAN)

Except for the rocks exposed in the deformed area near Kentland, Newton County, the oldest rocks exposed in Indiana crop out near the Ohio River in Switzerland County. These rocks, formerly designated the Cynthiana Formation, are now designated the Lexington Limestone. Although the Lexington Limestone is not known to contain thick units of high-calcium limestone, the underlying Trenton and Black River rocks do contain low-magnesium stone suitable as a cement raw material. Of more concern to us here, the Black River Limestone also contains the thickest unit of high-purity dolomitic limestone known in Indiana.

In a core taken by the Indiana Geological Survey near Patriot on the Ohio River in Switzerland County (pl. 1), Black River limestone averages about 95 percent combined calcium and magnesium carbonates from 400 to 570 feet, the total depth of the hole. The high-purity stone can be expected to continue to greater depth. From a depth of 495 to 528 feet the rock averages 97.3 percent carbonate, 1.83 percent SiO_2 , 0.28 percent Al_2O_3 , 0.16 percent Fe_2O_3 , 0.05 percent sulfur, and 0.004 percent P_2O_5 .

JEFFERSONVILLE AND NORTH VERNON LIMESTONES
AND DETROIT RIVER AND TRAVERSE FORMATIONS
(DEVONIAN)

Four formations of Devonian age, the Jeffersonville Limestone, the North Vernon Limestone, the Detroit River Formation, and the Traverse Formation, contain units of high-calcium limestone of commercial interest. The outcrop band of the Jeffersonville Limestone and the overlying North Vernon Limestone extends from the Ohio River to Cass County and approximates the distribution of Devonian rocks as shown on plate 1, but the outcrop is largely covered by glacial drift. The outcrop band of the Detroit River and Traverse Formations approximates the distribution of Devonian rocks in the narrow band that runs from Lake to Allen Counties (pl. 1) and is covered by thick glacial deposits. The Jeffersonville Limestone averages about 35 feet in thickness and the North Vernon only about 10 feet in thickness. The high-calcium limestone units in the Detroit River and Traverse Formations are about 20 feet thick. As thin as they are, these formations derive economic importance from the lack of thicker high-calcium limestone units north and east of the Mississippian outcrop band.

Where the North Vernon and Jeffersonville are exposed along the Wabash River in Cass County and along the Ohio River in Clark County, each contains a high-calcium unit about 11 feet thick (table 1). Where the Jeffersonville has been cored by the Indiana Geological Survey near Indianapolis (Survey drill hole 35) and in Bloomington (Survey drill hole 64), it appears to be composed entirely of high-calcium limestone (table 1). (In Survey drill hole 35, however, 19.5 feet of the 38 feet of rock drilled was not recovered. The loss is interpreted to have resulted from solution by groundwater derived from the glacial drift immediately overlying the Jeffersonville Limestone.)

West of Survey drill hole 35, the Jeffersonville Limestone is overlain by the New Albany Shale and is less likely there to have undergone much solution. Below the Jeffersonville Limestone are more than 100 feet of dolomite and limestone suitable for aggregate.

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Shallow underground mining of about 30 feet of high-calcium stone (leaving 5 feet of roof rock) would be necessary to exploit this or similar deposits. The lack of any source of high-calcium or crushed stone closer to Indianapolis makes such development worth considering.

In Survey drill hole 64, the Jeffersonville Limestone is composed entirely of high-calcium limestone but lies at a depth of about 900 feet. Because of its depth and the proximity of thick beds of high-calcium limestone exposed at the surface in the Salem Limestone, its economic exploitation does not appear possible. This core, as well as cores taken in Johnson and Lawrence Counties (table 1), is significant in that it shows the regional distribution of high-calcium limestone in the Jeffersonville.

A large area in Indiana in which high-calcium limestone in the Jeffersonville might be found at moderate depth or even near the surface stretches from Cass County to Clark County (pl. 1). In the few places that it is exposed along the belt, however, the Jeffersonville either contains only thin units of high-calcium limestone, as mentioned, or is largely dolomitic. Additional high-calcium deposits probably would have to be located by coring.

As part of a recent study of carbonate rocks in northern Indiana that might be mined by the shaft method (Rooney and Ault, in press), the Devonian carbonate rocks immediately above the thick evaporite unit in LaPorte County were sampled for chemical analysis. The analyses (table 1) reveal one of the purest limestone units in the state.

To my knowledge, high-calcium limestone from Devonian rocks has been used at only one locality in Indiana to manufacture lime.¹ Between 1868 and 1901, lime was produced about 4 miles east of Logansport, Cass County (Blatchley, 1904, p. 240), from what we assume was the North Vernon Limestone. Again, from about 1929 to 1943, the high-calcium limestone of the North Vernon was quarried

¹Since Blatchley's report of 1904, records of lime production in Indiana are mainly brief references in county reports and are very incomplete.

selectively by the France Stone Co. east of Logansport and was burned in vertical kilns that are still standing near the company's present plant. Although the quarry is located favorably with regard to markets and transportation, the fact that the high-calcium unit is only 11 feet thick would require either modest production or rapid lateral expansion of the quarry, with the attendant stripping and haulage costs. Under present market conditions, a lime plant in this area does not seem likely. Elsewhere in Indiana, the Jeffersonville Limestone may have been used for burned lime, but the limestone probably would not qualify as high-calcium.

At the present time, the Jeffersonville Limestone provides raw material for cement being manufactured in Clark County. As in Cass County, the high-calcium unit is about 11 feet thick and would pose the same problems of selective quarrying.

Limestone, possibly Devonian in age, has been quarried near Delphi, Carroll County, for the production of lime (Blatchley, 1904, p. 233). Most of the lime produced in that area, however, contained considerable magnesia. The possibility of finding thick units of high-calcium limestone in the Delphi area appears remote.

HARRODSBURG AND SALEM LIMESTONES (MISSISSIPPIAN)

The Salem Limestone, which crops out along a belt from Harrison County to Putnam County (pl. 1), contains the thickest units of high-calcium limestone exposed in Indiana. In some areas, strata in the underlying Harrodsburg Limestone are high-calcium limestone that could be quarried with the overlying Salem. In one area at least, in Harrison County (table 2), the Harrodsburg contains sufficient high-calcium limestone to be quarried for itself. Similarly in some areas a thin basal unit of the overlying St. Louis Limestone is of sufficient purity to quarry with the Salem, but in itself the St. Louis is not a potential source of high-calcium limestone. Where applicable, analyses of St. Louis and Harrodsburg limestones have been averaged with the underlying or overlying unit of Salem limestone (table 2).

Most Salem limestone and some Harrodsburg limestone are less

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well cemented than most limestone used for aggregate and therefore are easy to pulverize. Tests made by the Louisville Cement Co. show that Salem limestone burns to a white lime (Hyer, unpublished manuscript). But the light-gray color of the Salem and Harrodsburg, due to small amounts of organic matter, reduces their desirability for those uses that require whiteness of the limestone itself, and sulfur is one of the chemical impurities that in some places may exceed specifications for some uses.

Unfortunately for the lime industry, the thickest units of high-calcium limestone within the Salem for which we have analyses are found in the building stone belt in Lawrence and Monroe Counties (table 2). And it is this same limestone, high in calcium, that makes the best dimension limestone, which has a higher unit value in the ground than limestone used for most other purposes.

In Lawrence and Monroe Counties the building stone industry has been established for a hundred years. Much of the promising acreage has been leased by the building stone companies, which have not sought to diversify, partly because the quarrying and production methods and the markets of building stone are so different from the methods and markets of other industrial limestone. When diversification has been considered, it has been tied generally to the use of waste stone, which costs as much as good stone to quarry, but which has accumulated over the decades in huge obstructive pyramids. Except as riprap, however, no practical use of any large volume of the large blocks has been achieved.²

For some time mill spalls have been used by the Bedford Ground Limestone Co., Bedford, and the Indiana Calcium Corp., Bloomington, as a raw material for ground high-calcium limestone, but the annual production of ground limestone is limited by the annual pro-

²In 1902, a company was organized in Bedford to produce lime from both waste quarry blocks and mill spalls (Blatchley, 1904, p. 255), but I have no record of how long the company remained in business. The Indiana Limestone Co. produced lime from a plant at the same location in the early 1930's (Robert Nu, Indiana Limestone Co., Inc., 1966, oral communication), but it is believed that mill spalls rather than blocks were the raw material. For further information on this subject, see G. C. Mance, 1915.

duction of building stone. The total amount of spalls available each year from any one mill is not large enough to support a modern cement or lime plant. For the Salem Limestone to be used in large quantities as high-calcium limestone, it probably will have to be quarried as a primary product, not as a by-product of the building stone industry.

Thick deposits of high-calcium limestone not being exploited for building stone can be found in Monroe and Lawrence Counties. The sections exposed in abandoned quarries in extreme northern and southern Monroe County (locations 2 and 8, pl. 1) have thick units of ultra-high-calcium limestone. Analyses of channel samples and of three cores cut in an abandoned quarry in Lawrence County (location 7, pl. 1) reveal 45 to 50 feet of limestone averaging almost 97 percent CaCO_3 . These and many other deposits of Salem limestone of probable similar quality are potential sources of high-calcium limestone.

One objection raised to quarrying the Salem for purposes other than building stone is that blasting would shatter the nearby stone and make it unsuitable for use as building stone. The distance to which such damage could extend under any given blasting conditions would need to be assessed before selecting a quarry site. But prospecting for high-calcium limestone in the Salem need not be confined to Monroe and Lawrence Counties. Both north and south of the building stone belt the Salem and Harrodsburg Limestones contain thick units of high-purity stone. A unit of high-calcium limestone 27 feet thick is exposed in a quarry in Owen County (location 1, pl. 1) and a unit 42 feet thick is exposed in a quarry in Harrison County (location 1, pl. 1). Our lack of knowledge of other deposits results partly from the lack of natural exposures, quarries, and cores.

PAOLI AND STE. GENEVIEVE LIMESTONES (MISSISSIPPIAN)

The Paoli Limestone and the Ste. Genevieve Limestone, formations in the Blue River Group, crop out in Indiana from central Putnam County southeastward to the Ohio River (pl. 1). In most places less than 20 feet thick, the Paoli overlies the Ste. Genevieve and is treated

here as part of the same commercial unit. The combined average thickness of the two formations along the outcrop belt is between 100 and 150 feet. From top to bottom the Ste. Genevieve is divided into the Levias, Rosiclare, and Fredonia Members. In much of the Ste. Genevieve outcrop, the Lost River Chert Bed, a cherty limestone bed several feet thick, is present about 20 feet above the base of the Fredonia. Although high-calcium limestone of several types is found in the Ste. Genevieve, the oolite lithostrome within the Fredonia and Levias Members is actually and potentially the most important source of high-calcium limestone in the formation. In chemical purity it equals the best of the Salem and in whiteness surpasses it. The sulfur and phosphorus content of the oolitic rocks and other lithostromes in the Ste. Genevieve also is more consistently low than that of the Salem.

The oolite beds are composed mostly of coated, rounded fragments of limestone and fossils. The beds are widespread and discontinuous and vary abruptly in thickness. One interpretation is that they are ancient sandbars. In two quarry exposures they are clearly wider at the base than at the top. In the Radcliff, Inc., quarry in Orange County (fig. 1) the sharp contact between the oolite and argillaceous facies indicates that the latter was deposited on the oolite bed rather than with the oolite bed. Another interpretation is that effectively the oolite beds are sheet deposits, for they are found in every exposure of more than 50 feet of the Ste. Genevieve Limestone from Orange County to the Ohio River. A recent study of these deposits (Carr, 1969) sums up our knowledge of the geometry of the oolite bodies. The matter is of direct economic interest because knowledge of the probable width, thickness, and strike of a deposit, assuming the bodies are bars, would save considerable expense in coring and quarrying. In fact, development of this exceptional resource depends on establishing larger reserves than has been possible heretofore.

The chemical composition of the Ste. Genevieve varies more widely within shorter distances both stratigraphically and geographically than does the composition of the Salem. Any particular stratigraphic section is likely to contain high-calcium strata separated by strata of



Figure 1. Northwest face, Radcliff, Inc., quarry, Orange County (SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 24, T. 3 N., R. 1 W.), showing relationship between oolitic and argillaceous limestones of the Fredonia Member, Ste. Genevieve Limestone.

lower purity. In some places the units of high purity are thick enough to be quarried selectively; for example, 74 feet of high-calcium Paoli and Ste. Genevieve limestones in the Leavenworth section, Crawford County, is separated into three units 32, 29, and 13 feet thick (table 3) by a 1-foot unit and a 33-foot unit of low-purity stone. But many measured sections contain numerous thin beds of high-calcium limestone that could not be selectively quarried. Unlike Salem limestone, however, Paoli and Ste. Genevieve limestones make excellent aggregate and thus offer better possibilities for using stone that does not meet high chemical specifications.

The Paoli and Ste. Genevieve limestones, which are quarried for use as aggregate at many locations from Putnam County to the Ohio River, are used as a cement raw material in Putnam County. Oolitic limestone in the Ste. Genevieve has been quarried in Orange County

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and shipped to Ohio for use as fluxstone in open-hearth furnaces. Ste. Genevieve limestone has been widely used as raw material for lime. In fact, a plant which burned oolitic limestone from the Ste. Genevieve was in operation at Milltown until 1953.

The thickest known deposits of ultra-high-calcium Ste. Genevieve limestone in Indiana are in Orange and Harrison Counties (table 3). A deposit of high-calcium limestone 33 feet thick exposed in the abandoned Sonners quarry in Harrison County (table 3) is of special interest because of its proximity to the Ohio River.

CHESTERIAN ROCKS (MISSISSIPPIAN)

A few measured sections reveal units of high-calcium limestone about 15 feet thick in the Beaver Bend, Glen Dean, and Beech Creek Limestones (table 4), but these formations cannot be considered prime sources of high-calcium limestone. Because they do not lie far above the Paoli stratigraphically, they must compete with the Paoli and Ste. Genevieve Limestones, which offer thicker sections for quarry development. In several quarries, Chesterian rocks are quarried with the Paoli and the Ste. Genevieve.

Sources of Dolomite

The major sources of high-magnesium dolomite in Indiana are the Salamonie Dolomite, the Huntington Lithofacies of the Wabash Formation, and the Louisville Limestone, all Silurian in age. Near Kentland in Newton County, local intense deformation of the earth's crust has brought to the surface rocks of Ordovician age that normally lie at a depth of several hundred feet. Although part of the Black River Limestone exposed in the quarry near Kentland is high-magnesium dolomite (table 5), Ordovician rocks in general are too deeply buried, too calcareous, or too argillaceous to be considered sources of high-magnesium stone. Only two stratigraphic sections measured in the Geneva Dolomite of Devonian age contain a thick unit of high-magnesium dolomite (table 5).

According to information in the Indiana Geological Survey files, thick units of high-magnesium dolomite at moderate depth are likely

to be found only in the northern half of Indiana (table 5), a part of the state largely covered by a thick mantle of glacial drift. Much of the pure dolomite is found in reefs that are topographically high and therefore covered by drift of less than average thickness. Exploration for new deposits would depend largely if not wholly on drilling, following geologic and geophysical exploration for areas of thin drift. Through the detailed study of water well records and other drilling data (Rooney and Ault, in press), the Indiana Geological Survey recently defined an area of shallow bedrock in southern Lake County and adjacent counties. A core taken by the Survey revealed a reef composed largely of high-magnesium dolomite (table 5) that has large commercial potential.

Other than as aggregate and agricultural limestone, the high-magnesium stone of northern Indiana has been used in recent years for fluxstone and filterstone and for manufacturing glass. Many years ago it was used to manufacture dolomitic lime.

SALAMONIE DOLOMITE

The Salamonie Dolomite is widespread, contains various rock types, including reef rock, and is more than 200 feet thick (French, 1967, p. 19). In southern Indiana it is divided into the chemically impure Osgood and Laurel Members. In northern Indiana it contains thick units of high-purity stone, in fact the purest carbonate rock in the state. For example, 69 feet of exposed section and core sampled in the Rockledge quarry in Jay County and 77 feet of core in the Erie Stone Co. quarry in Wells County (table 5) are 99.5 percent carbonate. The latter section is the second-thickest section of pure dolomite in Indiana that has been chemically analyzed, and the pure dolomite most likely extends deeper. I have examined 200 feet of core taken in the floor of the Western Indiana Aggregates Corp. quarry in Pulaski County. The rocks have not been analyzed but appear to be nearly pure dolomite.

LOUISVILLE LIMESTONE

The Louisville Limestone does not contain so thick high-magnesium

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dolomite as the Salamonie Dolomite and the Wabash Formation (table 5), but in northern Indiana it contains a considerable thickness of high-purity carbonate rock. In the Meshberger Brothers Stone Corp. quarry, Adams County, for example, 57 feet of exposed stone averages 99.2 percent carbonate, 37 feet of which is high-magnesium dolomite (table 5).

WABASH FORMATION

During the time that the Salamonie Dolomite, the Louisville Limestone, and the Wabash Formation were being deposited, the shallow warm Silurian seas that covered Indiana were dotted by reefs colonized almost wholly by organisms whose skeletons were composed of CaCO_3 . In the interreef areas both carbonate and noncarbonate material was deposited. During Wabash time, however, the amount of clastic material, especially clay and silt, was considerably larger than in Salamonie time, a condition resulting in a distinct lithologic facies called the Mississinewa Shale Member (of the Wabash Formation). The reef rock, called the Huntington Lithofacies, was altered postdepositionally to nearly pure dolomite. The thickest unit of high-magnesium dolomite in the Wabash Formation thus far sampled and analyzed was discovered in 1969 by the Indiana Geological Survey in Lake County (pl. 1). At least 184 feet of high-magnesium dolomite separated into two units (table 5) by 2.6 feet of dolomite containing quartz sand was cored. At a total depth of 270 feet, the hole was still in high-magnesium dolomite.

Summary

High-calcium limestone and high-magnesium dolomite are abundant in Indiana. The Salem and Harrodsburg Limestones (Mississippian) contain the thickest units of high-calcium limestone (as much as 60 feet thick) in the state. The Ste. Genevieve Limestone (Mississippian) includes bodies of ultra-high-calcium oolitic limestone; it is the whitest, purest limestone known in Indiana and can meet stringent specifications. The North Vernon and Jeffersonville Limestones (Devonian) are the only high-calcium limestones exposed east of the Mississippian outcrop belt. In northern Indiana the Traverse and

Detroit River Formations (Devonian) contain high-calcium limestone but would have to be mined underground. The Salamonie Dolomite, the Louisville Limestone, and the Wabash Formation in northeastern Indiana contain thick units (as much as 125 feet) of dolomite more than 99 percent pure. The Geneva Dolomite in south-central Indiana contains some high-magnesium dolomite.

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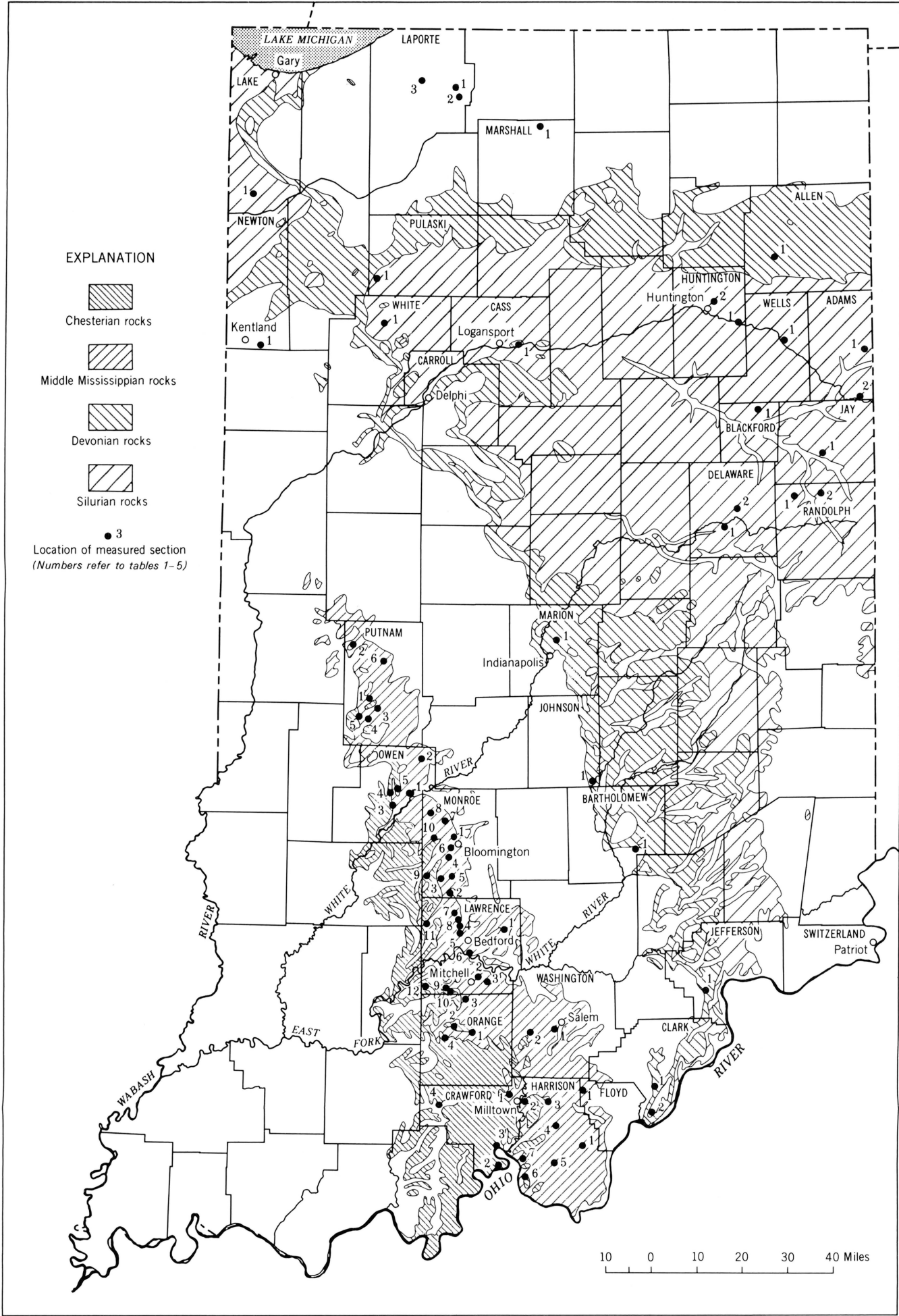
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MAP OF INDIANA SHOWING BEDROCK DISTRIBUTION
OF PRINCIPAL CARBONATE ROCKS

TABLE 1. CHEMICAL ANALYSES (IN PERCENT) OF HIGH-CALCIUM LIMESTONE IN THE NORTH VERNON AND JEFFERSONVILLE LIMESTONES (DEVONIAN), TRAVERSE FORMATION (DEVONIAN), AND DILLSBORO FORMATION (ORDOVICIAN), INDIANA

County	No. on map	Measured section	Formation	Location ¹			Thickness (feet)	CaCO ₃ + MgCO ₃	CaCO ₃	MgCO ₃	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	S	P ₂ O ₅
				Sec.	T.	R.									
Cass	1	France Stone Co. quarry face	North Vernon Limestone	NE¼ 27	27N	2E	11	98.4	97.7	0.69	1.15	0.16	0.06	0.41	0.005
Clark	1	Sellersburg Stone Co., Inc., quarry face	Jeffersonville Limestone	W½ 90 ²	1S	7E	10	96.4	95.4	0.98	3.24	0.08	0.14	0.08	0.004
	2	T. J. Atkins and Co., Inc., quarry face	Jeffersonville Limestone	W½ 10 ²	2S	7E	10	96.9	95.2	1.73	2.47	0.18	0.22	0.12	0.006
Johnson	1	Indiana Geol. Survey drill hole 20 (core, file 125)	Jeffersonville Limestone Dillsboro Formation ³	NW¼ 17	11N	5E	17 15	97.0 97.8	95.6 97.3	1.36 0.47	2.25 1.34	0.09 0.22	0.08 0.44	0.08 0.25	0.046 0.541
LaPorte	1	Northern Indiana Public Service Co. No. 1 E. Barthel (core)	Traverse Formation	SW¼ 17	36N	1W	24	99.4	96.3	3.10	0.17	0.03	0.17	0.09	0.004
	2	Indiana Geol. Survey drill hole 118 (core, file 268)	Traverse Formation	NE¼ 29	36N	1W	20 ⁴	99.2	97.4	1.75	0.42	0.02	0.20	0.04	0.004
	3	Indiana Geol. Survey drill hole 136 (core, file 318)	Traverse Formation	NE¼ 13	36N	3W	22 ⁵	98.4	97.2	1.16	1.21	0.06	0.11	0.11	0.002
Lawrence	1	Texas Gas Transmission Corp. No. 1 Kindred (core, file 149)	Jeffersonville Limestone Jeffersonville Limestone	SE¼ 7	5N	2E	25 ⁶ 13 ⁷	99.2 99.3	96.8 95.1	2.40 4.18	0.36 0.32	0.14 0.08	0.09 0.13	0.03 0.07	0.008 0.003
Marion	1	Indiana Geol. Survey drill hole 35 (core, file 145)	North Vernon Limestone	SW¼ 18	16N	4E	38 ⁸	99.1	98.3	0.75	0.64	0.06	0.06	0.02	0.009
Marshall	1	Northern Indiana Public Service Co. No. 1 C. Bollenbacher (core, file 445)	Detroit River Formation	NE¼ 29	35N	3E	18	97.3	95.9	1.39	1.93	0.24	0.17	0.08	0.013
Monroe	1	Indiana Geol. Survey drill hole 64 (core, file 188)	Jeffersonville Limestone	NE¼ 33	9N	1W	35	99.1	96.4	2.65	0.47	0.08	0.08	0.03	nd ⁹

¹See plate 1 for locations of measured sections.

²Clark Military Grant.

³Although Ordovician rocks, especially Trenton and Black River Limestones, probably contain many units of high-calcium limestone thicker than 10 feet, this is the only unit for which the Indiana Geological Survey has an analysis. The Indiana Geological Survey has no analyses of thick units of high-calcium limestone in Silurian rocks.

⁴Includes 1.5 feet of rock not recovered.

⁵Includes 3.5 feet of rock not recovered.

⁶Includes 1.7 feet of rock not recovered.

⁷Includes 1.0 foot of rock not recovered.

⁸Includes 19.5 feet of rock not recovered.

⁹nd - not determined.

TABLE 2. CHEMICAL ANALYSES (IN PERCENT) OF HIGH-CALCIUM LIMESTONE IN THE SALEM AND HARRODSBURG LIMESTONES UNDIFFERENTIATED (MISSISSIPPIAN), INDIANA

County	No. on map	Measured section	Location ¹			Thickness (feet)	CaCO ₃ + MgCO ₃	CaCO ₃	MgCO ₃	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	S	P ₂ O ₅
			Sec.	T.	R.									
Floyd	1	Natural exposure near Greenville	SW¼ 31	1S	5E	10	97.6	96.8	0.77	1.66	0.25	0.32	0.05	0.017
Harrison	1	Corydon Stone Co. quarry face ²	SW¼ 25	3S	4E	10	96.5	95.8	0.65	2.58	0.14	0.29	0.03	0.013
						42	97.0	95.8	1.24	1.87	0.26	0.39	0.16	0.043
Lawrence	2	Lehigh Portland Cement Co. quarry face	SE¼ 30	4N	1E	46	97.9	96.2	1.69	1.25	0.31	0.31	0.15	0.041
	3	Natural exposure near Mill Creek	NE¼ 33	4N	1E	35	98.3	96.1	2.16	1.24	0.13	0.16	0.03	0.013
	4	Indiana Limestone Co., Inc., Baalbeck quarry face ²	SE¼ 9	5N	1W	33	98.8	97.6	1.17	0.83	0.06	0.11	0.02	0.014
	5	Oolitic Ground Limestone Co. quarry face	SE¼ 16	5N	1W	54	98.1	96.3	1.81	1.34	0.19	0.17	0.07	0.014
	6	Road cut near White River	NE¼ 34	5N	1W	13	98.4	97.2	1.15	1.24	0.80	0.12	0.02	0.005
						27	99.1	98.0	1.08	0.53	0.05	0.16	0.04	0.019
Monroe	7	Heltonville Limestone Co. No. 3 Needmore Quarry ² (core)	SW¼ 16	6N	1W	49	98.6	96.6	1.96	1.06	0.06	0.14	nd ³	nd
	8	Indiana Limestone Co., Inc., P. M. & B. quarry face	NE¼ 33	6N	1W	58	98.7	97.0	1.67	0.84	0.08	0.15	0.04	0.009
	2	Cleveland Stone Co. ⁴ quarry face ²	NW¼ 20	7N	1W	60	98.8	97.8	1.03	0.84	0.11	0.09	0.02	0.009
	3	Victor Oolitic Stone Co. quarry face	SE¼ 12	7N	2W	49	98.7	97.7	1.20	0.70	0.05	0.15	0.02	0.010
	4	Carl Furst Stone Co. quarry face	NW¼ 18	8N	1W	47	98.5	97.4	1.08	0.92	0.11	0.20	0.05	0.012
	5	Indiana Limestone Co., Inc., quarry face ²	SW¼ 32	8N	1W	54	98.2	97.1	1.10	1.39	0.07	0.15	0.03	0.011
	6	Bloomington Crushed Stone Co. quarry face ²	NW¼ 28	9N	1W	29	97.6	95.3	2.28	1.51	0.26	0.26	0.19	0.070
	7	Ellettsville Stone Co. ⁴ quarry face ²	NE¼ 2	9N	2W	22	98.9	97.6	1.28	0.70	0.09	0.13	0.01	0.007
Owen	1	Dunn Limestone Co., Inc., ⁴ quarry face ²	SW¼ 10	10N	3W	27	97.9	95.4	2.47	1.61	0.13	0.16	0.03	0.008
						23	98.0	97.2	0.81	1.67	0.07	0.09	0.02	0.008
	2	Natural exposure at Spring Cave, near Quincy	SE¼ 6	11N	2W	23	98.0	97.2	0.81	1.67	0.07	0.09	0.02	0.008
Putnam	1	Ohio and Indiana Stone Co. quarry floor (core 5)	NW¼ 29	14N	4W	57	97.8	96.5	1.38	1.47	0.12	0.19	0.09	0.032
	2	Keeney (Spencer, Grimes) ⁴ quarry face ²	SE¼ 28	16N	5W	18	96.7	95.7	0.96	2.55	0.27	0.25	0.05	0.033
Washington	1	Hoosier Lime and Stone, Inc., quarry face	NE¼ 24	2N	3E	13	98.0	96.0	1.96	1.54	0.13	0.13	0.07	0.003
						12	98.1	96.2	1.88	1.43	0.09	0.16	0.11	0.004
						33	97.8	96.7	1.08	1.67	0.21	0.16	0.11	0.013
						17	97.1	95.8	1.30	2.32	0.16	0.26	0.25	0.041

¹See plate 1 for locations of measured sections.

²Abandoned.

³nd - not determined.

⁴No longer operates quarries.

Note: Where more than one high-calcium limestone unit is part of a measured section, the high-calcium units may be separated vertically by many feet of rock containing less than 95 percent CaCO₃.

TABLE 3. CHEMICAL ANALYSES (IN PERCENT) OF HIGH-CALCIUM LIMESTONE IN THE PAOLI AND STE. GENEVIEVE LIMESTONES UNDIFFERENTIATED (MISSISSIPPIAN), INDIANA

County	No. on map	Measured section	Location ¹			Thickness (feet)	CaCO ₃ + MgCO ₃	CaCO ₃	MgCO ₃	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	S	P ₂ O ₅
			Sec.	T.	R.									
Crawford	1	Hy-Rock Products Co. quarry face	SW¼ 6	2S	2E	12	99.0	97.8	1.15	0.64	0.14	0.05	0.05	0.007
	2	Mulzer Bros. No. 5 Jones (core)	SE¼ 25	4S	1E	10	97.8	96.5	1.33	1.36	0.38	0.18	0.06	0.010
	3	Natural exposure near Leavenworth	SW¼ 6	4S	2E	32	96.1	95.1	1.02	3.04	0.43	0.22	0.03	0.010
Harrison						29	96.4	95.3	1.14	2.86	0.44	0.13	0.02	0.009
						13	98.0	95.2	2.81	1.42	0.32	0.73	0.03	0.008
	2	Louisville Cement Co. quarry face ²	SE¼ 10	2S	2E	26	98.5	97.1	1.39	0.68	0.24	0.06	0.02	0.026
	3	Davis Crushed Stone and Lime Co. quarry face	SW¼ 15	2S	3E	10	98.6	97.8	0.76	0.88	0.12	0.12	0.01	0.005
						11	99.1	98.2	0.87	0.63	0.11	0.05	0.01	0.006
	4	Corydon Crushed Stone and Lime Co., Inc., quarry face	SE¼ 14	3S	3E	10	97.1	96.0	1.06	2.41	0.27	0.12	0.02	nd ³
						10	99.0	98.5	0.53	0.52	0.87	0.59	0.01	nd
	5	Mathes Stone Co. quarry face	NE¼ 13	4S	3E	17	99.0	98.7	0.31	0.68	0.15	0.58	0.03	0.009
						13	99.0	97.1	1.91	0.71	0.12	0.05	0.01	0.006
	6	Harrison County Highway Dept. (Sonners) ⁴ quarry face ²	NE¼ 12	5S	2E	33	98.0	96.6	1.40	1.44	0.26	0.10	0.02	0.005
Lawrence	7	Indiana Geol. Survey drill hole 152 (core, file 339)	SE¼ 14	4S	2E	10	97.0	95.2	1.82	1.48	0.54	0.49	0.08	0.024
						14	96.3	95.2	1.13	2.27	0.64	0.26	0.06	0.008
						12	97.2	95.4	1.82	1.77	0.41	0.28	0.05	0.005
						16	97.0	95.7	1.28	2.22	0.33	0.17	0.05	0.007
	9	Mitchell Crushed Stone Co. quarry face	NE¼ 11	3N	2W	24	97.1	96.3	0.78	2.19	0.31	0.15	0.05	nd
	10	Nally, Ballard, and Cato Co. ⁴ quarry face ²	SE¼ 12	3N	2W	26	97.8	95.8	1.97	1.63	0.29	0.09	0.03	0.009
	11	Bloomington Crushed Stone Co., Inc., quarry face	SE¼ 29	6N	2W	12	96.8	95.8	0.96	2.24	0.51	0.21	0.03	0.019
						15	97.4	96.7	0.67	1.72	0.40	0.17	0.02	0.005
						11	97.1	95.1	2.04	1.94	0.37	0.16	0.02	0.014
						13	96.4	95.9	0.52	3.12	0.16	0.07	0.01	0.038
Monroe	9	Quimby and Stephen ⁴ quarry face ²	SE¼ 6	7N	2W	21	97.2	96.7	0.51	2.16	0.37	0.11	0.02	0.010
	10	Bloomington Crushed Stone Co., Inc., quarry face	SW¼ 27	9N	2W	14	96.5	95.8	0.71	3.18	0.26	0.28	0.01	0.019
						11	97.3	96.5	0.78	1.80	0.31	0.13	0.01	0.007
						10	96.8	96.0	0.78	2.11	0.41	0.18	0.02	0.018
Orange						17	96.6	95.8	0.75	2.59	0.33	0.15	0.02	0.006
	1	Calcar Quarries, Inc., (core, file 337)	SE¼ 6	1N	1E	24	97.6 ⁵	96.4 ⁵	1.18 ⁵	0.99 ⁵	0.21 ⁵	0.11 ⁵	0.01	0.007
						22	98.2	96.4	1.83	1.05	0.26	0.13	0.03	0.012
	2	Cave Quarries, Inc., quarry face	SE¼ 29	2N	1W	10	98.9	97.9	1.03	0.59	0.15	0.08	0.00	0.041
						22	98.1	97.7	0.41	1.32	0.27	0.06	0.00	nd
Owen						19	97.6	95.1	2.49	1.68	0.40	0.11	0.01	nd
	3	Radcliff, Inc., quarry face	SE¼ 24	3N	1W	28	99.5	98.8	0.73	0.15	0.06	0.05	0.01	nd
						18	98.3	97.5	0.84	1.11	0.20	0.08	0.05	nd
	3	American Aggregates Corp. quarry face	NE¼ 30	10N	3W	26	96.7	95.6	1.11	2.25	0.57	0.16	0.08	0.017
	4	Winders and Sons quarry face ²	SE¼ 13	10N	4W	16	97.9	97.2	0.72	1.49	0.23	0.16	0.02	0.019
Putnam	5	Natural exposure near Cuba	SW¼ 32	11N	3W	29	96.7	96.2	0.51	2.65	0.40	0.14	0.02	0.014
	1	Ohio and Indiana Stone Co. quarry face	SW¼ 20	14N	4W	11	96.4	95.7	0.70	2.70	0.36	0.27	0.06	0.017
	3	Indiana State Farm quarry face	SW¼ 17	13N	4W	14	97.2	96.5	0.67	2.19	0.17	0.21	0.05	0.008
						34	95.8	95.1	0.68	3.25	0.32	0.22	0.07	0.021
	4	Concrete Materials Div. quarry face	SW¼ 24	13N	5W	18	96.2	95.6	0.58	2.85	0.37	0.33	0.05	0.012
Washington	5	Natural exposure near Reelsville	NE¼ 21	13N	5W	11 ⁶	96.1	95.5	0.62	2.58	0.46	0.57	0.03	0.063
	6	Harris Stone Service, Inc., quarry face	NW¼ 15	15N	4W	10	98.2	97.8	0.36	1.09	0.20	0.27	nd	nd
						10	98.2	97.8	0.36	1.09	0.20	0.27	nd	nd
	2	Washington County quarry face ²	SW¼ 31	2N	3E	13	95.9	95.2	0.74	3.09	0.66	0.13	0.04	0.008

¹See plate 1 for locations of measured sections.

²Abandoned.

³nd - not determined.

⁴No longer operates quarries.

⁵A layer of shale in this unit 0.2 foot thick was incompletely analyzed, and only determinations for S and P₂O₅ are included in these weighted averages.

⁶Eleven feet of high-calcium limestone in the Beaver Bend Limestone lies immediately above this unit. (See table 4.)

Note: Where more than one high-calcium limestone unit is part of a measured section, the high-calcium units may be separated vertically by many feet of rock containing less than 95 percent CaCO₃.

TABLE 4. CHEMICAL ANALYSES (IN PERCENT) OF HIGH-CALCIUM LIMESTONE IN CHESTERIAN ROCKS (MISSISSIPPIAN), INDIANA

County	No. on map	Measured section	Formation	Location ¹			Thickness (feet)	CaCO ₃ + MgCO ₃	CaCO ₃	MgCO ₃	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	S	P ₂ O ₅
				Sec.	T.	R.									
Crawford	4	Mulzer Bros. quarry face	Glen Dean Limestone	NE¼ 10	2S	2W	15	97.7	95.5	2.18	1.18	0.22	0.76	0.20	0.045
Lawrence	12	Natural exposure near Huron	Beech Creek Limestone	SW¼ 5	3N	2W	16	96.5	95.2	1.27	1.50	0.40	1.34	0.05	0.028
			Beaver Bend Limestone				13	97.9	96.9	0.98	1.20	0.20	0.54	0.04	0.030
Orange	4	Natural exposure near French Lick	Beaver Bend Limestone	NE¼ 2	1N	2W	16	96.3	95.1	1.16	2.16	0.41	0.88	0.02	0.020
Putnam	5	Natural exposure near Reelsville	Beaver Bend Limestone	NE¼ 21	13N	5W	11 ²	96.8	96.2	0.63	1.60	0.26	1.04	0.04	0.042

¹See plate 1 for locations of measured sections.

²Eleven feet of high-calcium limestone in the Paoli Limestone lies immediately below this unit.

TABLE 5. CHEMICAL ANALYSES (IN PERCENT) OF HIGH-MAGNESIUM DOLOMITE IN DEVONIAN, SILURIAN, AND ORDOVICIAN ROCKS, INDIANA

County	No. on map	Measured section	Formation	Location ¹			Thickness (feet)	CaCO ₃ + MgCO ₃	CaCO ₃	MgCO ₃	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	S	P ₂ O ₅
				Sec.	T.	R.									
Adams	1	Meshberger Bros. Stone Corp. quarry face	Louisville Limestone	c. 4	26N	15E	37	99.4	56.7	42.7	0.22	0.07	0.09	0.03	0.002
	2	John W. Karch Stone Co. quarry face	Salamonie Dolomite	SW¼ 31	25N	15E	22	99.3	56.8	42.3	0.45	0.15	0.13	0.01	0.005
Allen	1	May Stone and Sand, Inc., quarry face	Wabash Formation	NE¼ 29	30N	12E	14	98.8	54.9	43.9	0.62	0.15	0.22	0.14	0.002
	1	May Stone and Sand, Inc., quarry floor (core, file 142)	Louisville Limestone Salamonie Dolomite	NE¼ 29	30N	12E	78 51	97.1 97.7	54.6 54.7	42.5 43.0	2.31 1.84	0.22 0.17	0.14 0.10	0.05 0.07	0.002 0.003
Bartholomew	1	Meshberger Stone Co., Inc., quarry face	Geneva Dolomite	NE¼ 6	8N	7E	24	96.4	54.4	42.0	2.61	0.12	0.41	0.09	0.004
Blackford	1	J & K Stone, Inc., quarry face	Wabash Formation	NW¼ 3	24N	11E	20	96.2	53.8	42.4	2.20	0.50	0.25	0.03	0.003
Cass	1	France Stone Co. quarry face	Kokomo Limestone	NE¼ 27	27N	2E	18	97.3	54.0	43.3	1.35	0.44	0.38	0.05	0.007
Delaware	1	Muncie Stone and Lime Co. quarry face	Louisville Limestone	NE¼ 20	20N	10E	22	97.1	53.5	43.6	2.00	0.41	0.19	0.02	0.005
	2	Irving Bros. Stone and Gravel Co., Inc., quarry face	Louisville Limestone	NE¼ 25	21N	10E	16	96.8	54.6	42.2	1.88	0.58	0.22	0.02	nd ²
	2	Irving Bros. Stone and Gravel Co., Inc., quarry floor (core, file 269)	Salamonie Dolomite				24	97.9	54.8	43.1	1.28	0.24	0.16	0.02	nd
	1	Erie Stone, Inc., quarry face and floor (core, file 203)	Wabash Formation Louisville Limestone Salamonie Dolomite	SE¼ 11	27N	10E	33 58 63	98.7 98.5 99.0	56.0 55.7 56.2	42.7 42.8 42.8	0.56 0.77 0.51	0.22 0.24 0.12	0.22 0.23 0.19	0.02 0.03 0.01	nd nd nd
Huntington	2	Erie Stone, Inc., quarry face	Wabash Formation	SE¼ 12	28N	9E	70	98.6	55.1	43.5	0.65	0.20	0.17	0.02	0.005
	2	Erie Stone, Inc., quarry floor (core, file 277)	Wabash Formation Louisville Limestone Salamonie Dolomite and 5 ft of Louisville Limestone				30 27 87	97.4 97.4 96.2	54.4 55.0 53.5	43.0 42.4 42.7	1.35 1.72 2.56	0.51 0.26 0.47	0.22 0.14 0.27	0.01 0.02 0.07	nd nd nd
Jay	1	Rockledge Products, Inc., quarry face and floor (includes upper 24 ft of core, file 164)	Salamonie Dolomite	NW¼ 30	23N	14E	69	99.5	55.2	44.3	0.15	0.06	0.10	0.01	nd
Jefferson	1	Concrete Materials Div. quarry face	Geneva Dolomite	SE¼ 16	3N	9E	16	97.2	53.6	43.6	1.46	0.35	0.42	nd	nd
Lake	1	Indiana Geol. Survey drill hole 191 (core, file 458)	Wabash Formation	NW¼ 10	32N	9W	125 59	99.5 99.5	54.6 54.2	44.9 45.3	0.11 0.09	0.03 0.02	0.19 0.20	0.02 0.04	0.002 0.003
Newton	1	Newton County Stone Co. quarry face	Black River Limestone	NE¼ 25	27N	9W	37	96.4	54.1	42.3	2.31	0.42	0.38	0.09	0.005
Pulaski	1	Western Indiana Aggregate Corp. quarry face	Wabash Formation	SW¼ 16	29N	4W	38	98.9	54.1	44.8	0.46	0.17	0.26	0.06	0.004
Randolph	1	Portland Stone Co. quarry face	Salamonie Dolomite	NW¼ 11	21N	12E	18	97.9	54.4	43.5	1.32	0.18	0.15	0.01	0.004
	2	H and R Stone Co. quarry face	Salamonie Dolomite	SE¼ 12	21N	13E	31	98.1	55.7	42.4	1.12	0.26	0.26	0.01	0.007
Wells	1	Erie Stone, Inc., quarry face	Wabash Formation	NW¼ 28	27N	12E	27	96.3	53.8	42.5	2.28	0.68	0.30	0.08	0.003
	1	Erie Stone, Inc., quarry floor (core, file 276)	Louisville Limestone Salamonie Dolomite				25 77	97.7 99.5	55.2 53.9	42.5 45.6	1.28 0.14	0.32 0.03	0.23 0.11	0.09 0.00	nd nd
White	1	Monon Crushed Stone Co., Inc., quarry face	Wabash Formation	NE¼ 28	28N	4W	20	98.4	55.2	43.2	0.69	0.19	0.33	0.10	0.004
							22	98.5	55.6	42.9	0.56	0.16	0.27	0.08	0.002

¹See plate 1 for locations of measured sections.²nd - not determined.Note: Where more than one high-magnesium dolomite unit is part of a measured section, the high-magnesium units may be separated vertically by many feet of rock containing less than 42 percent MgCO₃.