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DOLOMITIZATION OF THE PLATTEVILLE LIMESTONE

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Introduction

It is the purpose of this paper to call attention to some distinctive dolomite spheroids in the Platteville limestone (middle Ordovician) from the Dixon area, Illinois, and to attempt to relate them to other aspects of the dolomitization. The specimens studied were collected from an abandoned quarry on the east side of the road in the SW. ¼ SW. ¼ NW. ¼ Sec. 22, T. 22 N., R. 9 E., Lee County (Dixon quadrangle) Illinois. The present study is limited to specimens from a six-foot zone in the Mifflin formation, designated by Templeton and Willman (1952 : 6) as the Hazelwood member. This member consists of well-bedded limestone with varying amounts of dolomite and is contained in the Platteville group which comprises approximately 125 feet of limestone and dolomite. A general account of the geology of the area is given by Knappen (1926) and a more detailed account of the stratigraphy by Templeton and Willman (1952).

The dolomite spheroids were discovered in a search for microfossils in residues from acid digestion. On first sight, they appeared to be an uncommon type of agglutinated foraminifera having carbonate tests similar to those reported by Yabe and Hanzawa (1935). Inasmuch as further study indicated that they were probably not foraminifera, an attempt was made to obtain information on their origin from a textural and mineralogic study of representative specimens of the host rock. This study was made with the aid of thin-sections, acid residues, stained and etched ground surfaces, and electron micrographs.

Textural Varieties

Six principal types of textural relationships of dolomite were observed in the dolomitic limestones. They are: 1) scattered crystals; 2) dolomite spheroids; 3) ''veinlets'' and strings of crystals; 4) ''discoidal'' masses; 5) streamers and festoons of crystals; and 6) ''fucoidal'' dolomite.

These six types occur in varying degrees of intensity of development and in various combinations to produce the different lithologic varieties in the Hazelwood member. The principal features of these textural types are summarized in the following descriptions:

1). *Scattered crystals.*—Scattered dolomite rhombohedra occur throughout the virtually undolomitized parts of the homogeneous aphanitic limestone that serves as the host material for all the types of dolomite distribution. The rhombohedra average approximately 0.1 mm. across and occur either as isolated crystals or as irregular clusters of up to a half-dozen crystals. Their concentration ranges from a thin scattering in some parts of the rock to a close crowding in other parts. This type of distribution is characteristic of the parts of the rock not occupied by the other types of dolomite.

2). *Dolomite spheroids.*— The spheroids have been recognized only in the parts of the limestone containing the scattered crystals of dolomite. They are irregularly distributed and generally are not closer to one another than a few centimeters.

More or less well-formed spheroids (Fig. 1) range from 0.2 mm. to 10 mm. in diameter, but the most regular ones average approximately 0.5 mm. Some range to elongate ellipsoids and many others exhibit varying degrees of irregularity. Sections through the spheroids reveal that many of the more regular ones have a central cavity approximately 1/10 to 1/8 of the total diameter, which is commonly filled with earthy limonite.

The spheroids consist of crystals of almost pure magnesian dolomite ($\omega = 1.681 \pm .003$) which average approximately 0.05 mm. across. The crystals are interlocking in the interiors of the spheroids and are euhedral along the contact with the surrounding limestone. Measurement

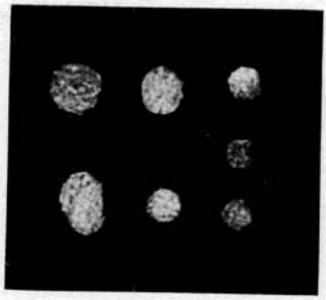

FIG. 1.—Typical well-formed dolemite spheroids. Magnification approx. X 36.

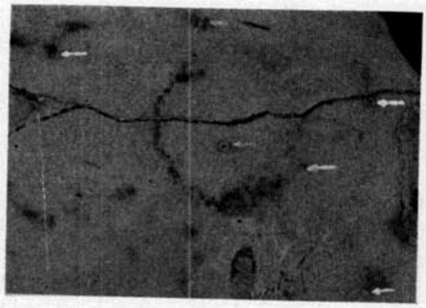

FIG. 2.—Scattered, well-formed dolomite spheroids, shown on etched and stained ground surface of slightly dolomitized Platteville limestone. Faint, irregular, pencil circle in central part of picture locates an especially well-formed spheroid. White arrows locate others. Magnification approx. X 9.

FIG. 3.—Ground, etched and stained dolomitized Platteville limestone showing: (a) micro-stylolitic fractures, two of which are indicated by arrows, (b) "discoidal" dolomite masses, following bedding fractures. Magnification approx. X 4.

of the orientations of the *c*-axes of the component crystals by the universal stage indicates a random orientation within the spheroids.

In general, the spheroids appear to be randomly distributed in the undolomitized parts of the limestone (Fig. 2), although locally a few appear to be distributed along the bedding.

That these spheroids are neither unaltered agglutinated carbonate foraminifera nor close pseudomorphs after such organisms is shown by: a) the closely interlocking nature of the crystals, as opposed to characteristically agglutinated foraminiferal tests; b) the common absence of a central cavity; c) the great thickness of the "walls" where a central cavity does occur; and d) the apparently continuous gradation from the regular to the highly irregular forms. However, although they are apparently not even approximate replicas of any recognizeable fossil, the evidence does not rule out the possibility that some kind of fossil served as loci for the formation of the spheroids.

3). *"Veinlets" of crystals.*—Small "veinlets" or strings of dolomite crystals are associated with two types of fractures. One type consists of micro-"stylolitic" fractures (Fig. 3) which are highly irregular in both form and distribution and which bear no apparent relation to the bedding or other structural features. The dolomite occurs irregularly as closely spaced rhombohedra along these fractures. The size of the crystals (approximately 0.1 mm.) is several times greater than the width of the microfractures.

The other type of "veinlet" is associated with larger fractures, some of which are oblique to and some parallel to the bedding. In these the dolomite is mostly contained within the fractures. Most fractures of this type, however, contain little or no such dolomite.

4). *"Discoidal" masses.*—A large amount of the dolomite in the rocks studied occurs in roughly discoidal masses which are aligned approximately parallel to the bedding. Most such masses are approximately one to three centimeters thick and several centimeters long. The boundaries of the masses are sharp. Within them the dolomite occurs as euhedral to subhedral crystals averaging 0.2 mm. in size with little interstitial material. There is, however, considerable enclosed material of two main types. Of these, the more common consists of coarsely crystalline calcite containing small amounts of scattered dolomite. The second type consists of enclosures of virtually unaltered aphanitic limestone, and it may be present either as completely enclosed areas or as embayments along the margins of the dolomite masses. A striking feature in one of these embayments is a line of dolomite crystals which is a projection of the boundary of the main embayment, where a smaller secondary embayment protrudes from it into the dolomite.

The shapes of these discoidal masses appear in places to be at least partly controlled by fractures of three main types. The more prominent fractures are those which follow the bedding, and these frequently transect the masses longitudinally. Subsidiary fractures, approximately parallel to these, coin-

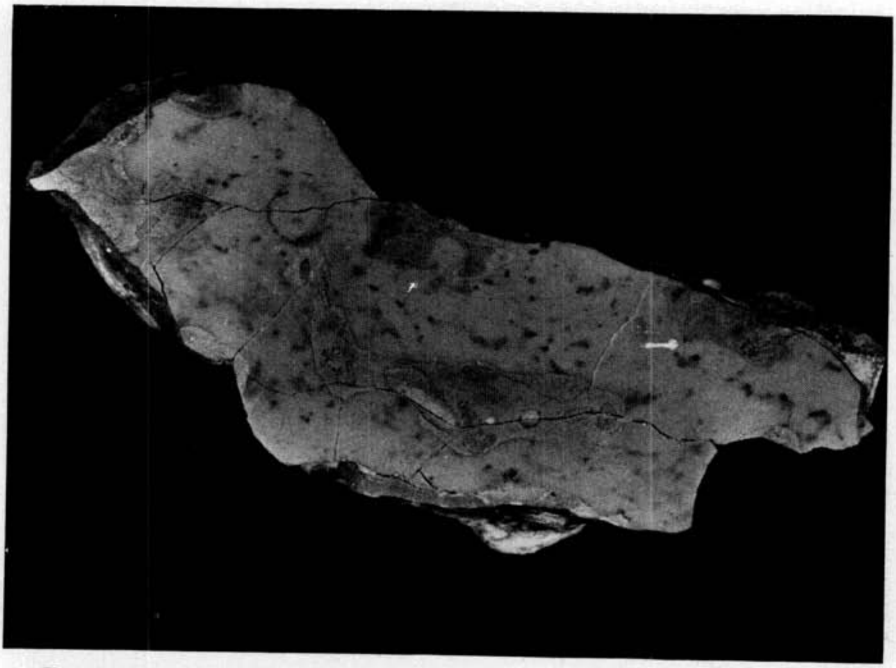

FIG. 4.—Ground, etched and stained specimen showing: (a) discoidal dolomite masses following bedding and oblique fractures, (b) cuspate boundaries to some such masses (indicated by arrow). The small pencil circle is the same as that shown in Figure 2. Magnification approx. X 1.

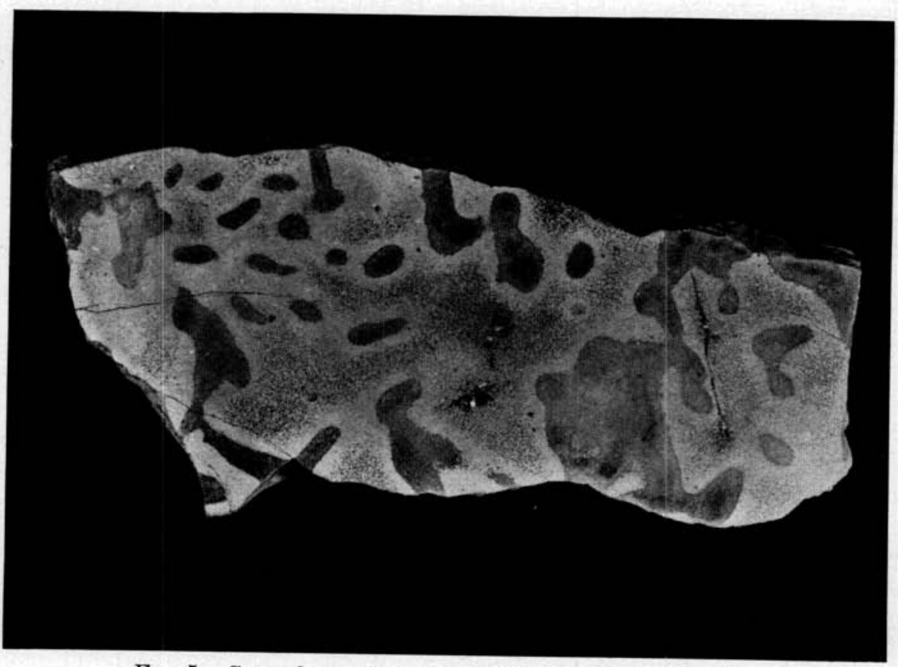

FIG. 5.—Ground, etched and stained "fucoidal" dolomite. Magnification approx. X 0.7.

cide with the dolomite boundaries in many places. These bedding fractures are commonly intersected by a series of sub-parallel oblique fractures, which also influence the shape of the dolomite masses in some places (Fig. 4). The third type of fracture is considerably smaller than the two noted above and consists of irregular to arcuate micro-fractures which commonly coincide with the boundaries of the dolomite masses. The intersection of these arcuate micro-fractures commonly produces cuspate projections of the dolomite into the limestone (Fig. 4).

5). *Festoons and streamers.* — A smaller amount of dolomite, commonly related to the discoidal masses, occurs in streamers and festoons of scattered crystals in the aphanitic limestone. Some of these develop parallel to fracture directions, while others show no obvious relationship to any structural feature. Still others represent the projections of the cusps or larger protuberances along the dolomite boundaries. These relationships suggest that such features may represent incipient stages of dolomitization.

6). *"Fucoidal" dolomite.* — The "fucoidal" dolomite represents an entirely different texture from any of those described above (Fig. 5). The dolomite in this occurs in two

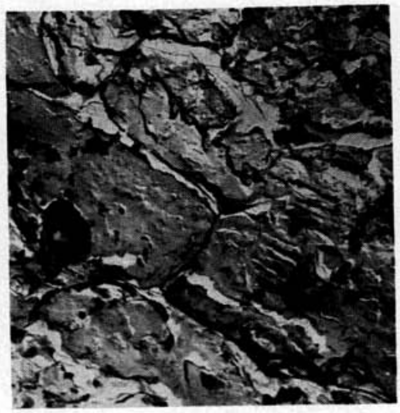

FIG. 7.—Electron micrograph of polished, etched surface of virtually unaltered Platteville limestone, showing rectangular fabric. Magnification approx. X 5,000.

FIG. 6.—Electron micrograph of polished etched surface of virtually undolomitized aphanitic Platteville limestone. Magnification approx. X 2,000.

FIG. 8.—Electron micrograph of fracture surface of virtually undolomitized Platteville limestone, showing acicular crystals, probably sepiolite. Magnification approx. X 2,000.

principal ways. In one of these the dolomite occurs within "fucoids" as rhombohedra 0.1 mm. across and associated with approximately equal amounts of coarse-grained calcite. Many of these dolomite crystals exhibit a darker central zone when stained with potassium ferricyanide. These "fucoidal" areas are surrounded by a second type in which the dolomite forms enclosing fronts of interlocking crystals with no interstitial calcite. Away from these fronts the density of distribution of dolomite crystals steadily decreases and is accompanied by corresponding increase in the interstitial aphanitic calcite.

Crypto-textures

In an attempt to detect any submicroscopic textural features which may have served as loci for the development of the various forms of dolomite, a considerable number of electron photomicrographs was made. These showed no apparent indication of any such controlling features, although they did reveal a number of other interesting features.

Thus, for example, the electron micrographs provided valuable information on the fabric of the aphanitic limestone. This fabric is commonly non-directional and is well illustrated in Figure 6. The grain size ranges from approximately 1 to 5μ. The random crystallographic orientations of the calcite may be determined from the faint cleavage traces shown in some of the photographs. A few photographs, however, exhibit a directional texture in which the grains are subrectangular and roughly aligned with one another (Fig. 7). We propose to discuss other aspects of these cryptotextural features in a later communication.

A striking mineralogical feature revealed by the electron micrographs is the presence in the aphanitic limestone of an acicular clay mineral which is probably sepiolite. (Fig. 8). The presence of such a magnesian clay mineral suggests a possible source for at least some of the magnesium involved in the dolomitization of the limestone. Further studies of this problem are being made.

Summary and Conclusions

The lithologic varieties of the Hazelwood member are due to different combinations of six textural types of dolomite. These different types suggest that the dolomitization may have proceeded in more than one way. One of these, the "fucoidal" type, was possibly controlled by the presence of fossils or by some primary texture within the original, almost lithographic limestone.

None of the other types can be related to primary features, with the exception of the discoidal masses which are roughly aligned parallel to the bedding. Even in this instance the controlling factor may have been the subsequently formed bedding fractures rather than the bedding itself. The dolomite spheroids, on the other hand, apparently represent one type of locus of dolomite nucleation in those parts of the limestone which are structureless, homogeneous and aphanitic.

Much of the dolomite is associated both directly and indirectly with fractures. Many of the "discoidal" masses of dolomite are transected by larger fractures which are parallel to the bedding. Parts of some of these masses follow oblique fractures. A distinctive feature of these discoidal masses is the coincidence of macro- and micro-fractures with their boundaries, in a manner highly suggestive of "boundary fences" to dolomitization. Much smaller amounts of dolomite occur along extremely irregular micro-"stylolitic" fractures.

Although preliminary electron microscopic study did not reveal any features that may have controlled the nucleation of dolomite to produce spheroids or other forms of distribution, the study demonstrated the presence of some interesting submicroscopic fabrics in the aphanitic parts of the limestone. Such micrographs also provided a valuable aid in determining the detailed mineralogy of these extremely fine grained rocks. Thus, for example, they indicated in this case the probable presence of a magnesian clay, such as sepiolite. It is suggested that this may provide at least some of the magnesium involved in the dolomitization.

Acknowledgments

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