HIGH-CALCIUM LIMESTONE AND DOLOMITE
IN INDIANA

By

DUNCAN J. MCGREGOR

Indiana Department of Conservation
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ERRATA

Page 14, line 22 - unit 1 should read unit 2.
Page 14, line 37 - units 1, 2, and 3 should read units 3, 4, and 5.
Page 21, line 6 - units 1 through 6 should read units 1 through 3.
Page 21, line 25 - unit 9 should read unit 5.
Page 23, line 15 - units 21-24 should read units 21-22.

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HIGH-CALCIUM LIMESTONE AND DOLOMITE IN INDIANA

By Duncan J. McGregor

ABSTRACT

High-calcium limestone and dolomite suitable for industrial use exist in Indiana. Selected measured stratigraphic sections and chemical spectrographic analyses are used to evaluate high-calcium limestone and dolomite. Regions favorable for quarrying high-calcium limestone and dolomite are the region of outcrop of Mississippian rocks and to a lesser extent the region of outcrop of Devonian rocks. Dolomite can also be found in the region of outcrop of Silurian rocks, particularly in northern Indiana.

INTRODUCTION

Indiana's mineral wealth is neither showy nor spectacular; it is plain, unromantic, and unglamorous and is of the everyday sort that appeals little to the speculator and even less to the public. Gold, silver, lead, copper, iron, and tin cannot be profitably extracted from Indiana's rocks. Consequently, the people of Indiana have not witnessed those periods of unreasoning excitement and financiering which characterized the development of mineral resources in the Western States.

But Indiana does have mineral resources that are immensely valuable to its people. These resources can guarantee the establishment of permanent industries that are just as valuable as those that mine precious metals. One of the most familiar and possibly least appreciated mineral industries in Indiana is the quarrying of limestone and dolomite.

Indiana lies in the center of a growing industrialized region. Some of the new industries that are established each year in the Midwest could profitably use local sources of high-calcium limestone and dolomite. The public is aware of the extensive use of limestone and dolomite as constructional material for homes, public buildings, bridges, and monuments. For such uses limestone and dolomite compete with other building materials, and the choice of materials is a matter of preference that is based on cost, appearance, durability, and upkeep. Limestone and dolomite in the form of crushed stone aggregate thus are used extensively in constructing and maintaining roads, and low-magnesium limestone is the basic material in manufacturing portland cement. There are, however, many other important commercial uses of limestone and dolomite for which there are no economical substitutes.

Liming of farm land, which is so necessary in many regions for the successful growing of crops, is an essential use of limestone that is almost unnoticed by city dwellers. But such use of limestone affects the quality of the food they eat and the prices they pay for it. And iron and steel, glass, and chemical industries cannot function for a single day unless they consume large quantities of limestone.

Chemical properties must be considered in evaluating high-calcium limestone and dolomite deposits because chemical properties rather than physical properties determine many present markets for limestone and dolomite. Minor constituents, which are mostly ignored for such uses of limestone as road metal and concrete aggregate, are critical factors in many chemical uses of limestone and dolomite.

Indiana's crushed stone quarries produce large quantities of relatively low-unit-cost limestone and dolomite. To produce high-purity limestone, however, may require the installation of special equipment at many quarries. Many high-calcium limestone and dolomite deposits have small clay seams or thin shale beds that must be removed. Specifications limiting the amount of dust in certain sizes of aggregates used in concrete emphasize the need for different procedures in handling rock products at the quarry. In most quarries washing or scrubbing facilities are adequate for solving the problem of harmful ingredients that are associated with the quarrying of high-calcium limestone and dolomite.

The purpose of this report is to present compiled information on limestone and dolomite in Indiana that may be suited for various industrial uses. The information contained herein is not adequate enough to indicate specific deposits but should serve to stimulate commercial quarrying of high-calcium limestone and dolomite in Indiana.

HIGH-CALCIUM LIMESTONE

DEFINITION OF HIGH-CALCIUM LIMESTONE

In general, the term limestone refers only to those rocks in which the carbonate ($CaCO_3$ and $CaMg(CO_3)_2$) minerals exceed the noncarbonate minerals. In some industries, such as the lime industry, limestone is a general term that refers to rocks which contain at least 80 percent calcium or calcium-magnesium carbonates and which, when calcined, give a product that slakes when water is added. In normal usage limestone refers to those rocks in which the carbonate is chiefly the mineral calcite ($CaCO_3$). In this report high-calcium limestone refers to a rock that analyzes 95 percent or more calcium carbonate.

ORIGIN OF HIGH-CALCIUM LIMESTONE

Most limestone is formed by: (1) the precipitation of $CaCO_3$ from water through plant and animal life processes, or the evaporation of water whereby $CaCO_3$ becomes too concentrated to stay in solution; (2) the accumulation of masses of animal skeletons or shells; and (3) any combination of the above.

Limestone is being formed today in oceans and lakes, and because we know about the various types of sands and muds that are associated with these bodies of water, we can easily see that limestone may contain many impurities.

Many factors govern the kinds of materials found in limestone. Not all these factors affect each kind of limestone, but all are factors that may affect various limestones. These factors involve changes that take place before and after consolidation of calcium carbonate ooze. Before the ooze on the sea bottom becomes hard, many animal scavengers plow through the ooze and consume it. The ooze, while going through many digestive tracts, probably undergoes significant chemical changes. Even plants and bacteria may cause changes in the chemistry of sea bottom sediments. Replacement of the element calcium by magnesium, iron, barium, strontium, or manganese is a common change in these sediments.

Streams carry much sand and mud, which may become impurities in carbonates during deposition. Limestone deposits become thick as calcium carbonate piles up to form layers or beds that are separated by breaks, called bedding planes. These planes, which are formed because of a pause in deposition, represent a time interval during which compaction and solidification take place. During the making of a limestone bed abrupt changes may occur. These changes may result in the establishment of temporary periods of erosion or in the formation of a different type of sedimentary rock, such as shale.

Soft-bodied organisms extract calcium carbonate from sea water and deposit it around or within themselves to form a protective framework. Where the accumulated shell debris or secreted residue of both animals and plants accumulates outside the stretches of sand and mud that commonly border the land, the purer limestone deposits are formed. Relatively pure limestone can be formed near shore if muddy sediments are absent. The water in which the animals and plants live probably is warm, not very deep, and reasonably quiet. It takes many thousands of years for a thick bed of limestone to accumulate from the secretions of animals and plants.

Limestones differ in texture and composition. Some limestone may be hard and fine grained and may break with a splintery or conchoidal fracture. Other limestone maybe coarse grained and massive and may look like a quartz sandstone. The colors of limestone vary greatly, but most are shades of gray or of buff that grades into white. Color intensity commonly is controlled by the intermixing of the impurities. Most limestone contains small amounts of aluminum oxide, silicon dioxide, magnesium oxide, iron oxide, sulfur dioxide, and phosphorus pentoxide. Pure limestone contains 100 percent calcium carbonate, but such limestone is rare.

Most high-calcium limestone in Indiana represents the accumulation of animal shells or the residue secreted by organisms that once flourished in the sea. A drop of dilute hydrochloric or nitric acid (1 part acid to 9 parts water) placed on a limestone causes the rock to effervesce or "fizz" briskly. Placing a drop of acid on limestone and observing the accompanying effervescence constitute a universal test for limestone. Limestone that contains clay, calcium-magnesium carbonate, or other impurities effervesces less strongly and proportionately to the amount of impurities present.

CRITICAL CONSTITUENTS OF HIGH-CALCIUM LIMESTONE

Calcium carbonate is the chief constituent sought in high-calcium limestone. Much limestone can be eliminated visually as a source of high-calcium material because of the impurities contained in or associated with it, but most limestone must be analyzed before an evaluation can be made. In some regions limestone containing 90 to 95 percent calcium carbonate may be worth considering because of economic factors. In this report, however, emphasis is placed on limestone containing at least 95 percent calcium carbonate.

The chief impurities in limestone result either from materials that are deposited at the same time as the limestone or from inclusions that enter the limestone at a later stage and before the limestone becomes hard or lithified. The most common impurities are:

(1) Clay minerals, if present in relatively large amounts, appear as excess silicon dioxide and aluminum oxide in the limestone analysis. The approximate amount of clay in a limestone can be ascertained by multiplying the aluminum oxide content by 3. For example, in table 6 the amount of Al_2O_3 for unit 1 is listed as .70. This figure multiplied by 3 gives 2.10, which is a rough estimate of the amount of clay in unit 1. A microscopic examination either of a thin section of limestone or of the insoluble residue that is obtained by dissolving a piece of limestone in hydrochloric acid is the best method to use in ascertaining the amount and kinds of impurities.

(2) Siliceous material, clay excluded, may occur as quartz grains and chert or as more complex silicate minerals, such as feldspar and mica. Silicon dioxide (SiO_2) in small amounts commonly is ignored, but for some uses of limestone as much as 5 percent may be tolerated. For example, in table 8 the amount of SiO_2 for unit 1 is 8.49. This unit could not be used for chemical-grade stone because of its high silicon dioxide content. Finely divided silicon dioxide fuses upon heating, and if it is present in excessive amounts in limestone, it tends to fuse or "glue" lumps of stone together. Free silicon dioxide in relatively large sizes does not readily form this "glue" and is therefore not harmful except as a useless diluent.

(3) The iron minerals limonite, pyrite, hematite, goethite, and magnetite may be harmful. Iron minerals when heated form a red iron oxide (rust), which may be undesirable. For example, in table 14 the amount of Fe_2O_3 for unit 16 is 2.40. This unit in itself contains too much iron oxide to be of commercial use for some purposes.

(4) Magnesium compounds, especially magnesium carbonate, may be regarded as impurities in some limestone. For example, in table 10 the amount of $MgCO_3$ for unit 4 is 18. 6. This amount is too high for high-calcium limestone because magnesium compounds tend to reduce the speed of slaking in lime and the fusibility of the melt in which lime is used.

(5) Excessive sulfur in limestone tends to produce calcium sulfate when the limestone is heated. Calcium sulfate is an objectionable impurity in lime, for it causes irregular hardening in mortar and makes lime useless for chemical purposes.

(6) Excessive phosphorus in limestone is harmful because poisonous phosphine gas may be formed when the limestone is heated. This gas may ignite spontaneously and cause an explosion.

PRINCIPAL USES OF HIGH-CALCIUM LIMESTONE

Chemical industries use calcium carbonate in the form of finely ground limestone as a neutralizing agent and for manufacturing carbon dioxide gas and various calcium compounds. Some uses of high-calcium limestone and the physical and chemical requirements for each use are given in table 1.

High-calcium limestone is an ideal soil neutralizer. Minimum specifications that must be met are set forth in the "Agricultural Conservation Program (ACP) Handbook for 1959" (p. 12):

> Standard agricultural ground limestone--(a) must contain at least 80 percent calcium carbonate equivalent, (b) must contain all the fine particles obtained in the grinding process and be ground sufficiently fine so that not less than 25 percent will pass through a U. S. Standard No. 60 sieve and 80 percent through a U. S. Standard No. 8 sieve, (c) the moisture content at the time of shipment must not exceed 8 percent, and (d) one or both of the calcium carbonate equivalent and the percent passing through a Standard No. 8 mesh sieve must be greater than the minimum so that the product of the two equals or exceeds 7200.

The calcium carbonate equivalent can be calculated by adding to the percent $CaCO_3$ the product of 1. 19 times the percent $MgCO_3$.

Limestone that is used as a neutralizing agent must be reasonably pure. Industry, however, prefers to use calcium oxide (lime), a product made from limestone, as a neutralizing agent. The chief objections to calcium carbonate (limestone) as a neutralizing agent are that larger amounts of calcium carbonate than of lime are needed and that more froth is produced during neutralization when carbon dioxide gas is evolved. In making carbon dioxide gas a high-calcium limestone of good chemical purity is desirable, as less tonnage and time are required. In manufacturing calcium compounds, such as calcium sulfide, limestone should contain at least 96 percent calcium carbonate and should be relatively free of silicon dioxide, aluminum oxide, and magnesium oxide. For example, unit 1 (table 19) would be an ideal source of raw material for manufacturing the abovementioned products.

Some glass manufacturers prefer high-calcium limestone to lime in the batch mixture because high-calcium limestone is more uniform in composition and is less disagreeable to handle and the gas that is given off causes a stirring action, which is advantageous.

In processing various metals, especially iron, copper, and lead, limestone is combined with silicon dioxide and aluminum oxide in the ore to form slag. Substances which combine with silicon dioxide and aluminum oxide to form slag are known as fluxes. Because of their cheapness the various natural forms of calcium carbonate are ideal fluxes.

Limestone used as a flux should be high in calcium carbonate and as free as possible from magnesium, silicon, sulfur, and phosphorus. (See table 18, units 1, 2, and 3.) Carbonaceous and bituminous matter are harmful and should not be present because they are difficult to burn out and tend to hinder the production of a thin fluid slag. Magnesium oxide tends to produce a viscous slag. Limestones that contain abundant silicon dioxide, silicates, and aluminum oxide are undesirable fluxes. These substances take up some of the calcium oxide, and thus the amount of slag and in turn the amount of limestone needed are increased. Sulfur in iron causes cracks to form when the iron is heated to a high temperature, and phosphorus in iron decreases the plastic deformation of the iron and thus may cause it to rupture.

Table 1.-*Physical and chemical requirements for limestone according to use*
(Modified from Bowen, 1957, p. 305.)

Use	Chemical requirements	Physical requirements
portland cement	Magnesium oxide (MgO) not more than 3 percent; preferably not more than 2 percent. Total alkalies not more than 0. 5 percent. Minimum calcium carbonate ($CaCO_3$) content varies from plant to plant relative to availability of other raw materials.	
lime (high-calcium)	Calcium carbonate ($CaCO_3$) content not less than 97 percent; preferably 98 percent or more.	Some manufacturers prefer lime stone that does not decrepitate during calcining; that is, that will hold its lump form throughout calcination.
steel flux (open-hearth)	Calcium carbonate ($CaCO_3$) content preferably more than 98 percent; lower grades occasionally accepted. Phosphorus (P) must not exceed trace amounts.	Some manufacturers specify that rock hold its lump form until it is consumed in the melt.
general chemical use	Calcium carbonate ($CaCO_3$) content should exceed 98 percent. Preferred rock runs more than 99 percent $CaCO_3$. Limestone as low as 97 percent $CaCO_3$ is sometimes accepted.	Some manufacturers require rock that will not leave a scum when it is dissolved in acid.
beet-sugar manufacturers	Silicon dioxide (SiO_2) not more than 1 percent. Magnesium oxide (MgO) not more than 4 percent. At some plants ferric oxide (Fe_2O_3) must not exceed 0.5 percent.	At most plants limestone must retain its lump form during calcination (burning).
agricultural limestone	In general, the higher the lime (CaO) content, the better the price. Rock containing less than 85 percent calcium carbonate ($CaCO_3$) is seldom accepted.	Other factors being equal, a soft, friable rock is more acceptable because it is cheaper to process.
calcium carbide and calcium cyanimide	Calcium carbonate ($CaCO_3$) content must exceed 97 percent and should exceed 98 percent. Magnesium oxide (MgO) should be less than 0. 5 percent; aluminum (Al_2O_3) and ferric oxides (Fe_2O_3) (together) less than 0.5 percent; silicon dioxide (SiO_2) less than 1. 2 percent; and phosphorus (P) less than 0.004 percent. Sulfur (S) must not be present in greater than trace amounts.	Rock must retain its lump form during calcination.
paint and filler	In general, the calcium carbonate ($CaCO_3$) content should exceed 96 percent, but magnesian limestones containing as much as 8 percent magnesium oxide (MgO) are (rarely) tolerated. The magnesium carbonate ($MgCO_3$) content generally is 1 percent. Other maxima are: ferric oxide (Fe_2O_3) 0.25 percent, silicon dioxide (SiO_2) 2.0 percent, and sulfur trioxide (SO_3) 0.1 percent.	Rock which breaks down into rhombic particles is preferred in some plants. The main controlling characteristic is the degree of whiteness shown by the processed material.

High-calcium limestone that has been ground to a fine powder is called whiting. Whiting is used in the paint and allied industries chiefly as a pigment, as a diluent, as a reducer or extender for other pigments, as a primer, and as an ingredient in putty. It must be white, free of abrasive material, such as quartz, and free of coloring agents, particularly iron oxide.

In manufacturing paper high-calcium limestone (whiting) is used to clean and bleach the raw materials by subjecting them to bisulfite of lime, which is made by the absorption of sulfurous acid gas in moist limestone. For this use impurities in the limestone are of little importance, but at least 95 percent calcium carbonate must be present. When high-calcium limestone (whiting) is used as a filler for paper, it must be almost free of impurities.

High-calcium limestone as whiting is also used as a flux for pottery glaze. It should be at least 96 percent calcium carbonate and very low in iron oxide and magnesium carbonate because magnesium carbonate produces a viscous melt that does not flow uniformly over the ware and iron oxide discolors the glaze.

High-calcium limestone is the most suitable for manufacturing lime (CaO). Lime is the product obtained by heating or burning limestone, a process that is called calcination, or, more commonly, burning lime. Burning limestone to make lime is one of the earliest arts known to civilized mankind.

If a pure limestone (100 percent $CaCO_3$) is heated to a temperature above 800°C, it decomposes to form a white solid, lime (CaO), and a colorless, odorless gas, carbon dioxide (CO_2). A chemist would represent this reaction in the equation $CaCO_3$ + heat = $CaO+CO_2$, in which $CaCO_3$ represents 1 molecule or 100 parts by weight of calcium carbonate, CaO represents 1 molecule or 56 parts by weight of lime, and CO_2 represents 1 molecule or 44 parts by weight of carbon dioxide gas. This means that from each 100 pounds of pure limestone the maximum amount of lime that can be made is 56 pounds, the maximum amount of carbon dioxide produced is 44 pounds, and there are no other products. In practice, however, many factors prevent the production of pure lime. One of these is impurities in limestone. Under normal conditions of burning, the impurities in 100 pounds of limestone are concentrated in approximately 56 pounds of lime; that is, the percentage of impurities by weight in the lime is almost double that in the limestone. Some uses of high-calcium and dolomitic lime and the physical and chemical requirements for each use are given in table 2.

Table 2.-*Physical and chemical requirements for calcium and dolomitic lime according to use*
(Modified from Bowen, 1957, p. 305.)

Use	Chemical requirements	Physical requirements
pulp and paper manufacturers	Calcium oxide (CaO) content must be more than 96 percent for most manufacturers.	
soft rubber goods	Dolomitic lime is generally used. Must be free from carbonates and should contain less than 3 percent total impurities other than carbon dioxide or magnesium oxide (MgO). In vulcanization such lime must also be free of all manganese, copper, and calcium oxides.	Must be thoroughly hydrated, fine grained, and free of grit.
lubricants (greases)	Calcium oxide (CaO) not less than 72.6 percent, magnesium oxide (MgO) not more than 1 percent, maximum silicon dioxide (SiO_2) plus iron oxide (Fe_2O_2) plus aluminum oxide (Al_2O_3) 1.5 percent, and maximum carbon dioxide (CO_2) (at point of manufacture) 1 percent.	Must be completely hydrated and free of grit.
textile dyeing	Calcium oxide (CaO) not less than 94 percent, aluminum oxide (Al_2O_3) plus iron oxide (Fe_2O_3) not more than 2 percent, silicon dioxide (SiO_2) not more than 2 percent, and magnesium oxide (MgO) not more than 3 percent.	
varnish	Must be very low in iron (Fe_2O_3) and magnesium oxide (MgO).	Must be very fine grained and very white.

DOLOMITE

DEFINITION OF DOLOMITE

Dolomite is a carbonate rock that in its pure form consists essentially of a double carbonate corresponding to $CaMg(CO_3)_2$. An ideal dolomite would consist of 54.3 percent calcium carbonate and 45.7 percent magnesium carbonate, and thus unit 11 of table 30 is very near in composition to a theoretical. dolomite. In this report the name dolomite is applied to a carbonate rock in which at least the minimum amount of 41 percent magnesium carbonate is present. This definition of dolomite follows that of Pettijohn (1957, p. 418).

ORIGIN OF DOLOMITE

How dolomite is formed is not definitely known. Most dolomite is thought to be secondary in origin and has been formed through the partial replacement of calcium by magnesium. Pettijohn (1957, p. 424) said:

> Dolomites are so commonly associated with salt and gypsum beds that high salinity and perhaps higher than normal temperatures promote dolomite formation. It may be that the waters of the basins that are partially isolated under conditions of aridity are enriched in magnesium by the continued inflow of normal sea water and by the precipitation of calcium carbonate and sulfate. Enrichment in this manner favors the formation of dolomite. It even may be that dolomite itself is precipitated under these conditions and that some dolomite is indeed a primary rock.

Dolomite closely resembles limestone, but close inspection shows many differences between them. Replacement of calcium in limestone by magnesium results in the recrystallization of the limestone to form dolomite. This replacement process, called dolomitization, generally tends to destroy the original or earlier texture and structure of the rock. For example, fossils once present commonly are destroyed, and ghostlike patterns remain to suggest their former existence. Complete recrystallization produces a rock in which many dolomite crystals are well outlined.

In general, dolomite is more even grained and less fine grained than limestone. The weathered surface of dolomite commonly is mottled and shows the outlines of dolomitic grains and generally shows the extent of dolomitization. Factors governing the kind of materials found in limestone also apply to dolomite.

CRITICAL CONSTITUENTS OF DOLOMITE

Magnesium carbonate is the chief constituent sought in dolomite. As in limestone, the impurities in dolomite result either from the materials deposited at the same time as the dolomite or from inclusions that enter the dolomite at a later stage and before the dolomite becomes hard or lithified. The most common impurities in dolomite are the clay minerals, siliceous materials, iron minerals, and excessive sulfur and iron.

PRINCIPAL USES OF DOLOMITE.

Dolomite has few uses in its raw state. It is used in making steel as a refractory lining (because of its ability to withstand high temperatures) in basic open-hearth furnaces and bessemer converters. It is used principally, however, as a source of agricultural lime and as a source rock for dolomitic lime ($CaO \cdot MgO$), which represents a dead-burned or calcined dolomite. Calcined dolomite is used chiefly for refractory purposes and for manufacturing paper, leather, and glass.

In manufacturing paper high-calcium lime is generally preferred. Dolomitic lime is commonly used, however, for the milk of lime process in manufacturing sulfite pulp. There should be a minimum of 40 percent magnesium oxide in the dolomitic lime.

Dolomitic lime is also used in making morocco leather, but it is objectionable for most processes in manufacturing leather products because of its slow slaking and the possible damage to leather by burning. Glass manufacturers use small amounts of dolomitic lime to make a tougher glass.

Ground dolomite is used in large amounts to neutralize soil acids. Dolomitic limestone has a greater neutralizing power than high-calcium limestone in that 84 parts of magnesium carbonate are equal in this respect to 100 parts of calcium carbonate, but dolomite is used principally in regions that lack sources of calcium limestone.

Some uses and the physical and chemical requirements for each use are listed in table 3 for dolomite and in table 4 for dolomitic limestone.

Table 3.-*Physical and chemical requirements for dolomite according to use*
(Modified from Bowen, 1957, p. 305.)

Use	Chemical requirements	Physical requirements
refractories	Magnesium oxide (MgO) not less than 18 percent. Silicon dioxide (SiO_2), ferric oxide (Fe_2O_3), and aluminum oxide (Al_2O_3) not to exceed 1 percent each, but lower grades sometimes accepted.	
agricultural dolomite	The use is dependent mainly on the calcium and magnesium carbonate content; rocks are seldom accepted if they contain less than 85 percent carbonate minerals.	other factors being equal, a soft, friable rock is more acceptable because it is cheaper to process.

Table 4.-*Physical and chemical requirements for dolomitic limestone according to use*
(Modified from Bowen, 1957, p. 305.)

Use	Chemical requirements	Physical requirements
lime (magnesian)	Magnesium oxide (MgO) content should fall between the limits of 10 and 15 percent, preferably 11 to 12 percent.	Some manufacturers prefer rock that does not decrepitate during calcining.
steel flux (blast furnaces)	Silicon dioxide (SiO_2) less than 5 percent; some plants specify less than 3 percent. Aluminum oxide (Al2O3) less than 2 percent. Magnesium oxide (MgO) from less than 4 percent to less than 15 percent at various plants. Phosphorus pentoxide (P_2O_5) not more than a trace, that is, 0.005 to 0.006 percent.	Some manufacturers specify rock that will not decrepitate when it is heated.
glass	Ferric oxide (Fe_2O_3) not more than 0. 05 percent, preferably not more than 0.02 percent. Calcium carbonate ($CaCO_3$) content should exceed 98 percent in limestone, or calcium magnesium carbonate content should exceed 98 percent dolomite.	
concrete aggregate, ballast, road metal, road base	Concrete aggregate should be low in alkalies and free of surface organic matter. Opaline silica is highly undesirable in concrete aggregate. Suitability of other aggregates is based chiefly on durability, particularly toughness.	Must be clean, strong, and durable and of low porosity.

GEOLOGIC FACTORS THAT AFFECT THE AVAILABILITY OF HIGH-CALCIUM LIMESTONE AND DOLOMITE

As the chemical industries are the principal users of high-calcium limestone and dolomite, the exploration for these commodities requires that careful attention be paid to the quality as well as the quantity of the stone. A thorough knowledge of all aspects of exploring for high-calcium limestone and dolomite is essential because the margin of profit in selling these commodities generally is low and unforeseen cost may be disastrous to the success of the operation. Limestone and dolomite in many regions generally are nonuniform, and the extent of nonuniformity determines ultimate use.

Exploratory drilling may be necessary in regions where there are no natural rock outcrops. Core drilling, based on geologic knowledge of the region, will provide samples for analysis and information useful for verifying predictions about thickness of overburden and usable rock.

Nongeologic factors, such as transportation facilities, fuel, markets, and population centers, commonly affect the establishment of a quarry or mine. Geologic factors therefore are not always the most important considerations. For example, the analyses in table 10 show high-calcium limestone in units 1, 2, and 3. The area from which samples used in table 10 were obtained is favorably situated for rail and truck transportation and is reasonably close to a favorable market. The analyses in table 25 show high- calcium limestone in units 1 through 6. The area from which samples used in table 25 were obtained is favorable for barge transportation on the Ohio River but not favorable for rail or truck haul. A favorable market is the problem here. When supply and demand justify the production of high-calcium limestone in this region, a quarry could possibly be opened.

OVERBURDEN

Unusable material, called overburden, overlies most limestone and dolomite deposits and must be removed and dumped elsewhere if open-pit quarry methods are used. The amount of overburden that must be removed to mine the quarriable rock and still have a profitable operation varies. The decision to open a quarry must be based on local conditions- -accessibility, thickness of available rock, and backward extension of rock--and on safe working conditions. Accessibility and economy may determine the position of the initial opening and subsequent development of the quarry, but, if it is feasible, geologic factors should determine the opening and development. For example, table 23 lists analyses of samples that were taken underground from the only limestone mine in the State. Note the thickness of the soil and rock overburden in unit 9. Because of the 121 feet of overburden it was more economical to develop the mine underground than to strip the overburden.

Glacial drift.-Thickness of glacial drift between the Illinoian and Wisconsin glacial foundaries (fig. 1) is difficult to determine accurately without detailed study. In general, the drift is thinner in southeastern Indiana than in southwestern Indiana and thicker northward from the Ohio River. Limestone quarry operators in southeastern Indiana commonly strip from 5 to 17 feet of glacial drift and soil from the underlying bedrock.

North of the Wisconsin glacial boundary (fig. 1) limestone and dolomite are near the surface only in valleys where stream erosion has reduced the thickness of drift or where a preglacial bedrock hill stood high at the time of glaciation and consequently was covered by only a thin veneer of drift. Table 7 lists analyses of samples from a location in which the overburden is composed of soil and glacial material. Because of erosion, the thickness of overburden averages only 5 feet, and thus opening a quarry at this location was feasible.

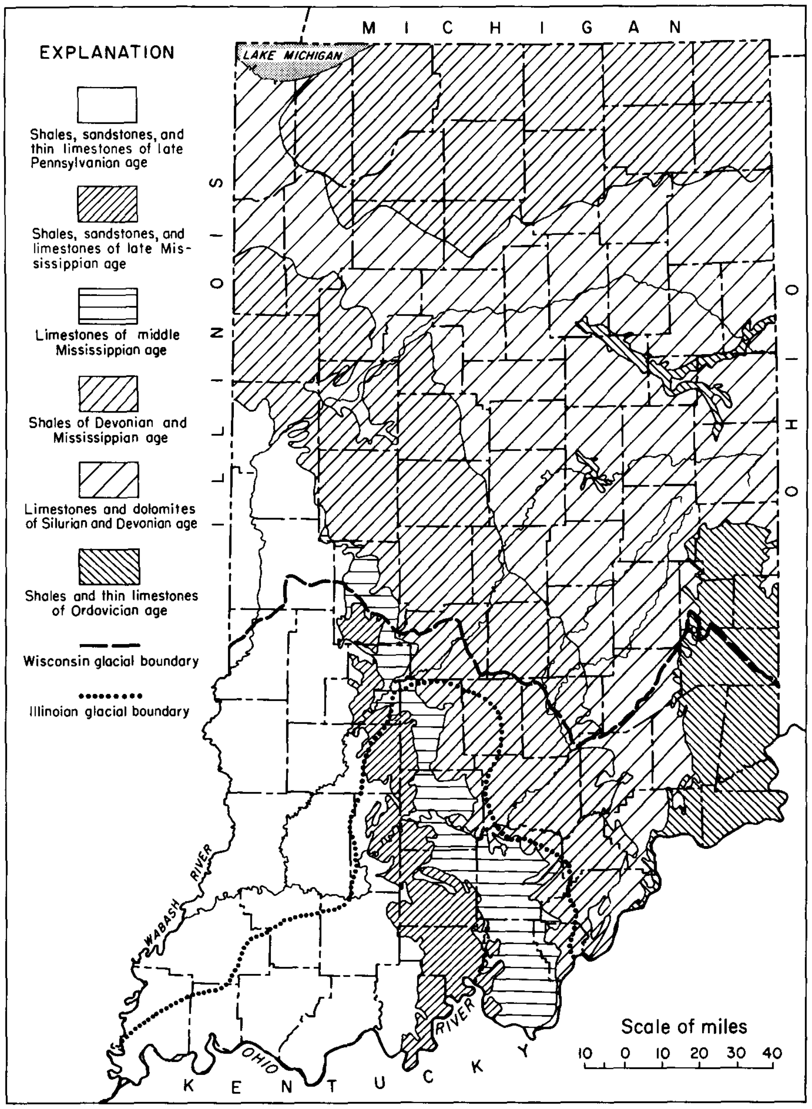

Figure 1.-Map of Indiana showing dominant lithologies of the bedrock.

Drift thickness generally ranges from 50 feet to more than 250 feet. The relationship of drift thickness to the underlying bedrock was stated by Deiss (1952, p. 11) as follows:

> If you will visualize Brown County filled and covered with drift that is 10 to 50 feet thick over the hills and more than 500 feet thick over the deeper valleys, you have a pretty good picture of what lies underneath the surface of more than three-fourths of central and northern Indiana. Herein lie the reason that in much of northern Indiana limestone is known in only a few places from 5 to 20 feet below the surface where the drift is thin, and the explanation for the fact that the limestone is absent elsewhere in the same county or township.

Wayne (1956) gave a detailed discussion of the thickness of glacial drift north of the Wisconsin glacial boundary.

Bedrock.-Sandstone and shale are regarded as overburden that must be removed from places where they lie over limestone and dolomite. For example, units 21-24 in table 16 are shale. This material must be removed and placed elsewhere before the underlying limestone can be quarried. Where excessive bedrock overburden exists, operations generally skirt the hillside, and underground mining may even be considered. Some advantages of underground mining are: (1) stripping cost and soil contamination are avoided; (2) laborers are protected from the weather; (3) cleaner stone can be produced; (4) selective mining of stone is made easier; and (5) production is steady during the entire year. These advantages must be weighed against those of open-pit quarrying, which include: (1) less drilling and blasting expense, (2) lower proportion of fines, (3) no ventilation problems, and (4) use of all stone (20 to 25 percent must be left as pillars in a mine).

TOPOGRAPHY AND DRAINAGE

Topography, drainage, and the shape and extent of the rock layers determine the maximum amount of rock that can be quarried. Topography and drainage are interdependent, and commonly both are controlled by the shape and extent of the rock layers. Drainage conditions limit the level to which rock can be worked unless pumping is used. Topographical conditions that control drainage therefore establish the level of a quarry floor at maximum development.

Topography and drainage are also related to weathering and erosion. Water and other agents cause physical and chemical changes in rock at or near the surface; these changes are called weathering. The texture of the rock and the degree to which water can move through it determine how much weathering affects limestone and dolomite. For example, the Salem Limestone, a porous rock formation, weathers to greater depths than do the dense beds within the St. Louis Limestone. Weathered rock or an accumulation of weathering products that are excessively thick must be discarded as overburden.

Erosion of limestone and dolomite results in a rough irregular top surface. The space between the rock knobs may be filled with clay, soil, or drift, and either the knobs of the rock and soil must be discarded, or the soil must be removed by expensive hand labor. Dissolution of limestone below the surface forms irregular open passageways, which may become filled with sand and mud. Extensive dissolution of subsurface limestone may cause a collapse of the cavern roof to form sinkholes, which later may become filled with mud. Such fillings can be very troublesome to a quarry operator. Parts of the Ste. Genevieve and Salem Limestones are noted for their irregular upper surfaces.

Erosion is the most significant factor in the distribution of limestone and dolomite, but nondeposition of these rocks may also be a factor. Limestones of Mississippian age successively disappear northward from the Ohio River. For example, most upper Mississippian limestones are present along the Ohio River, but erosion has largely removed them north of central Putnam County (fig. 1).

MARKETING HIGH-CALCIUM LIMESTONE AND DOLOMITE

High-calcium limestone and dolomite are expendable mineral resources. As they are used, they are destroyed or converted to a form that cannot be recovered. Converted material, however, may be of use as a byproduct, such as steel mill slag used in making cement and other building materials. Slag is composed of converted limestone or dolomite and various impurities that are removed from the iron ores.

High-calcium limestone and dolomite are mineral resources that are fixed as to location. They must be exploited where they are found or must be left for future use. Each individual deposit has its limits, and if it is worked over a long period of time, it will sooner or later be exhausted. In this respect a mineral industry differs sharply from agriculture and silviculture, which have produced food and forest products in some localities throughout recorded history. Utilizing and quarrying limestone or dolomite merely leave holes in the ground for the use of future generations. A mineral resource has no second crop. Continued extraction of a mineral commodity generally leads to increased costs as the material mined is taken from greater depths. Increased production costs are usually offset by increased retail cost per ton.

The source of supply of a mineral commodity can be expected to change. This change may be due to exhaustion of an individual deposit or to competition from newer and more cheaply operated plants in other areas. In general, as costs rise, the competition from those operators exploiting deposits which are more favorably located or which can be worked more profitably becomes keener.

TRANSPORTATION

Rock must be transported from the quarry or mine face to the crusher, from the crusher to the stockpile, and from the stockpile to the point of use or sale. Internal haulage is usually done by trucks, but a few plants use conveyor belts or rail haulage in conjunction with trucks. Rail, truck, or barge transportation is used for haulage from the processing plant to the point of sale. Transportation of processed material always seems to be a major problem because crushed limestone and dolomite are low-cost commodities that are not profitable if transportation costs are high.

Barge rates vary with distance and type of service. Three types of carriers and operators that perform line-haul freight service on inland waterways are common, contract, and private. Common carriers transport many kinds of freight at rates published in schedules filed with the Interstate Commerce Commission. Contract carriers transport freight, mainly bulk commodities, at rates that are not generally published but that are individual agreements between shipper and carrier. Private carriers are generally operated by the producer or manufacturer.

Transportation by barge is much more economical than transportation by truck or rail. Few plants are so located, however, that transportation by barge can be used. The rise in freight rates makes it necessary to limit the area of distribution from the processing plant. Because of transportation costs the trend in moving limestone and dolomite is toward the use of trucks.

MARKETS

As mentioned above, limestone and dolomite are low-cost commodities that generally must be produced within a limited distance from the processing plant. The cost of marketing limestone and dolomite can be expected to vary widely. For example, the producer of large quantities of limestone and dolomite may have a production cost of 25 cents per ton, but the producer of small quantities may have a production cost that is four times greater.

The producer who uses internal short-haul trucking for transporting his commodity may have a transportation cost that ranges from 7 to 10 cents per ton-mile. Use of conveyor belts may reduce the cost to 2 to 3 cents per ton-mile. This difference in cost is primarily in the cost of handling.

Rail freight rates are difficult to determine because they are computed on differing base levels. At a radius of 225 miles from Bloomington, Ind., the rail freight rate for crushed limestone and dolomite ranges from 4 to 5 dollars per ton.

PRICES

Prices for high-calcium limestone and dolomite are determined by processing costs and supply and demand for the product. The current market prices for various uses of high-calcium limestone and dolomite are reflected in the table below (data from Cotter and Jensen, 1960).

Uses	Average price in dollars per ton f. o. b. at the plant
Flux	$ 1.10
Agriculture	1.72
Alkali manufacture	1.12
Calcium carbide manufacture	1.07
Cement (portland and natural)	1.07
Coal-mine dusting	3.93
Filler (not whiting substitute)	
Asphalt	2.35
Fertilizer	2.44
Other	4.16
Filtration	1.60
Glass manufacture	3.02
Lime and dead burned dolomite	1.56
Limestone sand	1.62
Limestone whiting	10.80
Mineral food	5.23
Paper manufacture	4.19
Poultry grit	6.50
Refractory (dolomite)	2.65
Sugar refining	2.59

REGIONS FAVORABLE FOR PRODUCING HIGH-CALCIUM LIMESTONE AND DOLOMITE

HIGH-CALCIUM LIMESTONE

Region of outcrop of Mississippian rocks.-Natural or manmade exposures of various Mississippian limestones (Harrodsburg, Salem, St. Louis, Ste. Genevieve, and Paoli Limestones) provide the principal sources of rock for high-calcium limestone in Indiana (fig. 1 and table 5). These rocks crop out from central Putnam County southeastward to the Ohio River (fig. 1).

Parts of the Mitchell Plain and Crawford Upland physiographic units are in the region of Mississippian rocks. Illinoian glacial materials cover most of the northern third of these physiographic units, and the Wisconsin glacial boundary forms their northern limit (fig. 2).

Between the Illinoian and Wisconsin glacial boundaries (fig. 1) the drift may be as much as 100 feet thick, but in some places the drift may be only 5 to 15 feet thick. This area, in general, is part of an undulating or gently rolling plain broken by stream dissection. Major streams and their tributaries have in many places eroded through the drift and exposed middle and upper Mississippian rocks. Along the major streams and their tributaries the relief is great and may be as much as 90 feet from the stream in the valley to the top of the bluff. Valley slopes commonly are precipitous.

Post-Mississippian erosion caused rugged surfaces and in some places completely or partly removed the rock suitable for use as high-calcium limestone. In the area of glacially covered bedrock, potential quarry sites must be core-drilled at close intervals if the operator is to be certain that the post- Mississippian erosional surface does not drop below the expected quarry level somewhere on his property.

The Mitchell Plain is in some places very irregular because of sinkholes and rugged areas along stream channels. Sinkholes range from slight sags and watertight depressions to huge basins 50 feet or more deep. In the eastern part of the plain sinkholes are not so numerous and the topography is gently rolling. Some of the larger streams have cut below the general plain level, however, and have formed steep-sided gorgelike rock valleys.

Limestones of Mississippian age (upper part of the Harrodsburg Limestone and the Salem, St. Louis, and Ste. Genevieve Limestones) (fig. 1 and table 5) constitute part of the bedrock of the Mitchell Plain. The upper surface of the rocks maybe exceedingly undulating, and the low spots may be filled with red clay soil. Maximum relief of the Mitchell Plain is 90 feet.

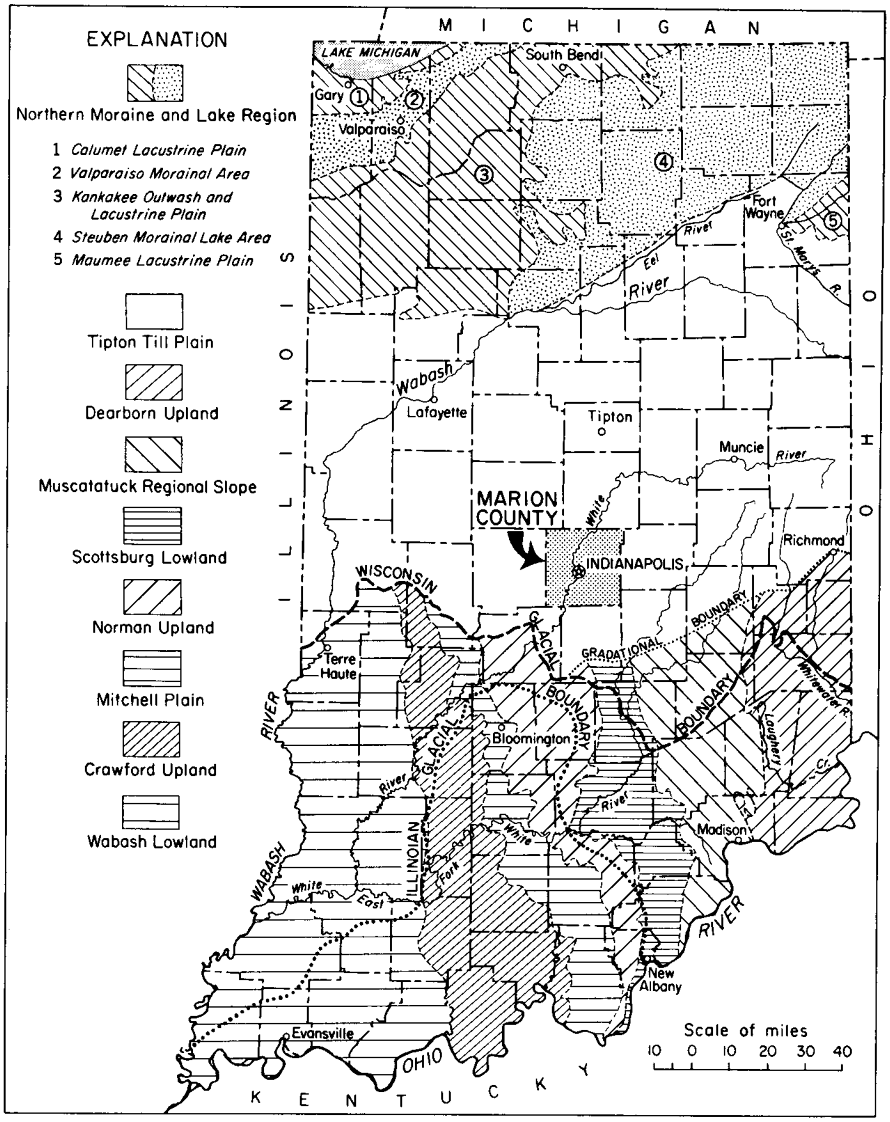

Figure 2.-Map of Indiana showing physiographic units.

Table *5.-Rock units of the Mississippian, Devonian, and Silurian Systems in the area of outcrop in Indiana*

Mississippian rock units	
Mississippian	
Kinkaid Limestone	20-35 ft
Degonia Sandstone	10-35 ft
Clore Limestone	10-35 ft
Palestine Sandstone	5-40 ft
Menard Limestone	25-50 ft
Waltersburg Sandstone	30-60 ft
Vienna Limestone	5-15 ft
Tar Springs Formation	40-90 ft
Glen Dean Limestone	27-60 ft
Hardinsburg Formation	25-45 ft
Golconda Limestone	15-50 ft
Big Clifty Formation	25-40 ft
Beech Creek Limestone	6-30 ft
Elwren Formation	20-50 ft
Reelsville Limestone	0-10 ft
Sample Formation	16-35 ft
Beaver Bend Limestone	1-20 ft
Bethel Formation	5-30 ft
Paoli Limestone	0-38 ft
Ste. Genevieve Limestone	70-120 ft
St. Louis Limestone	90-300 ft
Salem Limestone	20-80 ft
Harrodsburg Limestone	60-80 ft
Edwardsville Formation	40-200 ft
Floyds Knob Formation	0-15 ft
Carwood Formation	115-125 ft
Locust Point Formation	120-140 ft
New Providence Shale	190-290 ft
Rockford Limestone	0-4 ft
New Albany Shale (upper part)	

Devonian and Silurian rock units	
Devonian	
New Albany Shale (lower part)	
North Vernon Limestone	10-15 ft
Jeffersonville Limestone	60-90 ft
Pendleton Sandstone	0-15 ft
Geneva Dolomite	0-35 ft
Kenneth Limestone	30-40 ft
Silurian	
Kokomo Limestone	45-60 ft
Upper Niagaran rocks	160-240 ft
Lower Niagaran rocks	125-150 ft
Brassfield Limestone	0-12 ft

The Crawford Upland, which is a dissected plain with relief of about 200 feet, borders the Mitchell Plain on the west (fig. 2). To the north, ridge tops are broad and rounded, hill slopes are relatively gentle, and valleys are broad, whereas in the south, high steep ridges and narrow winding valleys are the prevailing surface features. A stream that begins in the hills commonly disappears in swallow holes when it reaches a valley.

Sandstones, shales, and limestones of the lower Pennsylvanian and upper Mississippian rocks form the bedrock of the Crawford Upland (table 5). These rocks commonly are found as outliers on the Mitchell Plain and appear as knobs and ridges that rise as much as 150 feet above the comparatively level sinkhole plain underlain by the St. Louis and Ste. Genevieve Limestones.

Overburden in the unglaciated region of Mississippian rocks consists of red clay, soil, shale, and sandstone. Glacial drift north of the Illinoian glacial boundary ranges from a few feet to 50 feet in thickness. Erosion has removed much of the drift from the higher areas, and the material has accumulated in the valley bottoms. The cover of soil and red clay ranges from 3 to 15 feet in thickness. The thickness of the shales and sandstones is variable, and where it is excessive, underground mining may be feasible.

Drainage in the region of Mississippian rocks is both surface and underground. For example, Lost River, a westward-flowing stream, disappears southeast of Orleans, Orange County, flows by an underground channel with a devious course for at least 8 miles (Malott, 1948, p. 237), and again rises to flow as a surface stream.

Chemical and spectrographic analyses of samples of Mississippian rocks (tables 6 through 26[1]) can be used in evaluating the chemical suitability of high-calcium limestone in selected areas in Indiana. (See fig. 3 for a map of Indiana showing regions of high-calcium limestone and dolomite.)

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[1] Chemical and spectrographic analyses shown in tables 6 through 44 were made from chip samples of measured stratigraphic sections. Chip samples were obtained by breaking uniformly sized rock chips from the outcrop in such a way as to include representative material in a continuous sequence from the bottom to the top of a rock unit. Where the lithology of one rock unit grades into that of another unit, a single sample was taken. Most samples, however, represent a single lithology. All results are expressed as weight percentages.

Chemical methods were used to obtain carbon dioxide (CO_2), total sulfur (S), and phosphorus pentoxide (P_2O_5). Spectrographic methods were used for all other determinations.

Many of the chemical and spectrographic analyses are listed in earlier reports of the Indiana Geological Survey but are duplicated here for ready access and completeness under one cover. When a table is duplicated, reference is made to all known publications in which the analyses were published in part, in modified form, or without change. All spectrographic and chemical work was done in the geochemical laboratories of the Indiana Geological Survey under the supervision of R. K. Leininger.

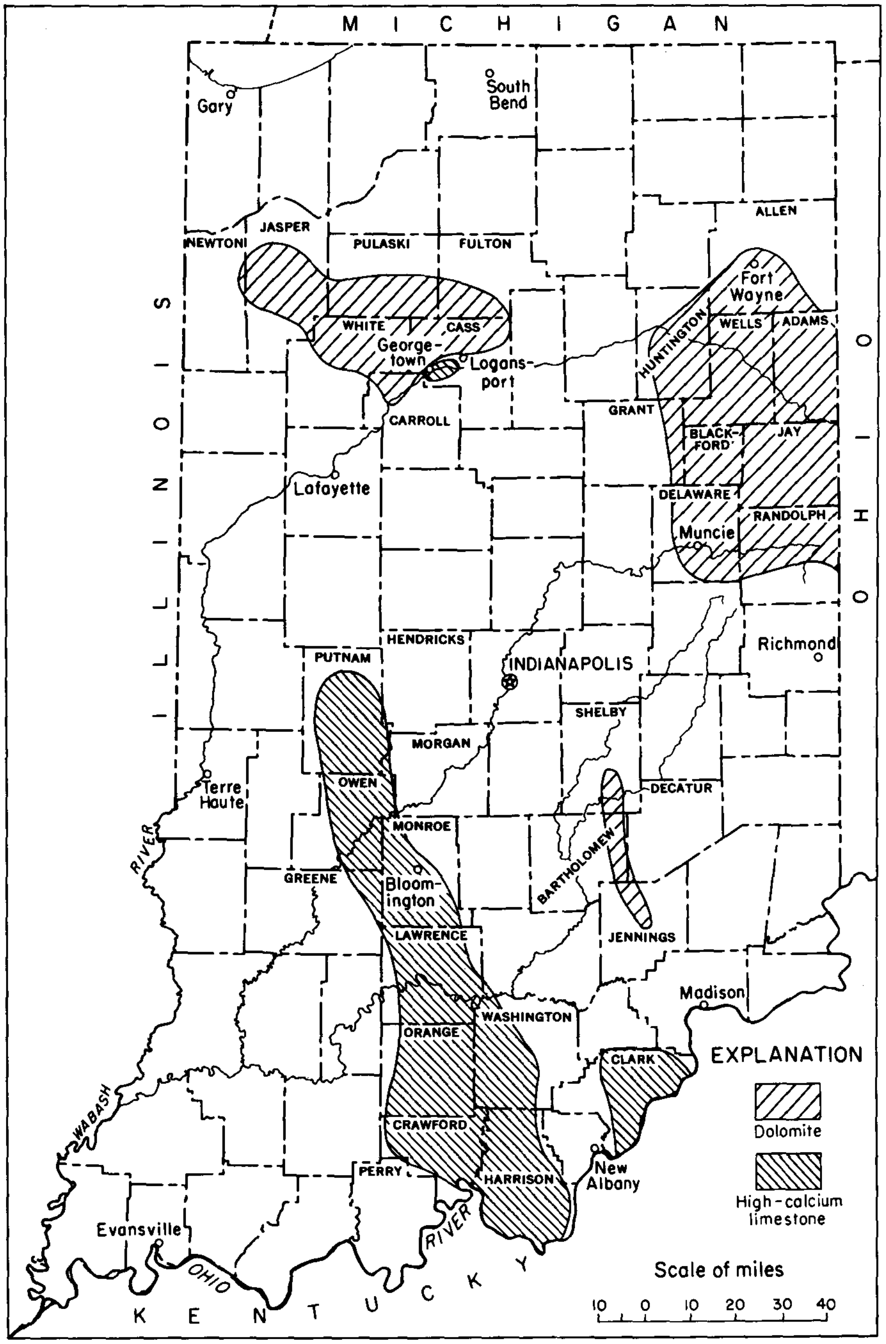

Figure 3.-Map of Indiana showing regions of high-calcium limestone and dolomite.

Table 6.-*Chemical and spectrographic analyses (in percent) of samples from the Russellville Stone Co. quarry, Putnam County, Ind. (NW¼SE¼ sec. 8, T. 16 N., R. 5 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
10	15.0	Soil										
9	11.0	St. Louis	82.9	3.36	9.95	1.73	.88	.10	.033	.20	.018	39.2
8	1.9	St. Louis	62.5	15.3	18.2	1.31	1.50	.11	.044	.21	.035	35.2
7	2.3	St. Louis	87.3	1.79	8.19	1.08	.51	.085	.024	.12	.030	40.5
6	3.2	St. Louis	56.5	26.6	11.8	1.73	2.20	.12	.054	.20	.026	38.5
5	6.6	Salem	97.1	.71	1.50	.12	.31	- - - -	.024	.052	.070	43.7
4	3.4	Salem	87.2	1.11	9.94	.63	.52	.052	.022	.21	.080	39.4
3	0.2	Harrodsburg	36.4	3.38	42.3	12.3	2.92	.67	.023	1.0	.059	16.8
2	3.2	Harrodsburg	84.0	1.28	11.4	1.58	.60	.11	.022	.18	.050	37.3
1	8.0	Harrodsburg	89.	2.55	6.22	.70	.82	.052	.029	.30	.061	41.1

[1] McGregor, 1958, p. 78; Patton, 1949, p. 42.

Table 7.-*Chemical and spectrographic analyses (in percent) of samples from the Ohio and Indiana Stone Co. quarry, Putnam County, Ind. (Junction of secs. 19, 20, 29, and 30, T. 14 N., R. 4 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
5	5.0	Soil										
4	16.2	Ste. Genevieve[2]										
3	8.1	Ste. Genevieve	90.2	.71	7.96	.38	.23	.041	.011	.039	032	41.0
2	11.3	Ste. Genevieve	95.7	.70	2.70	.36	.27	.036	.011	.057	.017	42.5
1	17.9	Ste. Genevieve	93.6	.75	4.67	.26		.028	.0081	.047	.021	42.1

[1] McGregor, 1958, p. 77; Patton, 1949, p. 43.

[2] Not sampled.

Table 8.-*Chemical and spectrographic analyses (in percent) of samples from the Manhattan Crushed Stone Co.*[1] *quarry, Putnam County, Ind. (NW¼SW¼ sec. 24, T. 13 N., R. 5W.)*[2]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
9	6.5	Soil										
8	9.5	Ste. Genevieve[3]										
7	5.0	Ste. Genevieve	96.0	.50	2.62	.24	.38	.034	.028	.004	.023	43.2
6	5.3	Ste. Genevieve	96.3	.40	2.47	.26	34	.033	.022	.086	.010	41.1
5	7.5	Ste. Genevieve	94.9	.77	3.27	.59	.25	.036	017	.060	.007	42 9
4	11.7	Ste. Genevieve	93.5	.59	4.51	.79	.34	.042	.013	.14	.009	42.0
3	14.7	Ste. Genevieve	94.0	.72	4.11	.70	.22	.034	.0097	.093	.017	42.1
2	10.3	Ste. Genevieve	86.6	6.64	5. 8	.59	.38	.029	.014	.090	.018	42.1
1	5.0	Ste. Genevieve	88.9	.78	8.49	.96	.30	.040	- - - -	.080	.060	39.4

[1] Now known as Standard Materials Corp.

[2] McGregor, 1958, p. 76.

[3] Not sampled.

Table 9.-*Chemical and spectrographic analyses (in percent) of samples from the State Farm quarry, Putnam County, Ind. (NW¼SW¼ sec. 17, T. 13 N., R..4 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
10	7.0	Soil and glacial drift										
9	2.0	Sample[2]										
8	1.0	Beaver Bend[2]										
7	6.0	Bethel[2]										
6	20.0	Paoli	92.8	.98	4.47	.87	.32	.048	.030	.081	.011	41.5
5	13.8	Ste. Genevieve	96.5	.67	2.19	.17	.21	.027	.014	.051	.008	43.3
4	16.2	Ste. Genevieve	93.1	.76	4.84	.39	.34	.036	.010	.13	.022	41.7
3	16.1	Ste. Genevieve	94.2	.62	3.98	.41	.27	.038	.0094	.090	.019	42.2
2	17.6	Ste. Genevieve	96.0	.73	2.59	.23	.17	.024	.025	.043	.022	42.8
1	3.2	St. Louis[2]										

[1] McGregor, 1958, p. 75.

[2] Not sampled.

Table 10.-*Chemical and spectrographic analyses (in percent) of samples from the Dunn Limestone Co.*[1] *quarry, Owen County, Ind. (NE¼SW¼ sec. 10, T. 10 N., R. 3 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
10	11.6	Soil and glacial drift										
9	11.9	St. Louis[3]										
8	7.0	St. Louis	67.3	19.3	9.28	2.08	.86	.12	.018	.077	.040	39.4
7	0.4	St. Louis	59.3	13.9	19.4	4.14	1.45	.27	.014	.97	.039	31.6
6	10.8	Salem	89.5	4.38	4.70	.59	.32	.039	----	.041	.013	41.6
5	0.9	Salem	79.1	3.30	13.3	2.70	.86	.24	----	.041	.014	36.2
4	2.7	Salem	74.2	18.6	5.18	.91	.56	.053	----	.029	.015	41.9
3	8.0	Salem	96.7	.88	1.99	.12	.14	----	----	.035	.007	42.6
2	6.0	Salem	97.3	.81	1.51	.097	.11	----	----	.030	.007	43.0
1	4.3	Salem	96.5	1.70	1.22	.12	.27	----	----	.025	.007	43.4

[1] Now known as American Aggregates Corp.

[2] McGregor, 1958, p. 66.

[3] Not sampled.

Table 11.-*Chemical and spectrographic analyses (in percent) of samples from an abandoned quarry of the France Stone Co.,*[1] *Owen County, Ind. (NE¼ sec. 30, T. 10 N., R. 3 W.)*[2]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
8	4.2	Soil and glacial drift										
7	2.0	Ste. Genevieve[2]										
6	14.5	Ste. Genevieve	90.8	.98	7.04	.53	.11	.024	----	.009	.014	39.5
5	14.7	Ste. Genevieve	92.5	1.97	4.17	.72	.12	.034	----	.019	.014	41.6
4	14.1	Ste. Genevieve	95.6	1.12	2.42	.56	.12	.022	----	.024	.014	42.4
3	4.9	Ste. Genevieve	92.0	1.48	3.92	1.27	.38	.048	.018	.31	.030	40.6
2	6.5	Ste. Genevieve	98.2	.81	.64	.080	.080	----	.021	.029	.014	43.4
1	10.4	Ste. Genevieve[3]										

[1] Now known as American Aggregates Corp.

[2] McGregor, 1958, p. 65.

[3] Not sampled.

Table 12.-*Chemical and spectrographic analyses (in percent) of samples from the Stinesville Quarry section, Monroe County, Ind. (SW¼NE¼ sec. 20, T. 10 N., R. 2 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
8	5.0	Soil										
7	3.7	St. Louis	49.7	28.3	15.3	3.68	1.24	.17	.015	.21	.037	36.8
6	4.7	St. Louis	97.1	1.20	1.21	.17	.13	----	.0080	.030	.005	43.4
5	6.9	Salem	95.7	1.26	2.44	.31	.11	----	.0074	.038	.008	43.0
4	1.1	Salem	----	-----	-----	-----	----	----		.012	.042	1.2
3	11.9	Salem	97.8	1.11	.69	.090	.12	----	.0073	.022	.009	43.6
2	16.0	Salem	97.5	1.13	.99	.065	.087	----	.0062	.029	.013	43.3
1	22.8	Salem	97.9	1.04	.70	.052	.11	----	-----	.021	.011	43.4

[1] McGregor, 1958, p. 64.

Table 13.-*Chemical and spectrographic analyses (in percent) of samples from an abandoned quarry of the Bloomington Crushed Stone Co., Monroe County, Ind. (SW¼NW¼ sec. 28, T. 9 No., R. 1 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
7	4.5	Soil										
6	7.0	Harrodsburg	68.5	18.0	10.1	1.53	.76	.089	.014	.26	.078	39.9
5	8.6	Harrodsburg	97.0	.96	1.39	.20	.20	----	.019	.14	.067	42.8
4	10.2	Harrodsburg	94.8	3.32	1.23	.28	.16	----	.024	.095	.082	43.6
3	10.2	Harrodsburg	94.4	2.34	1.89	.44	.40	----	.030	.33	.061	42.1
2	11.0	Harrodsburg	89.1	6.67	2.43	.96	.42	.030	.032	.24	.040	42.4
1	8.5	Harrodsburg	61.3	22.6	10.8	3.12	1.25	.11	.033	.43	.059	38.3

[1] McGregor, 1958, p. 63; Patton. 1949, p. 42.

Table 14.-*Chemical and spectrographic analyses (in percent) of samples from the Bloomington Crushed Stone Co. quarry, Monroe County, Ind. (SE¼SW¼ sec. 27, T. 9 N., R. 2 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
25	4.0	Soil										
24	11.6	Bethel[2]										
23	2.3	Paoli	96.3	.73	2.16	.11	.14	----	.039	.019	.055	43.2
22	5.3	Paoli	95.4	.71	2.67	.27	.43		.031	.010	.016	43.7
21	4.4	Paoli	96.7	.65	1.85	.12	.14	----	.029	.004	.007	42.8
20	1.6	Paoli	86.8	.88	9.98	.92	.39	.046	.026	.004	.011	41.3
19	1.3	Paoli	63.5	2.34	23.6	6.17	2.02	.40	.018	.020	.064	26.0
18	2.8	Paoli	70.6	1.08	23.8	2.36	1.06	.16	.018	.071	.026	31.2
17	10.7	Ste. Genevieve	96.5	.78	1.80	.31	.13	----	.020	.008	.007	42.7
16	1.4	Ste. Genevieve	57.3	30.5	6.13	1.57	2.40	.086	.044	.42	.028	41.4
15	3.4	Ste. Genevieve	94.9	.85	2.81	.59	.28	.045	.021	.024	.028	42.6
14	0.1	Ste. Genevieve	----	----	----	----	----	----	----	.006	.27	4.6
13	1.9	Ste. Genevieve	97.1	.59	1.44	.24	.13	----	.018	.006	.028	44.4
12	5.0	Ste. Genevieve	96.3	.80	1.89	.36	.13	----	.015	.027	.007	43.4
11	1.9	Ste. Genevieve	75.0	.61	23.0	.60	.22	.064	.012	.046	.014	34.0
10	2.7	Ste. Genevieve	95.3	.72	3.03	.32	.11	----	.014	.013	.008	43.1
9	2.7	Ste. Genevieve	53.0	1.61	37.0	4.47	1.91	.53	.011	.58	.030	21.8
8	1.0	Ste. Genevieve	97.1	.83	1.07	.32	.15	----	.016	.014	.012	42.7
7	2.5	Ste. Genevieve	96.3	.72	2.41	.18	.13	----	.012	.014	.006	42.8
6	2.3	Ste. Genevieve	93.5	.78	4.54	.45	.14	.069	.010	.011	.005	41.9
5	2.0	Ste. Genevieve	97.6	.85	.88	.26	.14	.051	.013	.022	.004	43.9
4	4.1	Ste. Genevieve	93.0	.84	4.76	.68	.17	.068	.010	.029	.008	41.7
3	1.9	Ste. Genevieve	98.4	.67	.49	.089	.15	.037	.013	.007	.003	44.2
2	2.8	Ste. Genevieve	97.9	.55	1.15	.048	.13	.032	.013	.001	.006	44.1
1	4.3	Ste. Genevieve	90.9	.75	7.00	.56	.18	.055	.010	.008	.040	40.7

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[1] McGregor, 1958, p. 62.

[2] Not sampled.

Table 15.-*Chemical and spectrographic analyses (in percent) of samples from the P. M. and B. Quarry, Lawrence County, Ind. (NW¼NE¼ sec. 33, T. 6 N., R. 1 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
12	5.0	Soil										
11	31.1	St. Louis[2]										
10	1.4	St. Louis	62.4	16.3	16.7	2.40	1.06	.17	.012	.80	.039	35.1
9	0.8	St. Louis	78.1	1.97	14.5	3.12	1.11	.18	.0086	.12	.022	33.6
8	0.7	St. Louis	17.4	6.91	55.5	13.6	3.90	.71	.017	.092	.059	6.6
7	10.0	St. Louie	92.5	1.65	4.59	.51	.22	.055	.0054	.056	.005	41.8
6	8.2	St. Louis	81.6	11.7	5.00	.65	.46	.062	.0098	.12	.007	41.9
5	11.9	Salem	94.3	3.41	1.41	.14	.24		.0068	.037	.005	43.2
4	13.7	Salem	97.2	1.46	.91	.066	.13	----	.0055	.033	.007	43.3
3	5.7	Salem	97.6	1.21	.70	.044	.18	.040	.0052	.050	.008	43.4
2	18.8	Salem	98.0	1.14	.51	.037	.089	----	.0058	.049	.011	43.4
1	7.8	Salem	97.7	1.11	.76	.046	.17	----	.0066	.028	.014	43.5

[1] McGregor, 1958, p. 73; Perry and others, 1954, p. 65.

[2] Not sampled.

Table 16.-*Chemical and spectrographic analyses (in percent) of samples from the Springville Quarry, Lawrence County, Ind. (SE¼SE¼ sec. 29, T. 6 N., R. 2 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
24	5.4	Soil										
23	8.6	Beaver Bend	94.6	1.07	2.38	.55	1.10		.078	.024	.024	41.8
22	1.6	Beaver Bend[2]										
21	26.1	Bethel[2]										
20	11.8	Paoli	95.8	.96	2.24	.51	.21	----	.038	.033	.019	42.4
19	4.6	Paoli	63.3	8.48	24.0	1.97	1.18	.12	.033	.20	.038	31.2
18	3.2	Ste. Genevieve	94.0	.98	3.11	1.01	.34	.036	.010	.029	.011	42.0
17	11.9	Ste. Genevieve	97.4	.59	1.35	.25	.12	----	.0093	.011	.004	43.0
16	4.5	Ste. Genevieve	88.7	7.07	2.70	.55	.48	.037	-----	.009	.013	43.0
15	6.0	Ste. Genevieve	97.2	.77	1.26	.17	.086	----	----	.004	.014	42.9
14	4.5	Ste. Genevieve	92.2	3.74	2.85	.65	.25	.037	-----	.034	.014	42.1
13	15.0	Ste. Genevieve	94.0	3.42	1.84	.34	.12	.027	-----	.013	.009	43.3
12	8.0	Ste. Genevieve	94.9	.70	3.08	.84	.23	.036	-----	.12	.011	42.0
11	2.7	Ste. Genevieve	68.2	1.52	22.0	2.96	1.16	.14	-----	.31	.041	30.4
10	7.0	Ste. Genevieve	99.2	.38	.28	.090	.031	----	-----	.019	.005	43.6
9	5.7	Ste. Genevieve	67.6	22.0	8.56	.86	.37	.054	-----	.064	.017	41.4
8	1.7	Ste. Genevieve	25.4	.30	73.7	.19	.075	----	-----	.012	.034	12.0
7	12.8	Ste. Genevieve	95.9	.52	3.12	.16	.073	----	-----	.011	.038	42.4
6	23.9	Ste. Genevieve	91.2	4.44	3.16	.66	.23	.037	-----	.073	.020	42.2
5	2.4	St. Louis	92.0	2.66	4.13	.54	.14	.031	-----	.019	.014	41.9
4	3.7	St. Louis	75.0	6.49	17.4	.46	.17	.034	-----	.035	.013	36.8
3	1.9	St. Louis	92.5	1.96	4.43	.43	.14	.036	-----	.040	.010	41.9
2	5.1	St. Louis	83.1	12.5	3.26	.46	.18	----	-----	.079	.023	42.7
1	9.5	St. Louis	83.7	6.33	8.26	.84	.27	.046	-----	.068	.051	40.1

[1] McGregor, 1958, p. 74; Perry and others, 1954, p. 62, 63, and 64.

[2] Not sampled.

Table 17.-*Chemical and spectrographic analyses (in percent) o f samples from the Oolitic Ground Limestone Co. quarry, Lawrence County, Ind. (SE¼SE¼ sec. 16, T. 5 N., R. 1 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
7	7.4	Salem	97.0	1.24	1.14	.13	.25	----	.0069	.040	.013	43.5
6	1.3	Salem	83.7	8.62	5.65	.61	.61	.072	.014	.045	.058	41.2
5	11.6	Salem	97.0	1.15	1.34	.095	.16	----	.0082	.037	.013	43.4
4	8.9	Salem	95.3	1.14	2.65	.15	.23	.025	.014	.026	.030	43.1
3	6.3	Harrodsburg	91.7	2.27	3.37	1.03	.59	.055	.0091	.35	.11	41.3
2	4.5	Harrodsburg	97.5	1.19	.76	.13	.22	----	.014	.058	.044	43.3
1	2.3	Harrodsburg	95.6	1.43	1.42	.29	.69	.032	.030	.39	.085	43.0

[1] McGregor, 1958, p. 72.

Table 18.-*Chemical and spectrographic analyses (in percent) of samples from the Lehigh Cement Co. quarry, Lawrence County, Ind. (S½ sec. 30, T. 4 N., R. 1 E.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
18	10.0	Soil										
17	10.0	St. Louis[2]										
16	12.0	Salem										
15	7.2	Salem	81.6	15.0	2.42	.33	.20	.029	----	.061	.006	43.3
14	5.5	Salem	86.0	11.2	1.91	.22	.16	.027	----	.24	.007	43.2
13	6.0	Salem	96.4	.84	2.33	.097	.11	----	----	.21	.009	42.3
12	4.2	Salem	89.2	.88	9.19	.081	.13	----	----	.11	.008	39.2
11	16.0	Salem	78.4	18.0	2.39	.39	.27	.034	----	.074	.013	43.3
10	4.7	Salem	96.8	.92	1.63	.086	.32	----	----	.19	.009	43.0
9	2.8	Salem	85.3	10.8	2.29	.62	.38	.032	----	.11	.041	42.5
8	4.3	Salem	88.6	8.66	1.65	.27	.32	.026	----	.13	.016	43.3
7	2.8	Harrodsburg	93.3	3.06	2.05	.49	.57	.029	----	.46	.022	42.4
6	5.2	Harrodsburg	89.7	4.94	3.32	.98	.46	.039	.023	.23	.058	41.9
5	4.4	Harrodsburg	96.8	1.01	1.08	.31	.26	.024	.028	.24	.035	42.6
4	11.9	Harrodsburg	96.9	1.76	.70	.18	.27	----	.018	.13	.041	43.5
3	12.0	Harrodsburg	97.3	1.39	.73	.13	.20	----	.016	.18	.033	43.0
2	12.1	Harrodsburg	93.8	1.85	2.11	.38	.32	.028	.020	1.10	.066	40.6
1	5.5	Harrodsburg	94.2	1.37	2.52	.74	.55	.036	.038	.28	.044	42.2

[1] McGregor, 1958, p. 71; Perry and others, 1954, p. 58-59.

[2] Not sampled.

Table 19.-*Chemical and spectrographic analyses (in percent) of samples from the Radcliff and Berry quarry, Orange County, Ind. (SW¼SE¼ sec. 24, T. 3 N., R. 1 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
22	6.0	Soil										
21	14.9	Paoli	94.6	.80	3.38	.90	.15	038	.018	019	.011	42.2
20	3.0	Paoli	48.0	32.2	14.9	2.25	1.76	.089	.034	.50	.026	38.6
19	8.8	Ste. Genevieve	95.4	.91	2.55	.76	.14	.029	----	.050	.006	42.6
18	8.0	Ste. Genevieve	97.4	.66	1.44	.24	.067	-- -	----	.007	.004	43.6
17	8.2	Ste. Genevieve	93.8	3.89	1.64	.24	.091	----	----	.004	.012	43.2
16	8.6	Ste. Genevieve	90.0	6.85	2.08	.36	.12	----	----	.017	.005	43.2
15	9.4	Ste. Genevieve	89.1	7.92	2.21	.26	.10	----	----	.020	.006	43.4
14	11.6	Ste. Genevieve	94.8	.69	3.59	.56	.098	.032	----	.022	.007	42.4
13	7.6	Ste. Genevieve										
12	7.6	Ste. Genevieve										
11	2.6	Ste. Genevieve	98.8	.68	.14	.11	.079	----	----	.016	----	44.0
10	2.4	Ste. Genevieve	98.8	.61	.23	.089	.079	----	.005	.010	----	44.3
9	5.0	Ste. Genevieve	98.9	.68	.11	.050	.042	----	.0061	.018	----	44.2
8	2.7	Ste. Genevieve	98.7	.60	.26	.15	.068	----	-----	.013	----	43.5
7	2.3	Ste. Genevieve (Lost River Chert)	55.0	.26	45.	.11	.14	----	-----	.021	----	17.9
6	6.5	Ste. Genevieve	98.9	.51	.25	.099	.049	----	.0055	.025	----	43.7
5	5.4	Ste. Genevieve	98.2	.79	.52	.17	.072	----	.0061	.039	----	43.4
4	6.0	Ste. Genevieve	95.5	1.24	2.58	.35	.13	----	-----	.10	----	43.1
3	3.0	Ste. Genevieve	57.2	38.2	2.82	.78	.42	----	.020	.53	----	45.1
2	6.7	Ste. Genevieve	97.7	.12	1.69	.23	.078	----	-----	.036	----	43.1
1	1.0	Ste. Genevieve										

[1] McGregor, 1958, p. 62.

[2] Not sampled.

Table 20.-*Chemical and spectrographic analyses (in percent) of samples from the Cave Stone Co. quarry, Orange County, Ind. (NW¼SE¼ sec. 29, T. 2 N., R. 1 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
8	15.0	Ste. Genevieve[2]										
7	7.6	Ste. Genevieve	86.8	8.03	3.51	.69	.43	.046	.014	.017	.015	42.4
6	4.6	Ste. Genevieve	96.8	1.01	1.61	.30	.097	----	.0060	.007	.011	43.4
5	5.8	Ste. Genevieve	93.5	2.62	2.66	.48	.20	.036	.0074	.008	.009	43.0
4	7.7	Ste. Genevieve	89.6	7.45	1.95	.30	.20	----	.0063	.020	.005	43.6
3	4.8	Ste. Genevieve	72.4	5.56	19.4	1.12	.38	.10	.0087	.028	.025	33.8
2	0.5	Ste. Genevieve	56.5	2.39	34.2	4.47	1.07	.33	.010	.42	.054	24.1
1	5.3	Ste. Genevieve	97.4	1.04	.95	.33	.061	----	.078	.012	.004	43.8

[1] McGregor, 1958, p. 69.

[2] Not sampled.

Table 21.-*Chemical and spectrographic analyses (in percent) of samples from the Calcar Quarries, Orange County, Ind. (SE¼SE¼ sec. 6, T. 1 N., R. 1 E.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
13	5.0	Soil										
12	1.5	Beaver Bend[2]										
11	13.4	Bethel[2]										
10	30.2	Paoli[2]										
9	4.3	Paoli	42.6	18.4	34.8	2.13	.98	.14	.023	.12	.026	28.4
8	8.4	Ste. Genevieve	94 6	.69	3.68	.61	.12	.032	----	.020	.011	41.9
7	11.9	Ste. Genevieve	98.8	.48	.40	.10	.035	----	----	.016	.004	43.7
6	5.2	Ste. Genevieve	86.4	11.2	1.22	.31	.35	.024	----	.010	.012	44.0
5	9.5	Ste. Genevieve	84.4	12.5	1.76	.49	.27	.028	----	.028	.022	43.5
4	9.6	Ste. Genevieve	79.8	17.7	1.52	.28	.15	.023	----	.037	.008	44.0
3	6.9	Ste. Genevieve	98.0	.65	.83	.26	.046	----	----	.030	.004	43.5
2	6.3	Ste. Genevieve	86.1	5.44	6.84	.82	.22	.034	----	.082	.022	40.5
1	9.3	Ste. Genevieve	98.3	.86	.44	.16	.043	----	----	.017	.007	43.9

[1] McGregor. 1958, p. 68.

[2] Not sampled.

Table 22.-*Chemical and spectrographic analyses (in percent) of samples from a section near Greenville, Floyd County, Ind. (NE¼SW¼ sec. 31, T. 1 S., R. 5 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
3	10.2	Salem	96.8	.77	1.66	.25	.32	----	----	.054	.017	42.9
2	1.7	Harrodsburg	83.4	6.03	7.32	1.48	.65	.072	.020	1.20	.045	38.7
1	13.9	Harrodsburg	94.6	1.72	2.50	.54	36	----	.030	.13	.042	42.3

Table 23.-*Chemical and spectrographic analyses (in percent) of samples from the Hy-Rock Products Co. underground quarry at Marengo, Crawford County, Ind. (SE¼SW¼ sec. 6, T. 2 S., R. 2 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
4	12.3	Ste. Genevieve	97.8	1.15	.64	.14	.054	----	----	.051	.007	44.2
3	10.3	Ste. Genevieve	80.7	12.7	5.28	.64	.16	.032	.019	.093	.015	42.2
2	8.8	Ste. Genevieve	85.4	7.81	5.51	1.02	.20	.053	----	.14	.015	41.3
1	5.0	Ste. Genevieve[1]										

[1] Not sampled.

Table 24.-*Chemical and spectrographic analyses (in percent) of samples from the Mulzer Bros. quarry north of Eckerty, Crawford County, Ind. (SW¼NE¼ sec. 3, T. 2 S., R. 2 W.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
6	1.9	Glen Dean										
5	6.9	Glen Dean										
4	5.9	Glen Dean	96.2	1.30	1.29	.27	.75		.056	.21	.074	43.0
3	9.5	Glen Dean	95.0	2.72	1.11	.19	.77	----	.053	.18	.017	43.5
2	7.9	Glen Dean	88.2	7.64	2.08	.50	1.01	.033	.055	.13	.014	42.9
1	10.7	Glen Dean	59.8	11.7	24.0	1.72	1.70	.12	.060	.16	.023	32.3

[1] Not sampled.

Table 25.-*Chemical and spectrographic analyses (in percent) of samples from an abandoned quarry near New Amsterdam, Harrison County, Ind. (NE¼NE¼ sec. 12, T. 5 S., R. 2 E.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
5	1.0	Soil										
4	9.3	Paoli[2]										
3	15.6	Paoli	95.0	2.34	1.92	.37	.15	----	----	.021	.005	43.4
2	3.3	Ste. Genevieve	96.2	.70	2.58	.24	.072	----	----	.020	.010	43.2
1	13.8	Ste. Genevieve	98.4	.50	.63	.13	.057	----	----	.017	.004	43.0

[1] McGregor, 1958, p. 83.

[2] Not sampled.

Table 26.-*Chemical and spectrographic analyses (in percent) of samples from a section measured near New Boston, Harrison County, Ind. (NW¼SE¼ sec. 1, T. 6 S., R. 4 E.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
22	4.0	Soil										
21	9.3	Salem	75.5	11.5	9.81	1.64	.88	.090		.10	.018	38.3
20	13.7	Salem	92.0	1.56	4.42	.53	.94	---		.38	.035	41.1
19	14.3	Salem	75.5	16.3	5.72	1.02	.88	.058		.24	.030	41.2
18	11.4	Salem	79.6	13.2	4.72	.90	.97	.052	----	.059	.045	42.0
17	20.0	Salem	68.	23.4	5.58	1.22	1.14	.058	.027	.049	.038	42.2
16	6.6	Salem	87.8	4.99	4.88	.89	.85	.047	.023	.17	.064	41.0
15	4.2	Harrodsburg	42.9	19.7	25.9	7.30	1.60	.59	.017	.40	.056	24.7
14	1.2	Harrodsburg	69.7	10.0	16.2	1.98	.99	.10	.017	.12	.033	35.4
13	8.6	Harrodsburg[2]										
12	4.5	Harrodsburg	87.1	2.11	9.4	.31	.49	.031	.014	.085	.028	41.0
11	4.7	Harrodsburg[2]										
10	3.2	Harrodsburg[2]										
9	28.8	Harrodsburg	87.2	1.82	9.23	.62	.59	----	----	.086	.039	39.3
8	0.3	Harrodsburg[2]										
7	4.2	Harrodsburg	87.5	4.02	6.94	.48	.47	.036	.022	.048	.049	41.3
6	3.3	Harrodsburg	45.8	6.05	44.5	1.75	.79	.010	.018	.034	.050	20.9
5	1.0	Harrodsburg	80.9	3.81	13.8	.40	.53	.033	.023	.088	.030	37.4
4	1.9	Harrodsburg	43.2	2.92	37.4	11.5	2.03	.86	.017	.021	.11	17.6
3	11.0	Harrodsburg	89.3	1.48	7.90	.46	.32	.039	.025	.015	.033	40.9
2	8.2	Harrodsburg[2]										
1	11.2	Harrodsburg	85.3	1.15	12.1	.56	.28	.042	.028	.018	.058	39.3

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[1] McGregor, 1958, p. 84.

[2] Not sampled.

Region of outcrop of Devonian and Silurian rocks.-Rocks of middle Devonian age lie beneath a relatively thin cover of glacial drift in central Clark County (fig. 3). The region lies within the Scottsburg Lowland (fig. 2), which is one of the flattest regions in the State. Major streams and their tributaries have eroded the soil and Illinoian drift and have exposed Devonian carbonate rocks and shales. These major streams have abrupt valley walls that rise 100 feet above the flood plain. Overburden in this region of Devonian limestones consists of glacial drift, soil, and Devonian shales. The thickness of overburden is variable and ranges from a few feet to as much as 50 feet.

Chemical and spectrographic analyses of samples of Silurian and Devonian rocks (tables 27 and 28) can be used to determine the chemical suitability of high-calcium limestone in selected areas in Indiana. The Jeffersonville Limestone (table 5) is principally a high-calcium limestone in deposits near the Ohio River, but to the north it becomes more dolomitic, particularly in its lower and middle parts.

In the area between Logansport and Georgetown, Cass County (fig. 3), part of the Kenneth Limestone contains more than 95 percent calcium carbonate (table 29). This limestone lies at the extreme north edge of the Tipton Till Plain physiographic unit (fig. 2), in which glacial drift and soil constitute the surficial materials. Overburden in the area is thin only in the valleys of major streams and at a few places in the upland areas. In some places preglacial erosion and glacial erosion removed much of the bedrock that might have been suitable for high-calcium limestone. There is little indication, however, that any high bedrock surfaces are present beneath the drift cover, which ranges from a few feet to more than 100 feet in thickness.

Table 27.-*Chemical and spectrographic analyses (in percent) of samples from the quarry of the Sellersburg Stone Co., Clark County, Ind. (SE½W¼ Grant 90, Clark Military Survey)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
15	12.0	Soil and glacial drift										
14	5.0	New Albany[2]										
13	3.8	North Vernon	90.9	4.15	3.82	.20	.38	----	.084	.073	.15	42.0
12	0.2	North Vernon	[3]55.7	17.4	14.4	2.73	4.65	.13	.078	1.4	9.2	25.9
11	5.5	North Vernon	53.7	29.0	11.5	2.33	2.26	.13	.075	.29	.042	38.8
10	1.0	North Vernon	66.9	15.4	11.4	2.92	1.23	.16	.056	.33	.042	37.5
9	3.0	North Vernon	60.5	19.0	13.5	3.19	1.59	.23	.067	.51	.047	36.7
8	6.1	North Vernon	61.6	17.4	14.1	3.26	1.39	.21	.060	.51	.064	35.8
7	1.8	North Vernon	82.9	5.08	7.21	1.60	.61	.065	.041	.33	1.8	38.0
6	5.6	Jeffersonville	88.4	5.81	2.97	.19	.53	---	.045	.36	.48	41.5
5	5.6	Jeffersonville	92.2	3.58	3.41	.092	.18	----	.033	.034	.11	42.0
4	10.3	Jeffersonville	92.1	3.81	2.38	.68	.45	.034	.022	.31	.009	42.1
3	10.0	Jeffersonville	95.4	.98	3.24	.083	.14	----	----	.078	.004	42.1
2	11.3	Louisville	65.4	15.0	14.5	3.22	.81	.12	.024	.42	.010	36.5
1	11.1	Louisville	66.6	13.9	14.5	3.22	.70	.12	.025	.25	.008	36.5

[1] McGregor, 1958, p. 80; Leininger, 1955, p. 58.

[2] Not sampled.

[3] Includes $Ca_3(PO_4)2$ expressed as $CaCO_3$.

Table 28.-*Chemical and spectrographic analyses (in percent) of samples from the Louisville Cement Co. quarry, Clark County, Ind. (Grant 132 and SW Grant 131, Clark Military Survey)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
12	7.0	Soil										
11	5.0	New Albany[2]										
10	3.1	North Vernon	91.5	3.39	4.12	.13	.26		.060	.082	.15	41.9
9	1.5	North Vernon	52 0	29.4	13.7	2.19	1.53	.15	.10	.73	1.22	36.7
8	7.8	North Vernon	53.2	25.5	15.8	3.24	1.22	.13	.044	.50	.038	36.9
7	6.1	North Vernon	60.6	19.2	14.1	3.99	.92	.16	.043	.60	.069	35.9
6	4.4	North Vernon	83.0	5.45	7.96	1.82	.66	.080	.042	.38	.48	38.6
5	12.3	Jeffersonville	91.7	4.27	2.44	.21	.32	.022	.043	.19	.41	42.0
4	8.6	Jeffersonville	91.9	3.81	2.66	.64	.46	.03	.022	.34	.008	42.6
3	11.0	Jeffersonville	94.7	1.75	2.25	.43	.30	.027	.017	.20	.006	42.5
2	3.7	Jeffersonville	92.7	1.98	4.47	.11	.18	----	.013	.075	.003	41.8
1	3.5	Jeffersonville	75.6	4.54	16.9	1.36	.45	.091	.011	.20	.004	35.2

[1] McGregor, 1958, p. 81; Leininger, 1955, p. 59.

[2] Not sampled.

Cumings and Shrock (1928, p. 109-110) discussed a region between Logansport and Georgetown where the Huntington Dolomite [upper Niagaran rocks] (fig. 3 and table 5) is actually a high-calcium limestone. They said:

> The south bluff of the Wabash River between Logansport and Georgetown furnishes one of the most surprising, and we may say perplexing, geologic sections in northern Indiana, if not, indeed, in the entire State. Here the Huntington formation [upper Niagaran rocks], in this case a nearly pure limestone, occurs in the form of great ridges, disconformably overlapped by younger strata of both Silurian and Devonian age. Four miles west of Logansport, on the south side of the river, a ridge-like mass of pink Huntington limestone extends back some distance from the valley bluff. The rock is an almost solid mass of perfectly preserved brachiopods of the genera Conclidium, Wileonia and Spirifer. Outcrops of the stone occur more than 90 feet above the river, and not over 300 feet from the bank of the stream. At water level in the river are outcrops of Kokomo limestone. Here then is a marked disconformity, in which the Kokomo has overlapped, or rather abutted against, the massive ridge-like masses of Huntington limestone. On the east the Kokomo and Kenneth limestones come in at the same level as the Huntington, but the exact contact between these three formations is hidden by talus and drift.
>
> One mile farther west, on the same side of the river, a second exposure of the pure limestone occurs, but is surrounded on all sides by younger strata. Here again the Kokomo limestone is exposed at the foot of the river bluff, the upper portion of which is composed of Huntington limestone capped with Kenneth limestone. Just across the road to the west, another mass of Huntington limestone begins and extends with some interruptions to Cedar Rapids, one mile east of Georgetown, where the Wabash River has cut a gorge through the northern extension of the limestone ridge which here has the structure of a reef. On both sides of the river the pure pink stone, loaded with a rich molluscan and coral fauna, is exposed in the bluffs from 10 to 20 feet high. The north bluff is capped with Devonian limestone. This great mass, through which the Wabash has cut its way, is a reef, as indicated by the sloping or inclined strata and by the great abundance of corals, Stromatoporoids and other reef-building organisms, many of them exquisitely preserved.
>
> It is significant that the representative of the Huntington formation in this region is a pure crystalline limestone.

The area discussed by Cumings and Shrock is the northernmost possible source of high-calcium limestone known at the surface in Indiana.[2]

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[2] During preparation of this manuscript, the Louisville Cement Co. began construction of a cement plant just west of Logansport. The plant will have a reported capacity of 1 million barrels.

Table 29.-*Chemical and spectrographic analyses (in percent) of samples from the Cass County Stone Co. quarry, Cass County, Ind. (NW¼SE¼ sec. 28, T. 27 N., R. 1 E.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
10	3.0	Soil										
9	8.9	Kenneth	86.9	.47	12.2	.16	.12	.017	.0087	.023	.004	39.3
8	6.0	Kenneth	95.2	.65	3.63	.18	.13	.020	.0064	.023	.002	42.7
7	5.3	Kenneth	92.5	.76	6.10	.30	.15	.026	.0059	.056	.002	40.5
6	5.3	Kenneth	87.5	3.45	8.16	.20	.14	.020	.014	.058	.002	40.6
5	6.5	Kenneth[2]										
4	4.5	Kokomo	53.7	41.4	1.82	.52	1.41	.030	.072	.006	.013	45.1
3	18.7	Kokomo	55.9	41.8	.95	.23	.57		.075	.008	.007	46.5
2	15.9	Kokomo	55.7	40.3	2.17	.66	.58		.041	.027	.010	45.4
1	9.3	Kokomo	55.7	41.6	1.34	.36	.44		.032	.012	.008	46.2

[1] McGregor, 1958, p. 85.

[2] Not sampled.

DOLOMITE

Silurian rocks of northern Indiana (figs. 1 and 3) that are usable as commercial dolomite lie in the western part of the Tipton Till Plain and in the southern part of the Kankakee Outwash and Lacustrine Plain physiographic units (fig. 2). The Tipton Till Plain is characterized by glacial material that has a flat to very gently rolling surface. It thus has little relief and has not been modified greatly by stream dissection. Divides are flat and may be swampy; streams may be sluggish and muddy. Valleys begin as small grooves; flowing streams then widen these valleys more rapidly than they cut downward. Few streams in this region have cut into bedrock. Wayne (1956, p. 15) said: "Throughout the till plain, variations in drift thickness are related almost entirely to the relief on the bedrock surface...."

Bedrock beneath the Tipton Till Plain is relatively level and is crossed by several incised steep-walled gorges, which may be as deep as 300 feet and are filled with glacial debris. Prior to glaciation the bedrock surface in many places was a sinkhole plain. Drillers of water wells have found some caves that were filled with red silt and clay and others that yielded large amounts of ground water. An interesting feature of the bedrock is the numerous reefs that commonly form knolls and buttress the walls of some gorges.

Relatively flat-lying sandy outwash deposits characterize the Kankakee Outwash and Lacustrine Plain. Dunes are common. Several scattered ridges 5 to 50 feet high and 50 feet to an eighth of a mile wide rise above the relative flat plain. The underlying bedrock is relatively flat. It is slightly dissected, but during the Ice Age a few drainageways were cut into it.

Overburden in the Tipton Till Plain and Kankakee Outwash and Lacustrine Plain physiographic units consists chiefly of soil and glacial drift and, as stated above, is thin only in the valleys of major streams and at a few places in the upland plains area. There is little indication that shallow bedrock surfaces are present beneath the cover of glacial drift.

In southern Indiana the Geneva Dolomite, middle Devonian in age, constitutes a potential source of dolomite (table 5). The Geneva lies on the west edge of the Muscatatuck Regional Slope physiographic unit (fig. 2), an area covered by thin Illinoian drift. Streams have steep-walled valleys, but the interstream areas are almost flat. Overburden consists of soil, glacial drift, and the overlying bedrock above the Geneva (tables 42, 43, and 44).

Chemical and spectrographic analyses of Silurian and Devonian rocks (tables 30 through 44) can be used as a guide to evaluate the chemical suitability of dolomite in selected areas in Indiana.

Table 30.-*Chemical and spectrographic analyses (in percent) of samples from the May Stone and Sand Corp. quarry near Fort Wayne, Allen County, Ind. (NW¼NE¼ sec. 29, T. 30 N., R. 12 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
24	90.0	Soil and glacial drift										
23	10.3	Undifferentiated Devonian and Silurian rocks	87.4	5.11	6.38	.36	.14	.040	.030	.081	.030	41.2
22	4.5		55.0	39.1	4.25	.80	.31	.032	.027	.17	.025	43.7
21	3.5		55.0	42.4	1.66	.31	.16	----	.037	.091	.013	46.4
20	3.3		54.7	37.2	6.07	.97	.48	.048	.025	.30	.023	43.7
19	4.1		56.7	39.4	3.20	.068	.11	---	.035	.057	.006	46.1
18	2.5		54.4	37.2	6.64	.82	.32	.041	.022	.20	.016	43.3
17	2.0		56.2	40.0	2.75	.38	.21	----	.031	.083	.013	45.7
16	2.0		54.1	43.8	1.36	.11	.11	----	.051	.13	.010	46.6
15	3.4		47.9	39.3	10.6	.81	.28	----	.028	.18	.020	41.2
14	3.8		55.0	42.9	1.40	.16	.082	----	.031	.029	.007	46.7
13	15.9		53.5	39.0	6.85	.23	.17	----	.014	.13	.004	44.0
12	14.2	Analyses of a core of upper Niagaran rocks	54.7	44.7	.18	.071	.20	----	----	.053	.001	47.4
11	5.5		54.4	45.1	.092	.032	.19	----	----	.081	----	47.5
10	8.9		54.4	45.0	.15	.050	.16	----	----	.056	.001	47.2
9	2.2		55.0	44.5	.055	.022	.19		----	.059	.001	47.8
8	2.5		54.3	45.0	.24	.10	.17		----	.038	.001	47.0
7	1.3		55.5	43.6	.26	.12	.21	----	.014	.055	.002	47.4
6	5.0		55.9	43.8	.04	.017	.078		.015	.022	.001	47.2
5	19.7		56.1	43.3	.17	.090	.14		.013	.022	.001	47.2
4	0.4		56.2	43.4	.073	.038	.079	----	.015	.018	.001	47.5
3	8.7		56.0	43.0	.41	.18	.16	----	.014	.014	.001	47.3
2	26.2		55.9	43.0	.61	.19	.090	---	.013	.017	.001	47.0
1	1.8		55.6	43.4	.48	.15	.089		.017	.019	.002	47.2

Table 31.-*Chemical and spectrographic analyses (in percent) of samples from the Francesville Stone Co.*[1] *quarry 1.7 miles south of Francesville, Pulaski County, Ind. (NE¼SW¼ sec. 16, T. 29 N., R. 4W.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
2	3.0	Soil and glacial drift										
1	37.6	Upper Niagaran rocks	54.1	44.8	.46	.17	.26	----	----	.059	.004	46.6

[1] Now known as Western Indiana Aggregates Corp.

Table 32.-*Chemical and spectrographic analyses (in percent) of samples from the Babcock Construction Co. quarry, Rensselaer, Jasper County, Ind. (SE¼SE¼ sec. 30, T. 29 N., R. 6 W.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
11	8.0	Soil and glacial drift										
10	3.3	Middle Devonian dolomite	52.7	41.3	3.31	.39	1.73	----	.066	.16	.030	44.8
9	2.4		53.0	42.3	2.55	.56	1.09	----	.058	.31	.020	45.0
8	7.8		50.8	41.2	4.43	.92	1.52	.043	.061	.31	.020	44.1
7	[1]0.7											
6	[1]1.6											
5	1.9		53.1	44.6	.53	.064	1.20	----	.069	.10	.005	47.0
4	0.9	Undifferentiated Devonian	48.8	40.5	7.08	1.29	1.18	.046	.068	.38	.13	42.4
3	[1]0.7											
2						1.59						
1	3.3		83.9	10.1	4.34	.56	.65	----	.027	.95	.010	42.4

[1] Not sampled.

Table 33.-*Chemical and spectrographic analyses (in percent) of samples from the Erie Stone Co. plant and quarry at Huntington, Huntington County, Ind. (SW¼SE¼ sec. 12, T. 28 N., R. 9 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
5	5.0	Soil and glacial drift										
4	13.0	Upper Niagaran rocks	53.7	44.2	1.18	.25	.20	----	.0091	.017	.005	46.6
3	13.0		57.9	41.2	.32	.13	.19	----	.0087	.020	.008	47.0
2	8.0		54.1	45.4	.086	.065	.16	----	.0086	.013	.002	47.4
1	9.7		59.4	39.7	.42	.18	.19	----	.0083	.012	.003	46.8

Table 34.-*Chemical and spectrographic analyses (in percent) of samples from the Monon Crushed Stone Co. quarry south of Monon, White County, Ind. (SE¼NE¼, sec. 28, T. 28 N., R. 4 W.)*[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
6	10.0	Soil and glacial drift										
5	2.7	Upper Niagaran rocks	55.5	42.9	.62	.17	.28	----	.032	.019	.004	46.5
4	17.3		55.1	43.2	.70	.19	.34	----	.026	.11	.004	46.6
3	26.0		53.4	40.0	3.98	1.01	.52	.044	.022	.16	.006	44.4
2	[2]5.0											
1	21.9		55.6	42.9	.56	.16	.27	----	.018	.078	.002	47.0

[1] Patton, 1949, p. 42.

[2] Not sampled.

Table 35.-*Chemical and spectrographic analyses (in percent) of samples from the Erie Stone Co. plant and quarry near Bluffton, Wells County, Ind. (SW¼NW¼ sec. 28, T. 27 N., R. 12 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
3	4.0	Soil and glacial drift										
2	19.0	Upper Niagaran rocks	54.9	44.0	.54	.32	.18	----	----	.016	.002	46.9
1	8.0		51.2	39.1	6.41	1.52	.59	.064	----	.24	.005	42.7

Table 36.-*Chemical and spectrographic analyses (in percent) of samples from the Meshberger Brothers Stone Co. quarry near Linn Grove, Adams County, Ind. (SE¼SE¼ Sec. 33, T. 26 N., R. 13 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
5	4.0	Soil and glacial drift										
4	2.9	Lower Niagaran rocks	55.0	37.8	4.70	1.02	.36	.055	.011	.036	.005	44.0
3	9.3		56.1	40.1	2.58	.44	.25	.033	.010	.088	.003	44.9
2	5.0		56.5	40.9	1.60	.25	.21	----	.012	.016	.003	46.0
1	12.4		56.7	40.4	1.93	.29	.19	----	.010	.035	.003	46.2

Table 37.-*Chemical and spectrographic analyses (in percent) of samples from the Stunts-Yeoman Co. plant and quarry at Delphi, Carroll County, Ind. (SW¼SW¼ sec. 19, T. 15 N., R. 2 W.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
8		Soil and glacial drift										
7	6.0	Upper Niagaran rocks	57.6	41.4	.33	.12	.31	----	.032	.017	.008	47.4
6	[1]4.0											
5	15.0		57.3	41.9	.25	.10	.25	----	.018	.040	.006	47.5
4	10.0		59.4	39.2	.66	.095	.20	----	.023	.032	.006	47 3
3	[1]5.0											
2	10.0		56.9	41.0	1.06		.36	----	.043	.033	.004	46.8
1	[1]9.0											

[1] Not sampled.

Table 38.-*Chemical and spectrographic analyses (in percent) of samples from the Montpelier Stone Co.*[1] *quarry at Montpelier, Blackford County, Ind. (SW¼NW¼ sec. 3, T. 24 N., R. 11 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
5		Soil and glacial drift										
4	29.8	Lower Niagaran rocks	53.7	44.0	1.34	.45	.24	.027	----	.015	.004	46.2
3	8.0		53.1	41.3	3.24	.90	.35	.051	.010	.040	.004	45.3
2	8.0		55.8	39.6	2.44	.74	.32	.045	.010	.037	.003	45.7
1	12.0		54.3	43.2	1.51	.24	.18		.010	.016	.002	46.3

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[1] Now known as J. and K. Stone Co.

Table 39.-*Chemical and spectrographic analyses (in percent) of samples from the Rockledge Products, Inc. quarry southwest of Portland, Jay County, Ind. (NW¼NW¼ sec. 30, T. 23 N., R. 14 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
4	15.0	Soil and glacial drift										
3	22.8	Lower Niagaran rocks	55.2	44.2	.22	.079	.089	----	----	.011	.002	47.3
2	11.8		55.2	44.6	<.05	<.05	.079	----	----	.015	.002	47.2
1	10.6		55.0	44.8	<.05	<.05	.087	----	----	.011	.002	47.8

Table 40.-*Chemical and spectrographic analyses (in percent) of samples from the H. & R. Stone Co. quarry southeast o f Ridgeville, Randolph County, Ind. (NE¼ and SE¼SE¼ sec.12, T. 21 N., R. 13 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
4	4.0	Soil and glacial drift										
3	17.5											
2	15.0	Lower Niagaran rocks	55 8	42.2	1 04	.31	.34	----	----	.013	.009	46.2
1	15.5		55.6	42.6	1.20	.22	.19	----	----	.008	.005	46.7

[1] Not sampled.

Table 41.-*Chemical and spectrographic analyses (in percent) o f samples from the J & K Stone & Gravel Co., Inc. quarry at Muncie, Delaware County, Ind. (SW¼SE¼ sec. 20, T. 20 N., R. 10 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
3	6.0	Soil and glacial drift										
2	22.4	Lower Niagaran rocks	55.7	40.8	2.46	.41	.17	----	----	.019	.004	45.8
1	16.8	Lower Niagaran rocks	53.3	38.2	6.44	1.11	.40	.041	----	.12	.010	43.1

Table 42.-*Chemical and spectrographic analyses (in percent) of samples from an abandoned quarry west of Geneva, Shelby County, Ind. (SW¼N W¼ sec. 22, T. 11 N., R. 7 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
4	1.9	Soil and glacial drift										
3	3.2	Geneva[1]										
2	5.0	Geneva	58.5	40.6	.33	.10	.23	----	.044	.029	.005	46.8
1	8.0	Geneva	54.4	41.8	2.86	.12	.15	----	.028	.028	.004	45.7

[1] Not sampled.

Table 43.-*Chemical and spectrographic analyses (in percent) of samples from Meshberger Stone Corp. northeast of Elizabethtown, Bartholomew County, Ind. (NE¼ sec. 6, T. 8 N., R. 7 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
14	12.0	Soil and glacial drift										
13	3.0	New Albany[1]										
12	2.6	North Vernon	94.4	1.07	2.27	.32	1.66	.043	.068	1.35	.50	41.0
11	7.4	Jeffersonville	89.8	4.22	5.16	.094	.15	.060	.039	.064	.10	41.5
10	1.3	Jeffersonville	69.8	27.6	1.42	.38	.28	.050	.043	.073	.14	45.2
9	11.0	Jeffersonville	59.9	33.4	5.27	.62	.20	.022	.036	.12	.017	44.3
8	11.2	Jeffersonville	59.2	33.6	5.39	.79	.25	.026	.035	.15	.019	44.2
7	2.7	Jeffersonville	63.8	33.4	1.63	.32	.31	---	.027	.10	.011	45.3
6	8.9	Jeffersonville	93.2	5.81	.39	.044	.25	----	.033	.053	.003	44.3
5	3.3	Jeffersonville	65.0	34.0	.20	.041	.43	----	.065	.044	.005	46.5
4	3.8	Geneva	59.2	39.7	.53	.089	.28	----	.036	.045	.009	46.8
3	20.3	Geneva	58.6	39.7	.67	.092	.44	----	.033	.22	.005	46.6
2	5.8	Geneva	58.9	37.6	2.45	.22	.25	----	.029	.068	.004	45.8
1	4.2	Louisville	59.8	37.1	1.79	.30	.48	.030	.038	.17	.007	45.4

[1] Not sampled.

Table 44.-*Chemical and spectrographic analyses (in percent) of samples from Berry Materials Corp. at the northeast edge of North Vernon, Jennings County, Ind. (NE¼ sec. 34, T. 7 N., R. 8 E.)*

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
13	8.0	Soil and glacial drift										
12	40.0	New Albany[1]										
11	3.4	North Vernon	97.8	.50	.76	.12	.47	----	.10	.17	.65	42.2
10	0.2	North Vernon	[2]72.2	[2]13.2	[2]8.19	[2]2.60	[2]1.65	[2].17	.084	.94	2.00	35.8
9	3.0	North Vernon	83.0	10.8	3.32	1.10	1.19	.050	.12	.90	.59	40.5
8	5.9	Jeffersonville	86.0	9.68	3.60	.085	.18	----	.078	.004	.076	42.4
7	4.4	Jeffersonville	64.8	32.0	1.88	.53	.34	.026	.044	.12	.016	45.2
6	11.8	Jeffereonville	64.0	32.2	2.40	.53	.44	.030	.036	.15	.015	45.0
5	5.6	Jeffersonville	65.0	33.4	.65	.088	.37	----	.053	.060	.005	46.5
4	3.1	Geneva	56.0	41.1	1.88	.25	.25	----	.049	.062	.004	46.5
3	6.3	Geneva	54.3	40.0	4.81	.024	.31	----	.060	.047	.002	45.4
2	1.6	Geneva	56.4	41.5	1.16	.15	.29	----	.047	.077	.005	46.8
1	0.8	Geneva	56.9	41.4	.77	.047	.36	----	.047	.13	.002	46.9

[1] Not sampled.

[2] Chemical determination.

CONCLUSION

High-calcium limestone and dolomite are mineral resources that are found in Indiana but that have never been extensively exploited. Chemical and spectrographic analyses combined with measured stratigraphic sections provide a basis for evaluating the economic merits of the rock units in various localities. Each table of analyses provides information about the amount of overburden, thickness of usable rock, and relationship of usable to nonusable rock; indicates the possibility of high-calcium limestone or dolomite at a particular location; and therefore serves as a guide for further exploration. Only a detailed drilling program, however, can provide information for a final decision about an area.

Persons interested in developing high-calcium limestone and dolomite resources in Indiana should consult geologists of the Indiana Geological Survey either before or after exploration has been undertaken.

SELECTED BIBLIOGRAPHY

[References marked with an asterisk are cited in the text.]

Ames, J. A., 1951 ?, High-calcium limestones in the area served by the Baltimore and Ohio Railroad: Baltimore, Md., Baltimore and Ohio Railroad Co., 105 p., 26 figs.

*Bowen, O. E., Jr., 1957, Limestone, dolomite, and lime products, *in* Wright, L. A., ed., Mineral commodities of California - geologic occurrence, economic development, and utilization of the State's mineral resources: California Dept. Nat. Resources, Div. Mines Bull. 176, p. 293-307, 11 figs., 4 tables.

Bowles, Oliver, and Jensen, M. S., 1941, Limestone and dolomite in the chemical and processing industries: U. S. Bur. Mines Inf. Circ. 7169, 15 p.

Bowles, Oliver, and Jensen, N. C., 1947, Industrial uses of lime= stone and dolomite: U. S. Bur. Mines Inf. Circ. 7416, 16 p.

Boynton, R. S., and Gutschick, K. A., 1960, Lime, *in* Industrial minerals and rocks, 3d ed.: New York, Am. Inst. Mining, Metall., and Petroleum Engineers, p. 497-519, 10 figs., 4 tables.

*Cotter, P. G., and Jensen, N. C., 1960, Stone: Prepr. from U. S. Bur. Mines Minerals Yearbook, 31 p.

*Cumings, E. R., and Shrock, R. R., 1928, The geology of the Silurian rocks of northern Indiana: Indiana Dept. Conserv. Pub. 75, 226 p., 58 figs., 2 maps, 1 chart.

*Deiss, C. F., 1952, Geologic formations on which and with which Indiana's roads are built: Indiana Geol. Survey Circ. 1, 17 p., 9 pls., 3 figs.

Gillson, J. L., and others, 1960, The carbonate rocks, *in* Industrial minerals and rocks, 3d ed.: New York, Am. Inst. Mining, Metall., and Petroleum Engineers, p. 103-201, 21 figs., 26 tables.

Johnstone, S. J., 1954, Minerals for the chemical and allied industries: Chapman and Hall Limited, p. 245-275.

Key, W. W., 1960, Chalk and whiting, *in* Industrial minerals and rocks, 3d ed.: New York, Am. Inst. Mining, Metall., and Petroleum Engineers, p. 233-242, 2 figs.

Kriege, H. F., 1948, Mineral aggregates in the chemical and processing industries and in certain uses, *in* Symposium on mineral aggregates: Am. Soc. for Testing Materials, p. 205-219.

*Leininger, R. K., 1955, Chemical composition of Devonian rocks of southeastern Indiana, *in* Murray, H. H., Sedimentation and stratigraphy of the Devonian rocks of southeastern Indiana: Indiana Geol. Survey Field Conf. Guidebook 8, p. 53-67, 10 tables.

*McGregor, D. J., 1958, Cement raw materials in Indiana: Indiana Geol. Survey Bull. 15, 88 p., 2 pls., 3 figs., 34 tables.

*Malott, C. A., 1948, Hudelson Cavern, a stormwater route of underground Lost River, Orange County, Ind.: Indiana Acad. Sci. Proc., v. 58, p. 236-243, map.

*Patton, J. B., 1949, Crushed stone in Indiana: Indiana Div. Geology Rept. Progress 3, 47 p., 1 pl. 1951, Industrial limestone in Indiana: Sci. Monthly, v. 72, p. 259-265, 1 pl. , 6 figs.

Patton, J. B., 1953, Limestone resources of southern Indiana (unpublished Ph. D. thesis): Bloomington, Indiana Univ., 356 p., 5 pls., 36 tables.

*Perry, T. G., and others, 1954, Salem Limestone and associated formations in south-central Indiana: Indiana Geol. Survey Field Conf. Guidebook 7, 73 p., 5 pls.

*Pettijohn, F. J., 1957, Sedimentary rocks, New York, Harper Bros., 718 p., 40 pls., 173 figs., 118 tables.

Robie, E. H., ed., 1959, Economics of the minerals industries: New York, Am. Inst. Mining, Metall., and Petroleum Engineers, 755 p.

Searle, A. B., 1935, Limestone and its products: London, Ernest Benn Limited, 709 p.

*U. S. Department of Agriculture, 1958, Agricultural conservation program for Indiana, *in* Agricultural Conservation Program Handbook for 1959: 25 p.

*Wayne, W. J., 1956, Thickness of drift and bedrock physiography of Indiana north of the Wisconsin glacial boundary: Indiana Geol. Survey Rept. Progress 7, 70 p., 1 pl., 10 figs.