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# PETROLOGY OF THE LAMINATED ARGILLACEOUS LIMESTONE AND DALMANELLA COQUINA IN THE HERMITAGE FORMATION (ORDOVICIAN) OF CENTRAL TENNESSEE

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## Introduction

### *General Statement*

Laminated argillaceous limestone (Wilson, 1949) is a prominent lithology of the Middle Ordovician strata in Central Tennessee. It is a complex lithology consisting of various textural types of calcite, fossils, and quartz sand. This lithology is the chief component of the Hermitage, the basal formation of the Nashville Group, but overlying strata as young as Leipers Limestone (Maysville) also contain this material. In the subsurface west of the Nashville Dome all the formations of the Nashville Group, as well as the Leipers Formation, grade laterally into Laminated argillaceous limestone. Though its complexity is apparent, this lithology never has been studied in detail.

Vertically and laterally the Laminated argillaceous limestone grades into a highly fossiliferous rock termed "*Dalmanella* coquina"[1] by Wilson (1949). These two intergrading lithologies are the subject of this investigation.

Two differing, but related, attributes of these rocks were investigated: (1) textural composition, and (2) mineral composition. It is believed that conclusions presented here result in better knowledge of the composition of the various textural components of the rock and their relation to bulk mineralogy. Though the lithologies intertongue, they had different origins, and so have differing compositions. This paper is adapted from a Masters thesis by Hatcher at Vanderbilt University directed by Stearns.

### *Present Investigation*

This paper reports the results of a detailed study which employed several techniques. The investigation commenced with measurement of stratigraphic sections and sampling; then examination of hand-specimens with hand lens and binocular microscope; followed by an examination of standard thin sections and etched thin sections (with calcite dissolved away by weak acid to emphasize minor less soluble constituents); point count modal analyses of the various materials seen in the standard and etched thin sections; X-ray diffraction studies of insoluble residues; and wet chemical analyses, which were calculated into percentages of minerals determined to be present by other techniques. The final data derived from this study are significant in themselves as a descriptive study of a lithology containing components of diverse origin, but perhaps equally important is the testing of the combinations of the various techniques which together give results that could not be established by one or two means alone.

The samples used in this investigation came from the Hermitage Formation in three localities in Central Tennessee (Figure 1). Locality No. 1 is near Columbia, Locality 2 near Franklin, and Locality 3 near Una. These will be referred to by number throughout the text of the paper.

## Acknowledgments

C. F. Bond of the Industrial Hygiene Service, Tennessee Department of Public Health, permitted the use of their X-ray diffractometer. D. F. Farrar, Chemist, Tennessee Division of Geology, made the chemical analyses. Miss Peggy Wrenne of the Geology Department, Vanderbilt University, made the photomicrographs. Robert A. Miller, Geologist, Tennessee Division of Geology, made the drawings of photomicrographs.

Advice by Prof. E. E. Russell, Geology Department, Mississippi State University, concerning techniques of preparing these samples for X-ray analyses is greatly appreciated.

Prof. W. B. Jewell, Chairman of the Geology Department, Vanderbilt University, Robert J. Floyd and Stuart W. Maher, Principal Geologists, Tennessee Division of Geology, and numerous other colleagues critically discussed this work and made editorial corrections in the manuscript.

## Megascopic Petrography

Generally, the Laminated argillaceous limestone of the Hermitage Formation is dark-gray to olive-gray or dusky yellowish-brown limestone containing variable amounts of very fine quartz sand. This rock is fine-grained with visible crystalline calcite locally scattered through the matrix or in small geodes or fracture fillings. Commonly, silty or shaly bands or partings run through the rock. Beds or partings of shale commonly separate the beds of limestone in a section. Brachiopod shells are not uncommon in this lithology, but generally the Laminated argillaceous limestone is unfossiliferous except where it alternates with highly fossiliferous beds of the *Dalmanella* coquina lithology. A few gastropods, ostracodes, cephalopods, and bryozoans also may be found (Wilson, 1949). Some of the brachiopod shells are replaced by light-blue chalcedony.

1. The modern proper generic name of this brachiopod is *Resserella*, but because of long historic usage, the name *Dalmanella* is herein retained.

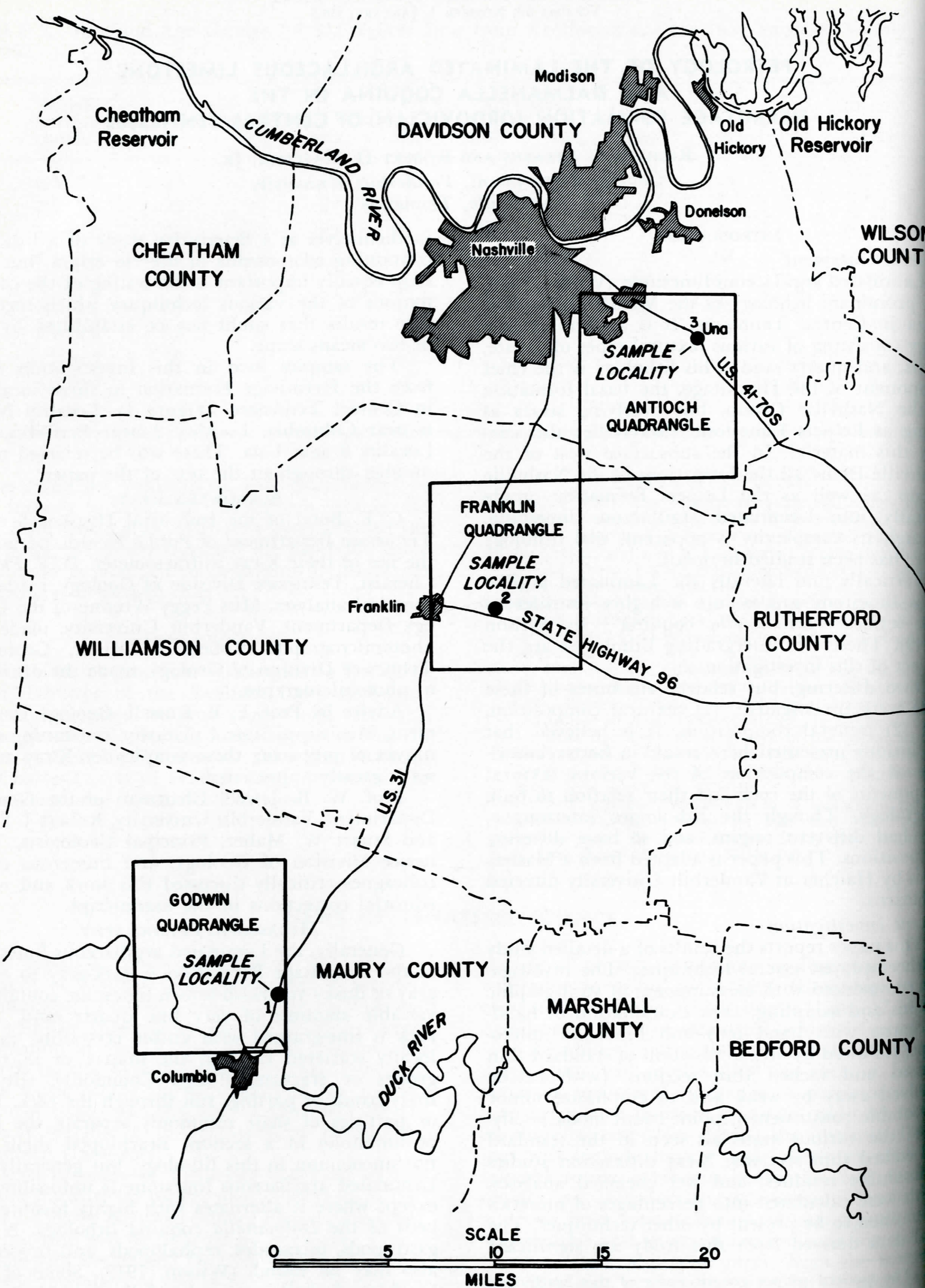



Fig. 1. Index map showing sample localities.

TABLE I. POINT COUNT ANALYSES (volume percentage of visible components)[1]

| | Laminated argillaceous limestone | | *Dalmanella* coquina | |
|---|---|---|---|---|
| | LOCALITY 1 (7 thin sections) | LOCALITY 2 (7 thin sections) | LOCALITY 1 (3 thin sections) | LOCALITY 1 (4 thin sections) |
| Microcrystalline ooze | 50.6 | 22.0 | 39.4 | 49.6 |
| Sparry calcite | 37.6 | 41.1 | 37.4 | 41.2 |
| Fibrous calcite | 1.9 | 4.5 | 10.4 | 2.1 |
| Quartz | 2.0 | 19.6 | 3.4 | 0.2 |
| Chalcedony | 1.4 | 0.2 | 6.5 | 2.5 |
| Dolomite | 0.3 | 0.2 | 0.6 | 2.4 |
| Opaque | 6.0 | 10.9 | 2.1 | 2.2 |
| Muscovite | 0.1 | 0.1 | 0.0 | ---- |
| Feldspar | 0.01 | 0.3 | 0.1 | ---- |
| TOTAL | 99.91 | 98.9 | 99.9 | 100.2 |

1. Made at a magnification of 80X, using a mechanical stage with click stops.

The color on the fresh and weathered surface indicates to some extent the composition of this member. On a fresh surface of Laminated argillaceous limesstone from Una, (Locality 3), dark-gray bands indicate higher concentrations of sand. At Columbia (Locality 1), alternating light- and dark-gray bands on a slightly weathered surface reflect the amount of clay present, the darker bands representing a higher clay content.

The *Dalmanella* coquina lithology is dominated by shells of the brachiopod *Dalmanella fertilis,* some of which are partially or wholly silicified by light-gray chalcedony. Other fossils occurring less commonly are straight-cone cephalopods and several microgastropods of the genus *Cyclora* in the more phosphatic samples. The cementing material in this rock consists of fine-grained light- to medium-gray calcite along with some more coarsely crystalline calcite, Commonly, patches of gray, fine-grained, sugary dolomitic material are present. These dolomitic portions contain few fossils.

### Description of Thin Sections

*General Statement*

Description of thin sections by qualitative observation is supplemented by quantitative determinations of each type of material. These "analyses" were made by using a mechanical stage with click-stops and identifying the material beneath the cross hair at 1,000 points per thin section.

The components counted in this manner are not all single minerals; some are textural varieties of essentially the same mineral composition, some are mineral mixtures, and some are of unknown mineral composition. The results are summarized in Table I.

Data from chemical analyses will be used in a later discussion to refine these descriptions so as to determine the mineral proportions of mixtures and to make some judgments of the composition of unknown material.

The major calcite textural components with which this study was concerned are sparry calcite (clear and relatively coarsely crystalline calcite aggregates), microcrystalline ooze, and fossil fragments. These are the components utilized by Folk (1959, 1961) in his petrographic classification of limestones. The sparry calcite of Folk has been subdivided further by Harbaugh (1961) into grain-growth calcite, blade calcite, encrusting calcite, and void-filling calcite. All but encrusting calcite were identified in thin sections of Laminated argillaceous limestone. Grain-growth and void-filling calcite were identified in thin sections of *Dalmanella* coquina.

### Laminated Argillaceous Limestone

*Carbonate Textural Types*

Thin sections of Laminated argillaceous display variable amounts of sparry calcite (28.36 to 46.86 per cent) and micro-crystalline ooze (21.98 to 61.33 per cent). In all the samples of this member from Localities 1 and 3 the microcrystalline ooze seems to be the dominant calcite textural component, whereas at Locality 2 sparry calcite predominates. A few grains of calcite sand, fossils, and fossil fragments are present in most samples.

Sparry calcite replaces microcrystalline ooze in the thin sections from Locality 2, where sparry calcite predominates. This is evidenced by large areas of crystalline calcite surrounding much smaller patches of unreplaced microcrystalline ooze. Although this type of replacement may occur in the rocks from other localities, it was not observed in the thin sections.

Some of the sparry calcite shows polysynthetic twinning. The untwinned spar commonly contains inclusions, in some instances resulting in a sieve texture, but the twinned crystals have few inclusions. Perhaps these inclusions prevent twinning.

The microcrystalline ooze probably is not pure carbonate. In the etched sections there are areas where the acid has left a blanket of brown clay after the carbonate was dissolved away. In some of the sections, on the other hand, areas of microcrystalline ooze seem to have been purer, because

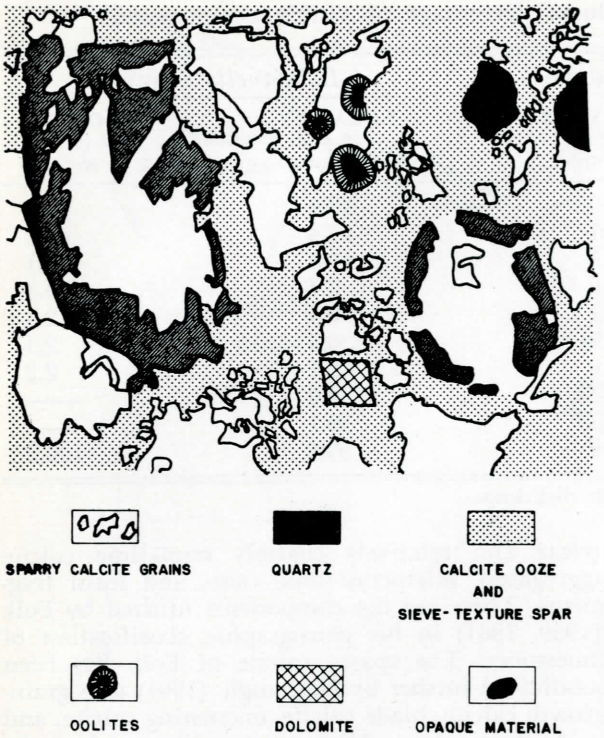



Fig. 2. Drawing of photomicrograph of Laminated argillaceons limestone. Note calcite replacing quartz.

clay was not present after etching. The sparry calcite which has many inclusions probably is recrystallized microcrystalline ooze, the inclusions consisting of clay and silt from the ooze.

Dolomite is the only other carbonate mineral observed in thin section. It appears as rhombs ranging from as large as ¼ mm. down to sizes barely discernible with the highest power objective. Rhombs were noted in all sections, but are not abundant (0.04 to 0.60 per cent).

*Silica Minerals*

Two silica minerals are present in the Laminated argillaceous limestone: quartz and chalcedony. Quartz is angular to subangular and contains variable amounts of inclusions. Quartz grains are imbedded in both microcrystalline ooze and sparry calcite, although in some thin sections they are concentrated preferentially in layers in one type or the other.

The quantity of quartz ranges from 1.6 to >50 per cent. At Locality 1 the maximum amount observed in thin section was less than 5 per cent, whereas at Locality 2 as much as 20 per cent was present, and at Locality 3 some samples are calcareous quartz sandstone (>50 per cent).

In some of the sections from Locality 2 quartz grains are partially replaced by sparry calcite. Replacement appears to have taken place from the inside of the grain outward, because generally the calcite is present in the center of the grains and is partly surrounded by an optically continuous rim of quartz. None of the partially replaced grain completely surrounds a center of calcite. Stuar Maher (personal communication) suggests tha these grains possibly are redeposited overgrowth of quartz on calcite, reflecting a much more com plicated history. Also present in the sections fro Locality 2 are quartz grains partially replaced b pyrite.

Chalcedony generally is present in thin section from Localities 1 and 3 but is not common i those from Locality 2. It occurs in isolated patche that apparently replace the groundmass (mainl microcrystalline ooze) or fossils and is believed t be of secondary origin, formed by the dissolutio of quartz and reprecipitation as chalcedony (Ca rozzi, 1960; Pettijohn, 1957; Folk, 1961).

*Minor Constituents*

As much as 15 per cent "opaque" material i present. It is not all completely opaque. Some i semitranslucent and is probably calcareous aggre gates of clay or silt.

Feldspar was noted in almost all the thi sections (0.02 to 0.28 per cent). Plagioclase feldspa ranging from $An_{24}$ to $An_{46}$ is the dominant typ but microcline and orthoclase also are present. Th amount of orthoclase indentified probably is con siderably less than the amount actually presen because of the ease of confusion with quartz grain of similar size and shape.

Although rarely seen, grains of chlorite, biotite and muscovite were identified in the thin section of Laminated argillaceous limestone. The mos common fossils are brachiopods, principally *Dal manella fertilis,* but a few gastropods and bryozoan also were observed.

Pyrite was visible in the thin sections as opaqu 4- to 8-sided grains of various sizes. These grain alter to "limonite" upon the slightest weathering but the crystal outline is maintained even after mos of the carbonate has been leached.

## Dalmanella Coquina

*Major Constituents*

In addition to sparry calcite, (39.3 per cen and microcrystalline ooze (44.5 per cent), shells o the brachiopod *Dalmanella fertilis* are the majo constituents.

The patches of sparry calcite present in th rock generally are larger than those in the Lam nated argillaceous limestone, but they exhibit th same characteristics of twinning, inclusions, et Sparry calcite is present in slightly smaller amoun than microcrystalline ooze.

Microcrystalline ooze is similar to that in Lam nated argillaceous limestone, but in several section patches of this ooze contain numerous dolomit rhombs of different sizes. These patches may com prise as much as half of a thin section. The dolo mite patches have sharp boundaries between then and "normal" rock and are unfossiliferous. Prob ably these patches have undergone diagenetic o secondary dolomitization. The total amount of dolo mite rhombs from these patches and elsewhere in the section is 2.4 per cent.

The shells of *Dalmanella fertilis* range in length up to about 1 cm. and are composed of calcite of a texture that resembles Manila rope. Where shells are replaced by chalcedony they retain the ropey texture. Such shells seem to be most susceptible to silica replacement, because wherever a small amount of chalcedony is present it is restricted to the *Dalmanella* shells. Where a relatively large amount is present, other fossils and even the microcrystalline groundmass are replaced partially. Chalcedony ranges from 2.5 to 6.8 per cent.

*Minor Constitutents*

Opaque material (total 1.4 per cent) is present as brown phosphatic replacement of the gastropod *Cyclora minuta,* in addition to the semitranslucent or totally opaque material also present in Laminated argillaceous limestone.

Quartz grains like those in the Laminated argillaceous limestone are a minor constituent in these sections (1.8 per cent). Pyrite, and "limonite" formed as alteration of pyrite, are also minor constituents.

### Mineralogy of the Fined-Grained Acid Insoluble Residue

The less than 5 micron insoluble fraction was separated from the limestone by a combination of procedures described by Ostrom (1961) and E. E. Russell (personal communication) and by trial and error. A General Electric X-ray diffractometer using Cu ($K\alpha$) radiation employing 50 Kv. with 15 ma. was used to determine the mineralogy of these residues. All the samples determined by this method came from Locality 1. Only muscovite, kaolinite, quartz, and chlorite were found. All the samples contained "illite" (muscovite) and $\alpha$-quartz. Kaolinite was present in all the samples. Chlorite definitely was present in two samples of Laminated argillaceous limestone and probably in one other sample of Laminated argillaceous and one of *Dalmanella* coquina. Actually, the 14.2 A basal spacing peak for chlorite was not observed, possibly because of starting at $5° 2\theta$, or because of low concentration of that mineral.

### Chemical Analyses

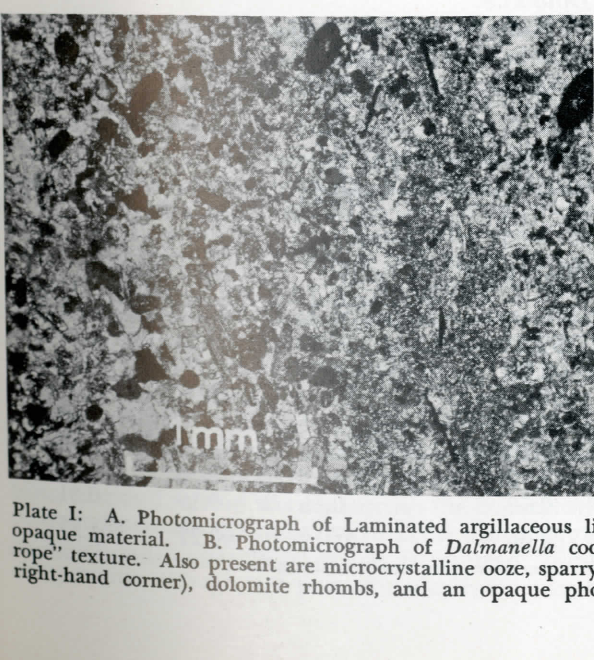
Seven chemical analyses of typical and composite samples were made by D. F. Farrar, Chemist, Tennessee Division of Geology, from Localities 1 and 2. The results are presented in Table 2. These will be used to calculate the mineralogy as a supplement to point count modal analyses from thin sections.

### Normative Calculations

It is desirable to supplement the modal and X-ray analyses with quantities obtained from chemical analyses, because only a few modal "components" give pure mineral quantities (eg., quartz grains and chalcedony are silica). Others (e.g., "opaque") tell us essentially nothing about the mineralogy. It is hoped that by comparing theoretical minerals which can be calculated from chemical data we can better determine the composition of the unknown components.

### Method of Calculating

In order to use chemical calculations it is necessary to have a method that permits a narrowing of the choices as each mineral is calculated. For example, we already know from X-ray data that muscovite and kaolinite both are present; both contain $Al_2O_3$ and $SiO_2$ but only muscovite contains $K_2O$. Our approach is to calculate the percentage of muscovite by using $K_2O$, a unique oxide; this utilizes a certain amount of $Al_2O_3$ and $SiO_2$. Now we have a unique remainder of $Al_2O_3$ which can be used to calculate kaolinite. When both muscovite and kaolinite have been calculated, the remainder of $SiO_2$ must all be in quartz (feldspar being quantitatively negligible).



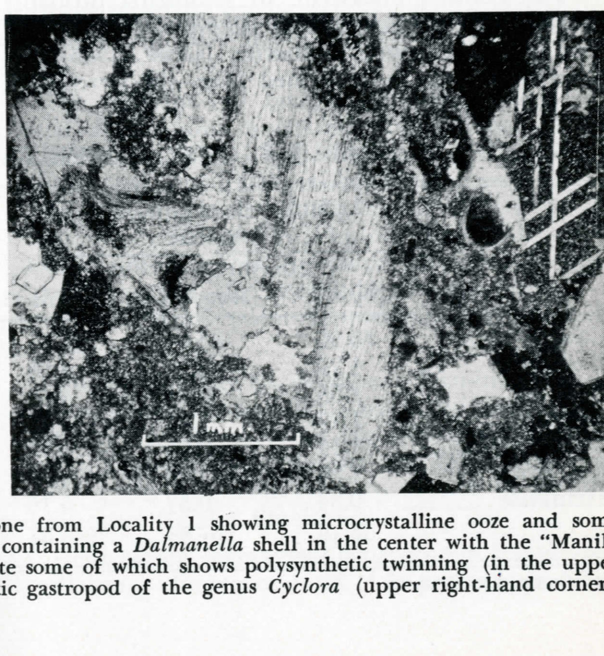



Plate I: A. Photomicrograph of Laminated argillaceous limestone from Locality 1 showing microcrystalline ooze and some opaque material. B. Photomicrograph of *Dalmanella* coquina containing a *Dalmanella* shell in the center with the "Manila rope" texture. Also present are microcrystalline ooze, sparry calcite some of which shows polysynthetic twinning (in the upper right-hand corner), dolomite rhombs, and an opaque phosphatic gastropod of the genus *Cyclora* (upper right-hand corner).

TABLE 2. CHEMICAL ANALYSES (in per cent)

| | LOCALITY 1 | | | | | | LOCALIT |
|---|---|---|---|---|---|---|---|
| Samples | [1]I | [1]II | [2]III | [2]IV | [1,3]I-C | [2,3]II-C | [1,3]C |
| Acid insoluble | 6.62 | 6.46 | 11.62 | 13.78 | 9.20 | 4.62 | 32.6 |
| $SiO_2$ | 5.20 | 5.04 | 10.92 | 12.24 | 7.20 | 4.16 | 28.5 |
| $Fe_2O_3$ | 0.34 | 0.16 | 0.19 | 0.31 | 0.37 | 0.15 | 0.6 |
| $Al_2O_3$ | 1.08 | 0.86 | 0.41 | 1.56 | 1.63 | 0.55 | 1.7 |
| $P_2O_5$ | 0.50 | 0.40 | 0.15 | 1.10 | 0.40 | 0.30 | 4.3 |
| CaO | 49.73 | 50.13 | 47.47 | 42.93 | 48.96 | 52.08 | 35.0 |
| MgO | 1.02 | 1.01 | 1.04 | 3.62 | 1.07 | 0.85 | 0.6 |
| $K_2O$ | 0.27 | 0.18 | 0.09 | 0.27 | 0.06 | 0.06 | 0.2 |
| $CO_2$ | 39.80 | 40.70 | 38.34 | 36.16 | 38.80 | 40.84 | 23.7 |
| Ign. loss | 40.87 | 41.38 | 39.30 | 37.46 | 38.94 | 41.20 | 23.9 |
| TOTAL | 99.01 | 99.16 | 99.57 | 99.49 | 98.63 | 99.35 | 95.0 |

1. Laminated argillaceous limestone.
2. *Dalmanella* coquina.
3. Composite analysis.

In calculating the normative minerals, equations analogous to the following example were used:

$$\frac{\%K_2O}{\text{Mol. wt. } K_2O} = \frac{\%K\ AlSi_3\ O_8}{\text{Mol. wt. } K\ Al\ Si_3O_8}$$

These are chemically analogous to the CIPW method of recalculating chemical analyses of igneous rocks, and were derived in detail by Hatcher (1962). Table 3 summarizes the normative minerals calculated.

### Normative Minerals

The normative minerals selected (except for hematite and apatite) are minerals observed in thin sections or identified by X-ray diffraction. Even though discrepancies are created by using theoretical normative compositions, these differences are insignificant compared with the increase in accuracy of mineral determination.

*Muscovite and Kaolinite*

Fine-grained muscovite in sediments probably contains more aluminum in isomorphous substitution than does pure muscovite (Grim, 1953). Because muscovite is calculated from the percentage of potash and not alumina, this does not affect t percentage of that mineral. However, because composition of pure muscovite is used in the c culations, some alumina assigned to kaolinite a ually is in muscovite. Kaolinite therefore is ov estimated. This is probably the only signific theoretical error in calculating kaolinite, beca there is thought to be little substitution of a minum for silicon in natural kaolinites (Stubic and Roy, 1961).

*Calcite*

Calcite probably contains isomorphous sub tuted magnesium, the evidence for which is do mite rhombs that appear to have exsolved. Also microcrystalline ooze and sparry calcite with inc sions dolomite is mixed with clay and phospha material. Normative calculations thus undere mate the mineral calcite.

*Dolomite*

Some of the normative dolomite is present rhombs, but not much is present as the mine dolomite; rather, magnesium substitutes for calci

TABLE 3. NORMATIVE CALCULATIONS (weight percentage)

| | Laminated argillaceous limestone | | | | *Dalmanella* coquina | | |
|---|---|---|---|---|---|---|---|
| | LOCALITY 1 | | | LOCALITY 2 | LOCALITY 1 | | |
| | Sample 1 | Sample 1-C[1] | Sample 11 | | Sample 11-C-[1] | Sample 111 | Sample IV |
| Calcite | 85.90 | 84.6 | 86.8 | 57.9 | 90.7 | 81.9 | 66.9 |
| Dolomite | 4.70 | 4.93 | 4.65 | 2.90 | 3.91 | 4.98 | 16.6 |
| Quartz | 3.65 | 6.24 | 4.54 | 27.5 | 3.83 | 10.9 | 11.3 |
| Apatite | 1.77 | 1.42 | 1.42 | 15.3 | 1.06 | 0.53 | 3.91 |
| Muscovite | 1.14 | 0.25 | 0.76 | 1.10 | 0.25 | 0.38 | 1.14 |
| Kaolinite | 1.99 | 3.96 | 1.68 | 3.79 | 1.23 | 0.79 | 3.21 |
| Hematite | 0.34 | 0.37 | 0.16 | 0.60 | 0.15 | 0.19 | 0.31 |
| | 99.49 | 101.77 | 100.01 | 108.09 | 101.13 | 99.27 | 104.37 |

1. Composite analysis.

in the calcite crystal lattice. Some magnesium may be accepted in the calcite crystal structure without the structure reverting to that of dolomite (Goldsmith, 1959). Normative calculation therefore will overestimate the mineral dolomite at the expense of calcite.

*Quartz*

Normative quartz is distributed in quartz, chalcedony, and fossil chalcedony (chalcedonic material that has replaced calcite in fossils, mainly *Dalmanella* shells). Many of the quartz grains contain obvious impurities as inclusions. Though these are of unknown nature and composition, they are quantitatively insignificant and do not affect comparison of normative quartz with observed quartz.

*Apatite*

The phosphate mineral present is probably not apatite, but some polymeric, cryptocrystalline or amorphous "mineral" of indefinite composition, such as collophane. This may account for the excess of $CO_2$ in all but one of the norms. Apatite was chosen arbitrarily because of its definite composition.

*Hematite*

Pyrite rather than hematite is the iron mineral present in these rocks, but hematite will suffice for approximate calculation of oxides and hydrated oxides. Also, some of the iron probably is contained in chlorite, which was seen in a few thin sections and detected by X-ray diffraction. Chlorite was not selected as one of the normative minerals because of its indefinite composition.

*Feldspar*

Feldspar was not calculated as a part of the norm. Only a few detrital grains were seen. It is quantitatively negligible, even though some of the grains identified as quartz may be orthoclase. This omission results in a slight overestimate of quartz, kaolinite, and perhaps muscovite.

## Summary and Conclusions

*General Statement*

Laminated argillaceous and *Dalmanella* coquina limestones, prominent lithologies of the Middle Ordovician rocks of Central Tennessee, though grossly different megascopically, actually are found to contain similar materials in variable proportions when viewed under the microscope. The units can be divided logically into component textural and mineral types, which are (in decreasing proportions): (1) calcareous ooze, (2) sparry, crystalline calcite, (3) opaque material, (4) quartz grains, (5) chalcedony, (6) fibrous fossil shell calcite, (7) dolomite crystals, (8) feldspar grains, and (9) muscovite.

By applying several techniques, information accumulated with each method yields supplemental data: (1) examination of samples by low-power binocular and in thin section furnish the framework of directly visible textural and mineral components to which additional information is referred; these components, though not pure chemically or mineralogically, are the "common sense" units of observation, (2) by etching the sections, dolomite, clay, and other insolubles are made visible and can be referred to the textural-compositional type in which they occur; (3) X-ray analysis identifies the fine-grained insoluble minerals but cannot reveal their distribution in the components; (4) normative mineral calculation from chemical analyses indicates the quantities of minerals that were identified by other means.

*Origin of the Textural and Mineral Components*

Ooze, fossil shells, sand, and silt-size detrital material, grains of quartz, feldspar, and perhaps muscovite, clay and some phosphatic material of unknown mineralogical composition were deposited originally. Sparry calcite and chalcedony result from diagenetic recrystallization of calcite in ooze and silica from quartz grains, respectively, dolomite is exsolved from supersaturated calcite, and opaque material probably is due to diagenetic formation of iron sulfide and phosphatic material which stained or replaced patches of ooze, spar, or fossils.

*Mineral Composition of Individual Components*

*Sparry Calcite* (average 33.2 percent of Laminated argillaceous limestone and 39.3 percent of *Dalmanella* coquina). Although sparry calcite appears to be much purer than other carbonate components, it in fact contains appreciable impurities. Calcite is saturated with magnesium (approximately the equivalent of 5 percent dolomite). Also, because it probably originated from recrystallization of fine-grained ooze, it contains disseminated clay (1 to 4 percent), fine quartz (probably 2 percent), and perhaps small phosphatic mineral fragments. It also probably contains submicroscopic dolomite crystals.

*Ooze* (average 41.0 percent of Laminated argillaceous limestone and 44.5 percent of *Dalmanella* coquina). This material is identical in composition with the purer-appearing spar. Some opaque patches probably are ooze made opaque by iron sulfide stains.

*Opaque Material* (average 8.5 percent in Laminated argillaceous limestone and 2.1 percent of *Dalmanella* coquina). This material remains quantitatively unknown. Calcite, phosphate, pyrite, and perhaps organic material (in decreasing proportion) compose this material. It is known that all the phosphate is not contained in opaque material, because in some samples chemically determined phosphate exceeds the total point counted opaque material present.

*Quartz* (average 8.0 percent in Laminated argillaceous limestone and 1.8 percent in *Dalmanella* coquina). Quartz in these rocks is a nearly pure mineral. The few inclusions are inherited from older rocks and have no quantitative or genetic significance for this limestone.

*Chalcedony* (averages 1.0 percent in Laminated argillaceous limestone and 4.5 percent in *Dal-*

*manella* coquina). No inclusions were seen in this material. Except for water in its crystal lattice, it is probably pure silica.

*Fibrous Calcite* (averages 2.7 percent in Laminated argillaceous limestone and 6.2 percent in *Dalmanella* coquina). This is believed to be nearly pure calcite formed by brachiopod shells, mainly *Dalmanella fertilis.*

*Dolomite* (averages 0.28 percent of Laminated argillaceous limestone and 1.5 percent of *Dalmanella* coquina). This material is probably pure, having been exsolved from calcite oversaturated with magnesium.

*Feldspar* (0.1 percent of Laminated argillaceous limestone and 0.04 percent of *Dalmanella* coquina). As in quartz, the minor inclusions are of no significance. The minerals are essentially pure.

*Muscovite* (averages 0.09 percent in Laminated argillaceous limestone and is rarely seen in *Dalmanella* coquina). The muscovite seen was individual crystals without inclusions.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## A NEW FIND AT THE SMITHVILLE METEORITE LOCALITY


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### Earlier Finds

Farrington (1909) has summarized the known history of Smithville meteorite finds prior to 1909. No further finds have been reported since. Briefly, then, the record is as follows:

| Date Found | | Weight (Lbs.) | Location |
|---|---|---|---|
| 1. | c.1839 | over 36 | "a few miles west of Cany Fork, near the road from Liberty" |
| 2. | c.1863 | 8 | Berry Cantrell farm |
| 3. | c.1863 | over 1 | Berry Cantrell farm |
| 4. | 1892 | 15 | J. D. Whaley farm |
| 5. | 1892 | 65 | James Beckwith farm |
| 6. | 1892 | 7 | J. D. Whaley farm |

Number 1 was described by Troost (1840, 1845) who purchased it between 1840 and 1845. Some "chips" had been removed for assaying; hence the original weight is uncertain. If "a few miles" in the location as given by Troost was actually 7 miles, this find came from the same area as the others.

Numbers 2 and 3 were described by Glenn (1904), who acquired them in 1903 but says they were found "about 40 years" earlier. The smaller mass (No. 3) had "had a portion removed."

Numbers 4, 5, and 6 were described by Huntington (1894). They had been purchased in 1893 by H. A. Ward of Rochester, N.Y., from Herman Meyer, a bank cashier in Carthage, Tennessee. Huntington quotes a letter from Meyer to Wa stating that "the spot where (they were) found three-eighths of a mile south from the Smithvil and Lebanon Pike, two miles from Smithville, a on (the) extreme southwest field of J. D. Whal and adjoining field of James Beckwith." Th boundary between the Beckwith and Whaley farm has shifted back and forth over the years, but th west line in 1892 probably followed Falls Cree as shown in Figure 1.

What may have been a seventh specimen mentioned by Glenn (1904) as having been se to the U.S. National Museum. However, this spe men is not listed in Merrill's catalog of the museu collection as of 1916.

### 1962 Find

In January, 1962, the writer visited the Smit ville locality and spent several days searching favo able stretches of ground with an electromagnet metal detector. The device used was copied fro one owned by Mr. H. O. Stockwell of Hutchinso Kansas, custom-built for him quite a few years ag by Hedden Metal Locators, Inc., formerly of Miam Fla. It features overlapping D-shaped transmittin and receiving coils about 4 feet in diameter and mounted on a wooden wheelbarrow-like frame.

In the absence of information concerning th location of the Cantrell property, plots close to th Beckwith-Whaley line were sampled more or le at random. It now appears that better results migh have been obtained by concentrating on an ar farther southwest. (See Figure 1.) A further sear is planned for January, 1963.