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PETROLOGY OF THE MAXVILLE LIMESTONE FROM PARTS OF MUSKINGUM AND PERRY COUNTIES, OHIO[1]

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Scope of the investigation

The Maxville limestone from parts of Muskingum and Perry Counties, Ohio, was studied in order to determine its mineral composition and texture and to interpret its depositional and postdepositional history in this area.

Previous work on the Maxville limestone has been mainly field mapping, paleontological study, and chemical analysis.

The field work for this paper was done in the autumn of 1951 and in the spring of 1952. Stratigraphic sections of the Maxville limestone were measured at five localities (fig. 1) in western Perry County and southwestern Muskingum County. One section was measured from a core which was drilled east of Philo, in Wayne Township, Muskingum County. Most of the samples were collected at 1-foot intervals at the time the sections were measured. Specimens from a few thin units were combined so as to have one sample for each foot of the beds that were measured. In units more than 1 ft. thick, specimens were collected from each foot and combined to form one sample for the unit. For a unit over 5 or 6 ft. thick, the upper half was designated "a" and the lower half "b". A sample then was collected from each half of the unit. Sample localities are as follows:

Locality 1. At type locality, abandoned quarry, center sec. 17, T. 14 N., R. 16 W., Monday Creek Township, Perry County.

Locality 2. Abandoned quarry, SE¼ NW¼, sec. 25, T. 17 N., R. 17 W., Reading Township, Perry County.

Locality 3. At entrance to mine operated by Pittsburgh Plate Glass Company near Fultonham, SW¼ NW¼, sec. 20, T. 15 N., R. 14 W., Newton Township, Muskingum County.

Locality 3a. In a large quarry of the Pittsburgh Plate Glass Company near Fultonham, SE¼ SE¼, sec. 18, T. 15 N., R. 14 W., Newton Township, Muskingum County.

Locality 4. A drilled core near Philo, SE¼ NE¼, sec. 29, T. 13 N., R. 12 W., Wayne Township, Muskingum County.

Locality 5. West end of Kent Run gorge, NW¼ NW¼, sec. 2, T. 17 N., R. 15 W., Newton Township, Muskingum County.

Petrographic analyses were made at The Ohio State University during the winter and spring of 1952. A total of 116 insoluble residues were prepared and examined under a stereoscopic binocular microscope. Ten thin sections were studied, and 15 specimens were etched and/or stained.

[1]A paper dealing with this subject was submitted to the Graduate School in partial fulfillment of the requirements for the degree, Master of Science in the Department of Geology at The Ohio State University, June, 1952.

Stratigraphy of the Maxville limestone

Definition and distribution. Andrews (1870, p. 83) named the Maxville limestone for exposures near Maxville, Monday Creek Township, Perry County, Ohio. He described the Maxville as a limestone formation which "always rests upon the top of the Logan sandstone group" with disconformity and is overlain disconformably by the Pottsville formation.

The Maxville limestone crops out in isolated patches between southeastern Scioto County (Morse 1910, p. 81) and Hopewell Township, Muskingum County (Stout 1921, p. 37). The limestone is well-exposed in the Fultonham area, in the banks of Jonathan Creek and Kent Run in western Muskingum County, and in the banks of Little Monday and Little Rush Creeks and their tributaries in Perry County (fig. 1).

The Maxville limestone is quarried and mined extensively for use in cement manufacture in the Fultonham area. In southeastern Ohio it formerly was used for road metal, railroad ballast, agricultural lime, furnace flux, lime for mortar, and building stone.

Lithology and thickness. The lower 10 to 27 ft. of the Maxville limestone in southeastern Ohio consist of fine- to medium-grained light gray-tan, light-gray, or light blue-gray limestone, dolomitic limestone, or dolomite. The lower part is dense, massive, arenaceous, somewhat clayey, and sparsely fossiliferous. The upper 22 to 43 ft. consist of fine- to medium-grained light gray-tan to blue-gray dense limestone, which is fossiliferous and well-bedded.

Both the upper and lower parts of the Maxville limestone are exposed in the Fultonham area. Here, near the top of the lower part, is an unusual wavy contact between two dolomitic limestone units. The crests in the wavy contact are about 3 to 5 ft. apart.

At the type locality at Maxville (No. 1 of figure 1 and 2), at Kent Run, and at the abandoned quarry in Reading Township, 10 to 15 ft. of the lower part of the Maxville limestone are present, but the upper part is absent. The lower part, at these localities, consists of very fine- to fine-grained tan-gray to light blue-gray massive limestone, dolomitic limestone, or dolomite. At Maxville, a layer of calcareous chert 10.3 in. thick composes the lower-most unit of the limestone. This chert probably corresponds to units B3 and C5 in the sections described by Morse (1910, p. 74–75).

A core which was drilled in Wayne Township, Muskingum County (No. 4 of figure 1 and 2), penetrated 70 ft. of the Maxville limestone and included both the upper and lower part of the formation. The upper part consists of fine-grained . . . light-gray to light tan-gray . . . dense . . . sparsely fossiliferous limestone, interbedded with calcareous . . . silty green-gray, tan-gray, or dark-gray shale. The lower 15 ft. 2 in. of the upper part of the formation are sparsely oolitic. The lower part of the formation is 27 ft. thick, and it is fine-grained gray-tan massive dense limestone, dolomitic limestone, and dolomite. The lower 9 feet of the Maxville limestone are composed mainly of limestone breccia and at least two zones of calcareous oolites. Morse (1910, p. 60) described a unit which contains minute calcareous concretions from the Maxville in the Kent Run area. This unit possibly corresponds, in part at least, either to unit 4, 6, or 7 of the cored section, each of which contains calcareous oolites.

Forty-two feet of the limestone are exposed in the large quarry in the Fultonham area. At this locality only the upper contact is exposed.

Age and correlation. The Maxville limestone is the youngest formation of the Mississippian system exposed in Ohio. Morse (1910, p. 108) stated that fossils from the Maxville, identified by Ulrich and others, indicate a Ste. Genevieve age. Weller (1948, p. 160) identified trilobites from the limestone as Ste. Genevieve in age. The Maxville limestone thus can be considered as belonging to the Meramecian series.

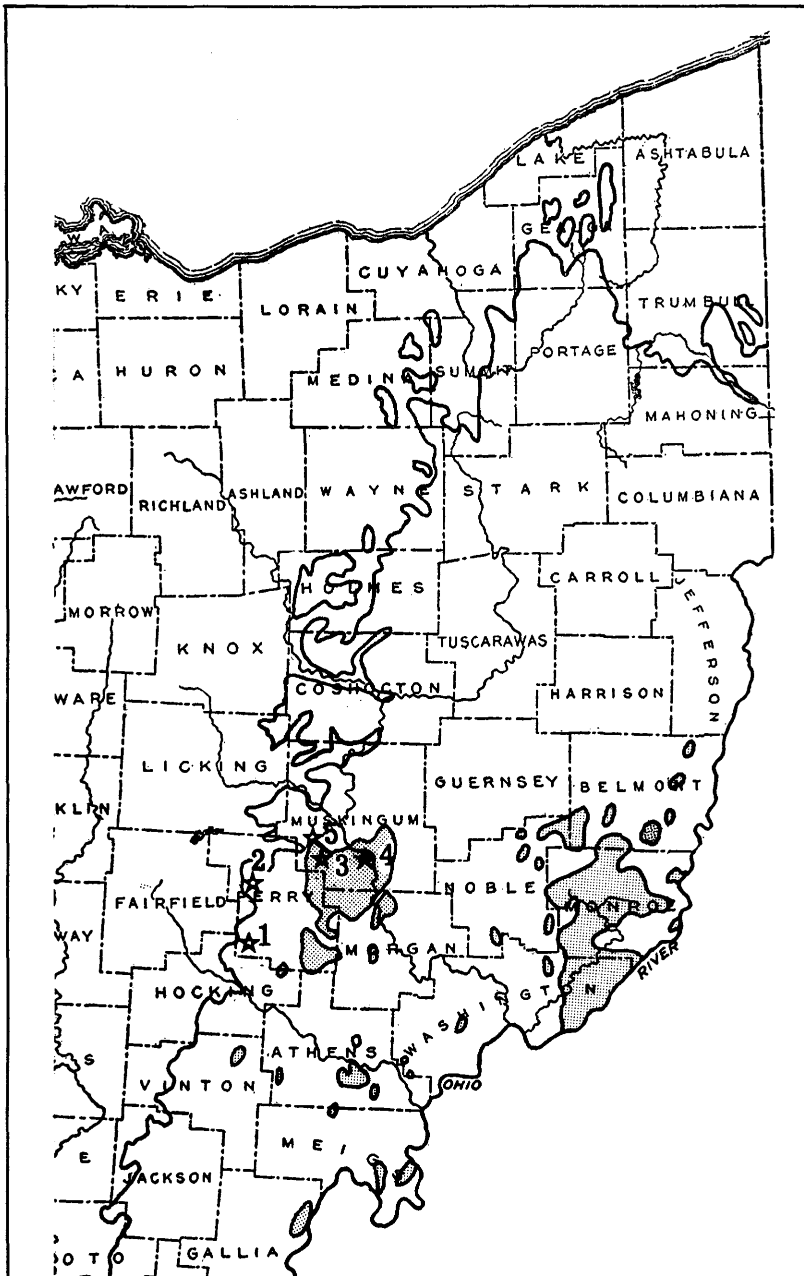

FIGURE 1. Map of Eastern Ohio showing the line of outcrop of the Mississippian–Pennsylvanian contact, areas of occurrence of the Maxville limestone below drainage, and localities of samples taken.

Prior to 1948, the Maxville was believed to be equivalent in age to the Greenbrier limestone in West Virginia, Virginia, southern Pennsylvania, and Maryland; to the Ste. Genevieve limestone in eastern Missouri, southern Illinois, Indiana, Iowa, Kentucky, Tennessee, northern Alabama, and northern Mississippi; and to the Bayport limestone in Michigan (Morse 1910, p. 111; Wilmarth 1937, p. 129, 886–887, 1324–1325, 1873–1876). In 1948, the Mississippian Subcommittee of the Geological Society of America published a chart in which some significant differences in correlations of the Maxville limestone are shown. The Maxville limestone is shown in large part as equivalent in age to the Big Lime subsurface formation in southwestern Pennsylvania and north-central West Virginia, and to the top of the lower part of the Greenbrier series in southern Randolph County, West Virginia.

The writer believes that the textures of the Maxville limestone and relative percentages of insoluble minerals in this limestone are similar to those in part of the Greenbrier limestone described by Rittenhouse (1949, p. 1704–1730).

PETROLOGY

Insoluble residues

Procedure. A total of 116 samples of the Maxville limestone were reduced to small chips and digested in a 50 percent solution of hydrochloric acid. About one-fourth of the samples were heated to the boiling point of the acid solution in order to quicken digestion; the rest of the samples were digested at room temperature. After digestion had been completed, the acid was decanted, and the residues were washed. A few of the residues were crushed and rewashed in order to separate shaly particles from the coarse residue. After each washing had been completed, the contents of the beakers were stirred, and the coarse residue was allowed to settle. The fine residues were not studied. The coarse residue was dried and weighed in the beaker. The percentages of the coarse residues are shown on graphs (fig. 2).

Each coarse residue was studied under a binocular microscope to determine the mineral content, the size and shape of the grains, and the relative percentage of each mineral present. Thirty-five residues were mounted in Canada balsam and examined under a petrographic microscope in order to identify tourmaline, zircon, and feldspar, and in order to see inclusions in the detrital grains of quartz.

Mineral composition of the coarse residue. The insoluble minerals present in the Maxville limestone are detrital and secondary quartz, pyrite, magnetite, hematite, albite, orthoclase, microcline, tourmaline, and zircon. Inclusions of semi-opaque needles of rutile are present in some of the detrital grains of quartz. Banded chalcedony, a variety of quartz, is present in only one of the residues.

Detrital grains of quartz are abundant in the lower part of the Maxville limestone, but are rare in the upper part. Secondary quartz is abundant in the upper part but rare in the lower part. Although pyrite, magnetite, and hematite are rare in the Maxville limestone in most localities, they are abundant in the Fultonham area. Orthoclase and microcline are rare; tourmaline and zircon are present in small amounts in the lower part, and are rare or absent in most localities in the upper part.

Detrital grains of quartz average 81 percent of the total coarse residue in the lower part of the Maxville limestone and 13 percent in the upper part. These quartz grains range from 0.03 mm. to 1.00 mm. in diameter and average 0.11 mm. to 0.24 mm. Thus some of the grains are silt size, some are medium sand size, and most are fine sand size. The quartz grains are transparent or frosted, angular, subangular, or subrounded. Frosted subangular to subrounded grains are dominant. Secondary quartz has been deposited on many of the detrital grains and can be seen with a binocular microscope. A few of the grains that show secondary

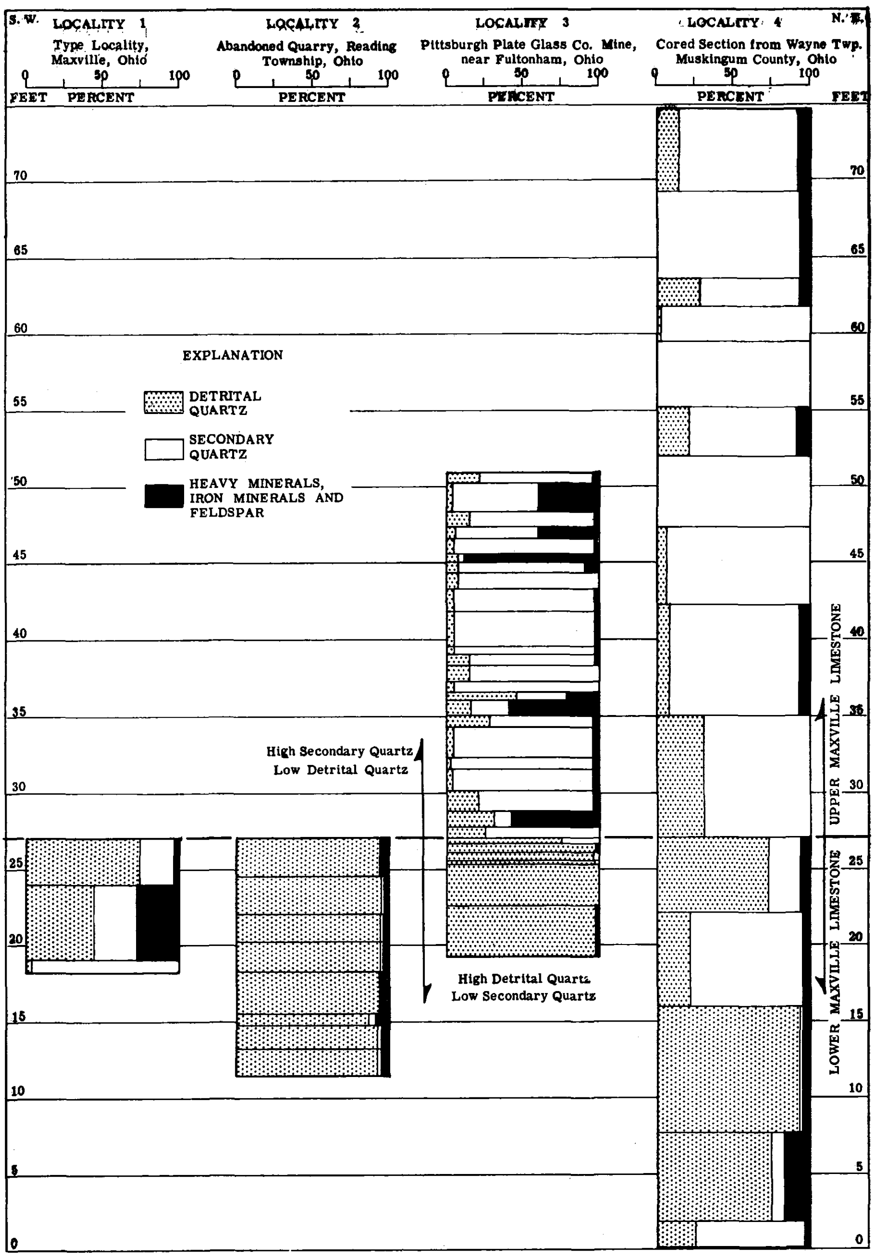

FIGURE 2. Graphs of coarse insoluble residues, showing the percentage relationships of detrital and secondary quartz, and heavy minerals.

growth are doubly terminated short prisms. The outline of the original subrounded detrital grains, with an overgrowth of quartz which forms well-developed crystal faces, can be seen with a petrographic microscope. Small carbonate rhombs are included in some of the secondary quartz that has been deposited on the detrital grains. Inclusions of semi-opaque needles of rutile and short prismatic grains of tourmaline are present in a few detrital grains of quartz.

Aggregates of secondary quartz average 56 percent of the coarse residue in the upper part of the Maxville limestone and 12 percent in the lower part. Most of the aggregates are snow white; some are gray to tan. The aggregates are rod-shaped, in fossil fragments, in shapes suggesting fossil fragments, and in irregular shapes. The rod-shaped aggregates range from 0.04 mm. to 3.28 mm. in length, and the fossil fragments have a maximum diameter of 3.87 mm. At Maxville, the type locality, an insoluble residue from the lowermost unit in the section is 99 percent secondary quartz. This quartz is in clear to milky angular grains and banded aggregate grains of chalcedony. A mass of orange quartz is present in the center of a few of the banded grains.

Irregular aggregates and grains of brassy-yellow pyrite average 7 percent of the coarse residues from the Maxville limestone; in the Fultonham area the pyrite averages 10 percent. The aggregates and grains range from 0.08 mm. to 0.30 mm. in diameter. Most of the pyrite aggregates are granular and show poorly to well-developed minute pyritohedral and cubic crystal faces; octahedra are rare. Pyrite in the shape of rods also is rare. Aggregates of pyrite mixed with secondary quartz are present in a few of the residues.

Magnetite octahedra and aggregates of magnetite and hematite average 8 percent of the coarse residues in the Maxville limestone; in the large quarry near Fultonham, however, these minerals average 20 percent. The aggregates and octahedra range from 0.13 mm. to 0.40 mm. in diameter. Magnetite and hematite commonly are in the same aggregates.

Feldspar is present in the upper and lower parts of the Maxville limestone in amounts ranging up to 6 percent, and averaging 0.2 percent, of the coarse residues. Euhedral grains of albite and orthoclase show no signs of abrasion and therefore are authigenic. Two subrounded grains of microcline and microperthite were identified; these are detrital.

Tourmaline and zircon are rare or absent in the residues from the upper part of the Maxville limestone, but they are up to 3 percent in many of the residues from the lower part. Most of the tourmaline grains are dark blue-green or amber in plain light under the petrographic microscope. Most of the tourmaline grains are rounded, some are elongate, and a few are equant with sharp edges. The tourmaline ranges from 0.05 mm. to 0.33 mm. in diameter, and therefore is of very fine to fine sand size. Most of the zircon grains are pink or red and oval or subrounded. The size range of the zircon is the same as that of the tourmaline. Under the petrographic microscope a few of the zircon grains appear highly fractured.

Thin sections and etched and stained specimens

General statement. Seven thin sections were prepared from the lower and three from the upper part of the Maxville limestone from the localities shown in figure 1. A total of 15 specimens from the lower and upper parts of the limestone were cut in two and ground flat with carborundum powder on a glass plate. Each of the cut specimens was etched by immersion in dilute hydrochloric acid for 30 to 90 sec. All specimens but one were stained, after they were etched, by immersion in a boiling solution of malachite green for 3 to 4 min.

Textural varieties. A study of the thin sections and the etched specimens shows five textural varieties; four are from the lower part of the Maxville limestone and one is from the upper part.

One textural variety from the lower part of the Maxville is dolomitic limestone breccia from the lower part of the cored section. The fragments are composed of dolomite rhombs about 0.01 mm. in diameter and some calcite, and the matrix consists of slightly coarser dolomite and calcite. Detrital grains of quartz are present in the rock unit in amounts up to 3 percent, and are present largely in the matrix. Small carbonate rhombs are included in secondary quartz that has been deposited on the detrital grains of quartz. In the matrix, aggregates of secondary quartz which have replaced calcite are rare.

A second textural variety is present in a few of the units from the lower part of the Maxville, and it shows calcareous oolites ranging from 0.17 mm. to 1.00 mm. in diameter. Etching reveals the concentric structure of the round, subround, oval, or elongate oolites. A few of the oolites have a core of detrital quartz rimmed by concentric layers of very fine-grained calcite. Most of the oolites contain cores of colorless transparent calcite, which is coarser grained than that in the concentric layers. The matrix is colorless calcite which composes about 15 percent of the oolitic limestone. Irregular patches of coarser calcite and some of chalcedony are scattered unevenly throughout the matrix. Fibrous calcite, which may be fossil material, is present in variable but small amounts.

A third textural variety, from the lower part of the Maxville, is shown by very fine- to fine-grained limestone containing scattered patches of colorless calcite which are coarser grained than the matrix. Some of this coarser calcite occurs in fossil fragments. Fibrous calcite is rare. Detrital grains of quartz are present in the rock unit in amounts up to 2 percent. Small carbonate rhombs are included in secondary quartz that was deposited on these detrital grains.

A fourth textural variety, from the lower part of the Maxville, is shown by very fine-grained dolomitic limestone, of which slightly less than half is composed of closely spaced subhedral to euhedral dolomite rhombs averaging 0.01 mm. in diameter. The other half is fine-grained calcite. Scattered patches of calcite coarser grained than the matrix are rare. Some of this coarser calcite occurs in fossil fragments. A trace of fibrous calcite, which may be fossil material, is present. Detrital grains of quartz are present in the rock unit in amounts up to 25 percent and averaging 5 percent. A few spherulites of chalcedony that show radial extinction are present. Rounded or oval grains of tourmaline and zircon are rare. This fourth texture was seen only in thin section.

The most typical texture of the upper part of the Maxville limestone shows abundant fossil fragments and shapes suggesting fossil fragments. This texture is clearly shown by the etched surfaces. Most of the upper part of the Maxville consists of fine-grained calcite; the calcite in the fossil fragments is transparent and coarser grained than that in the rest of the rock. Fossil fragments rarely are rimmed by a thin layer of secondary quartz which stands above the rest of the etched surface.

Diagenesis and secondary replacement

General statement. Insufficient facts are available to determine the sequence of formation of the diagenetic and secondary minerals present in the Maxville limestone. Dolomite probably is diagenetic. Secondary minerals are pyrite, quartz, chalcedony, albite, orthoclase, magnetite, and hematite.

Dolomite. The Maxville changes from dolomite and dolomitic limestone to limestone within a distance of a few miles, as is shown by variable amounts of dolomite in the same parts of the formation from different measured sections. In the Fultonham area and in the cored section the dolomitic limestone contains cavities and is more porous than the overlying limestone.

Magnesium-bearing waters may have circulated through the lower part of the limestone and thus deposited dolomite which replaced calcite. If the dolomite replaced calcite before the induration of the Maxville was complete, the replacement occurred during the diagenetic stage of rock formation.

Secondary quartz, pyrite, and feldspar. Secondary quartz is abundant only in the upper part of the Maxville limestone. Most of the quartz occurs as replacements in rod-shaped fragments, in shapes suggesting fossils, and in fossils.

The chert bed, in the section at Maxville, the type locality, consists largely of clear to milky angular microcrystalline quartz. None of the quartz shows signs of abrasion; it is believed to be secondary. The bed probably was porous limestone in which the calcite in large part was replaced by quartz.

As shown by a study of the thin sections, inclusions of carbonate rhombs which may be dolomite are present in some of the aggregates of secondary quartz. This quartz may have replaced calcite; the dolomite, which may not have been so readily replaced, was entrapped in the quartz.

Secondary quartz, pyrite, and feldspar (albite and orthoclase) may have formed slightly below the surface of deposition throughout Maxville time. Another possibility is that in post-Maxville time these minerals may have been precipitated from circulating ground-water. Finally, the minerals may have developed both during and after deposition of the Maxville. The correct hypothesis cannot be determined at this time.

The secondary feldspar consists of albite and orthoclase crystals. These crystals show no evidence of rounding and are believed to be authigenic.

Magnetite and hematite. Insoluble residues from the sections from Kent Run, from the abandoned quarry in Reading Township, and from the mine near Fultonham average 20 percent of magnetite and hematite. Most of the magnetite is present in aggregates with irregular shapes like the secondary quartz, thus suggesting that the magnetite also is secondary. Excellent magnetite octahedra rarely are present. The octahedra show no evidence of rounding and are believed to be authigenic. Spiroff (1938, p. 818) synthesized magnetite octahedra, and he described an occurrence in Michigan of magnetite which probably was deposited from meteoric solutions. Brown (1943, p. 137–148) summarizes 10 occurrences of low temperature authigenic magnetite. Two of these occurrences are in the Grenville limestone (pre-Cambrian) of Ontario, Canada, and Balmat, New York.

It is believed that the magnetite in the Maxville limestone probably was formed in post-Maxville time by circulating ground-water Friedman (1954, p. 101).

This mineral is present throughout the section from the large quarry, where its abundance suggests that there may have been a local concentration of iron salts in the sediments overlying the Maxville at that place. Many of the aggregates of insoluble iron material from the Maxville contain both red hematite and black magnetite. Small amounts of magnetite are present in some hematite aggregates as shown by the attraction of some of the aggregates by a magnet. Thus it seems likely that the hematite in the Maxville was formed by oxidation of the authigenic magnetite.

Secondary growth on detrital grains of quartz. Most of the detrital grains of quartz in the material studied show secondary growth. This growth has resulted in some grains that show doubly terminated short prisms. The grains with secondary growth contain cores of detrital quartz which can be seen clearly in the mounted residues under a petrographic microscope. Under crossed nicols some of the cores show one or more color rings, whereas the secondary quartz growth is gray or white of the first order. The color difference occurs because the cores are thicker than the secondary growth.

As seen in the thin sections, secondary growth on detrital grains of quartz is suggested by inclusions of small carbonate rhombs.

CONCLUSIONS

The insoluble minerals present in the Maxville limestone are, in order of decreasing abundance, secondary quartz including chalcedony; detrital quartz; secondary pyrite, magnetite, and hematite; detrital tourmaline, zircon, microcline, and microperthite; and secondary feldspar (albite and orthoclase).

The upper or high-calcium part of the Maxville limestone may be differentiated from the lower or dolomitic part by a comparison of the relative percentages of the detrital and secondary quartz present in the insoluble residues. Detrital grains of quartz average 81 percent of the total coarse residue from the samples studied from the lower part and 13 percent from the upper part. Aggregates of secondary quartz average 12 percent of the coarse residue from the lower part and 56 percent from the upper part.

Chemical analyses of the limestone have been made, but they may not be useful in distinguishing the upper part from the lower part in places where the magnesium content is not sufficiently high to be diagnostic of the lower part. In this case, a study of the insoluble residues may be useful.

The cored section from Wayne Township, Muskingum County, contains about 30 ft. of high calcium limestone between the depths of 330 and 360 ft. The lower 15 ft. are in part silicious. Insoluble residues show that these 30 ft. range from 91 to 95 percent carbonate. If the magnesium content does not exceed 5 percent, this part of the formation could be mined for use in cement manufacture.

Magnetite which is authigenic occurs in the Maxville limestone. An examination of the geological literature of the United States indicates that the occurrence of authigenic magnetite in a Mississippian limestone previously has not been reported.

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