HIGH-CALCIUM LIMESTONE DEPOSITS OF CUMBERLAND VALLEY, PENNSYLVANIA[1]

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ABSTRACT

High-calcium limestones occur in the upper part of the New Market Formation, of Lower Middle Ordovician age, in Franklin and Cumberland Counties, Pennsylvania. The high-calcium facies of the New Market Formation is represented by sublithographic limestone or vaughanite, which probably formed in quiet water, low-energy environments such as intershoal lagoons, or in protected bays similar to the present-day Florida Bay environment. Rapid facies changes are characteristic of the strata.

The better grade of stone lies in the upper 100 to 125 feet of the New Market Formation and averages 95–97% calcium carbonate. Silica and magnesia are about equal in amount as impurities.

One high-calcium belt extends from the Maryland state line through Chambersburg and Newville to beyond Carlisle. The strata in this belt are structurally complex, which requires careful field study and core-drilling prior to exploitation.

Stone suitable for blast-furnace flux is present in relatively large amounts, but stone for open-hearth use or portland cement requires more selective quarrying.

INTRODUCTION

At the request of the Industrial Development Department, the Pennsylvania Railroad, a study was made, in 1954, of potential sources of metallurgical limestone lying near the Railroad and as close as possible to eastern markets. The limestones of the Cumberland Valley district were chosen for investigation for several reasons: this belt has produced large quantities of fluxing stone in Maryland, rock of the same age has been quarried for many years in West Virginia, and small quarries for flux were once operated near Williamson, a few miles west of the belt investigated. The formation studied is the New Market Limestone, St. Paul Group, Middle Ordovician (Neuman, 1951).

PREVIOUS WORK

The area was mapped many years ago by the U. S. Geological Survey (Stose, 1909). More recently, stratigraphic studies were made on the St. Paul Group by Neuman (1951), and on the limestones above the St. Paul Group by Craig (1949). Miller's book (1934) on the limestones of Pennsylvania was useful in compiling data from the early Pennsylvania Geological Surveys. Publications on the limestones in Washington County of Maryland (Cloos, 1941; Cloos et al., 1951), the Shenandoah Valley of Virginia (Edmundson, 1945), and the Martinsburg area of West Virginia (McCue, Lucke, and Woodward, 1939) also provided valuable data. More recent studies on the area have been published by Swartz and Thompson (1958) and O'Neill (1964).

PROCEDURES

During June and July, 1954, F. M. Swain and J. C. Kraft, assisted by D. B. Lewis, studied the St. Paul Limestone in old quarries in Pinesburg, Maryland, and other localities, and visited and located on maps the best outcrops of this limestone along a 30-mile belt between Greencastle and Carlisle, Pennsylvania. Using this information, Swain and Kraft examined the New Market Limestone along the outcrop in order to select core-drilling localities. After necessary options

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and drilling permits had been obtained, core drilling was begun near Kauffman. Between July 15 and September 1, eleven core holes were drilled in the area between Greencastle and Carlisle. The locations of the core holes are shown on figure 1, and a plate of one of the drill sites is given in figure 2.

The drilling was done by the Longyear Company of Minneapolis. J. G. Palacas supervised most of the drilling and described some of the cores. The other cores were shipped to Minneapolis for description and chemical analysis.

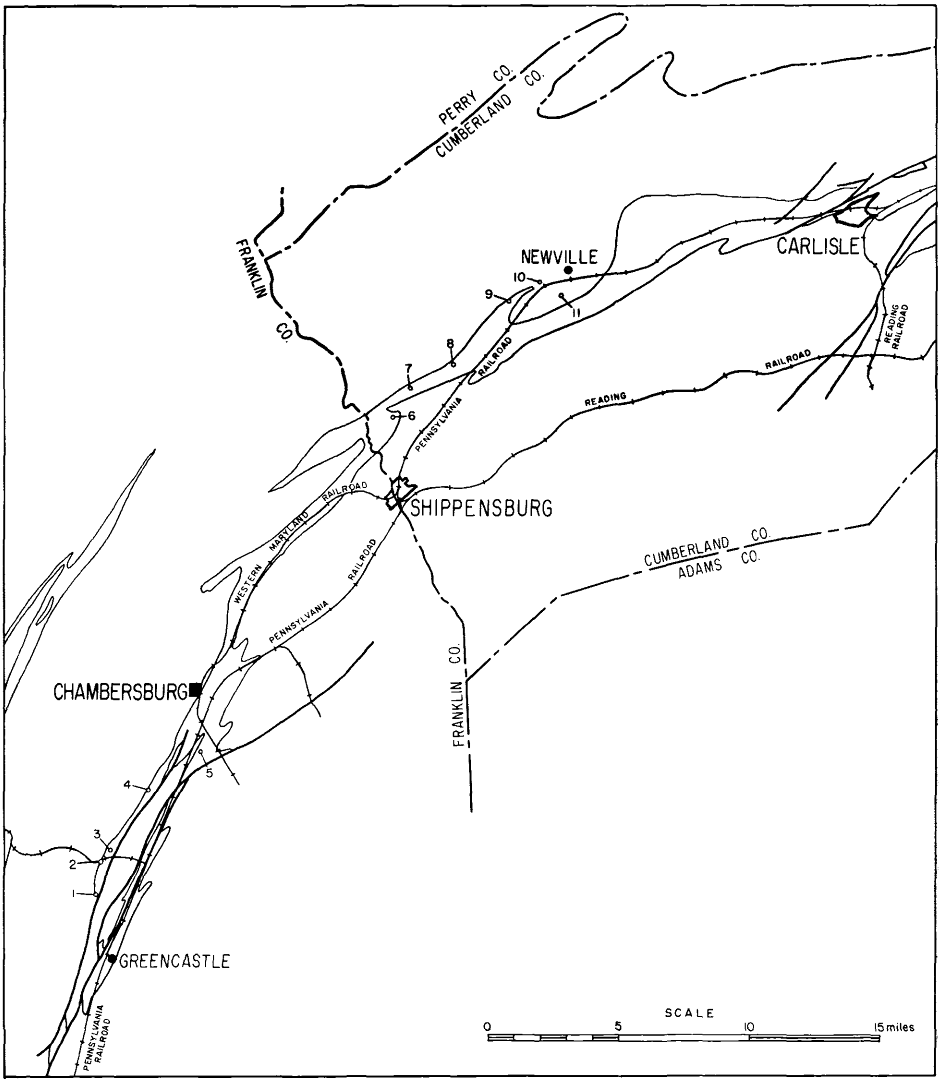
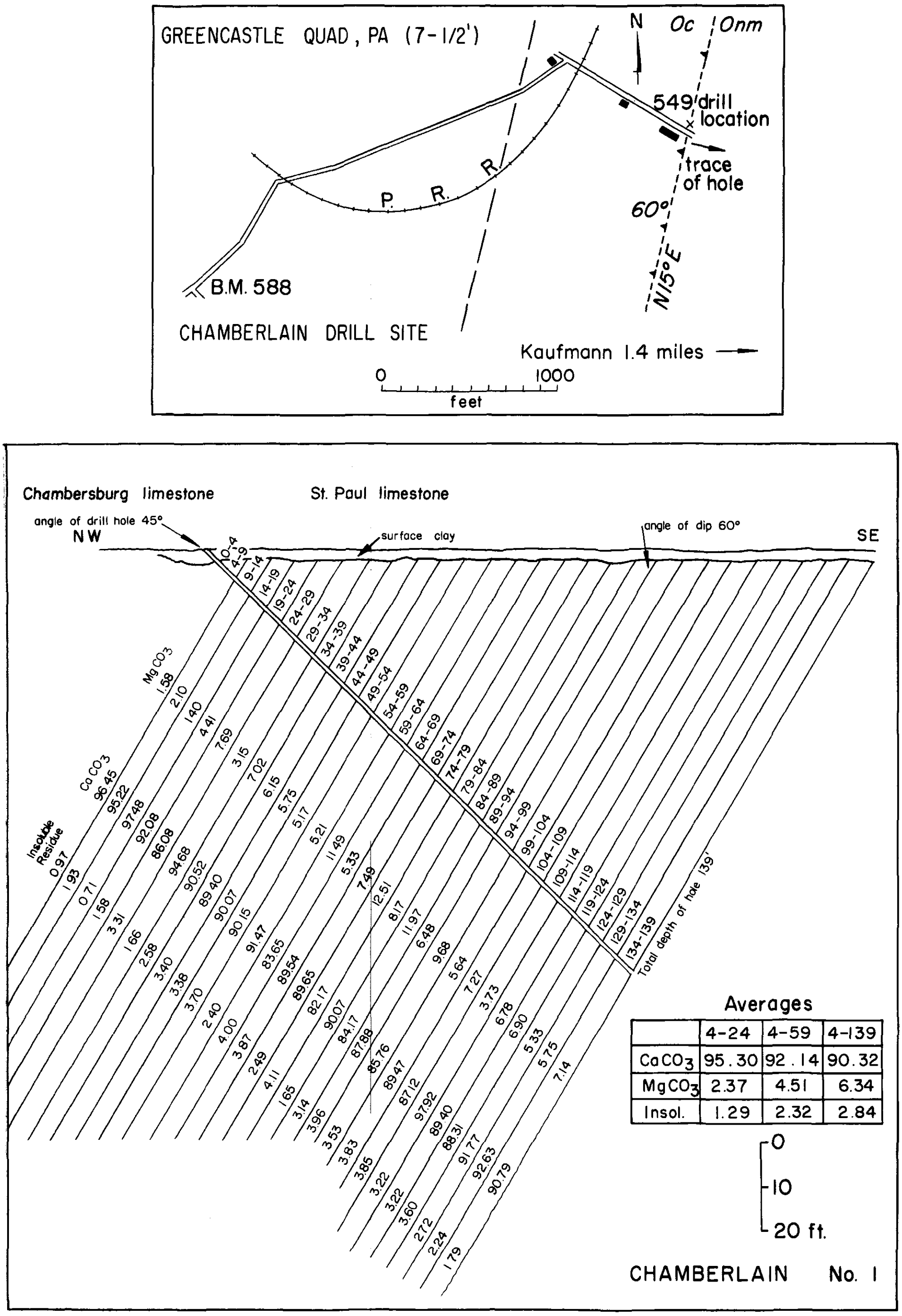


FIGURE 1. Index map showing areas investigated in Franklin and Cumberland Counties, Pennsylvania. The core holes are located by number; further data may be obtained from the Pennsylvania Railroad. The outcrop belt of the St. Paul Group is taken from the Geologic Map of Pennsylvania, 1960. The fact that some of the core holes appear to lie outside the belt of outcrop of the St. Paul Group indicates the need for the details of the State's Geologic Map to be corrected. A corrected map is in the files of the Pennsylvania Railroad.



	4-24	4-59	4-139
$CaCO_3$	95.30	92.14	90.32
$MgCO_3$	2.37	4.51	6.34
Insol.	1.29	2.32	2.84

FIGURE 2. Cross-section and plate of Chamberlain No. 1 core hole (No. 2 on index map). Similar information may be obtained on other core-hole sites from the Pennsylvania Railroad.

Swain and Kraft described these cores, and analyses were performed by the Twin City Testing Laboratories, St. Paul. Permanent storage of the cores is in the freight station of the Pennsylvania Railroad at Chambersburg, Pennsylvania.

Petrographic study was conducted on some limestone samples of the St. Paul group by Palacas as a Master of Science thesis under F. M. Swartz at the Pennsylvania State University.

The stratigraphic sequence of the Middle Ordovician limestone formations in the Cumberland Valley is as follows:

ORDOVICIAN SYSTEM
- CHAMPLAINIAN SERIES
  - MOHAWKIAN STAGE
    - Martinsburg Shale
    - Oranda Formation, shale and limestone
    - Chambersburg Limestone, including Mercersburg and underlying Shippensburg Limestone Members of Craig (1949)
  - CHAZYAN STAGE
    - St. Paul Group
      - New Market Limestone
      - Row Park Limestone
- CANADIAN SERIES
  - Beekmantown Group

ST. PAUL GROUP

The purest limestone in the lower Middle Ordovician of this area is light to medium "dove" gray, very dense to lithographic stone, called "vaughanite" (Kindle, 1923). Although it is distributed throughout this section, the vaughanite is most abundant and thickest in the upper part of the New Market Formation. Stone resembling vaughanite in color and texture is present in the upper Beekmantown, but it is high in magnesium. A little vaughanite-like rock also occurs in the lower part of the Chambersburg Formation.

Vaughanites of the St. Paul Group have been quarried for fluxing stone in the area around Martinsburg, West Virginia, and in smaller quantities in Virginia, Maryland and near Williamson, Pennsylvania. Some of the layers of vaughanite are pure enough for chemical lime, but other closely interbedded layers contain over 2 per cent non-calcium-carbonate fractions.

The work of Neuman (1951) revealed several important stratigraphic features with regard to the St. Paul Group, which are discussed below.

1. The Stones River Limestone of Bassler (1905, 1919) and Stose (1909) in Pennsylvania and Maryland is not the same as the Stones River of Safford (1851) in central Tennessee. The strata in Pennsylvania and Maryland were renamed by Neuman the St. Paul Group, from St. Paul's Church nine miles west of Hagerstown, Maryland.

2. The St. Paul Group is underlain by dolomite and limestone of the Beekmantown Group, and overlain by the Chambersburg Limestone. The contact between the Chambersburg and underlying St. Paul, in most places south of Chambersburg, Pennsylvania, is marked by a fairly abrupt change from thinly laminated, nodular, dark gray, fossiliferous, fine- to medium-crystalline limestone above to medium- and thick-bedded lighter gray, less fossiliferous, sublithographic vaughantic limestone below.

The contact with the underlying Beekmantown, in some places (e.g., Marion, Pennsylvania), is marked by a basal 50-foot vaughanitic limestone of the Row Park Formation underlain by laminated dolomitic limestone of the Beekmantown Group that weathers yellowish gray. In other localities, as at the east edge of Greencastle, there is striking interfingering of Beekmantown and lower St. Paul ithologies in the contact zone.

3. The St. Paul Group was divided by Neuman into two formations, the New Market Formation above and the Row Park Formation below. The New Market had previously been named by Cooper and Cooper (1946) for limestone exposed in the Shenandoah Valley, Virginia. The New Market Limestone comprises vaughanite, fine- and medium-crystalline limestone, and magnesian limestone, with scattered black chert nodules in the lower part. The coral *Tetradium* occurs in many of the New Market vaughanites. The most conspicuous fossils in the drill cores of the New Market are smooth leperditiid and leperditellid ostracodes (Swain, 1957).

The Row Park Limestone is mostly dark gray, finely crystalline limestone, in part laminated, typically medium- to thick-bedded, and containing a few coarsely crystalline calcarenite layers, considerable magnesian limestone, and scattered black chert nodules in the middle and upper parts. Vaughanite beds, mostly only a few feet thick, occur at various levels throughout the Row Park. At the base of the Row Park, in some places, there is a vaughanite bed more than 50 feet thick. The Row Park vaughanites do not contain corals and contain more magnesium than those of the New Market. The Row Park limestones contain abundant specimens of the large gastropod *Maclurites magnus* Lesueur.

4. The thickness of the New Market Limestone ranges from 90 feet near Winchester, Virginia, to 710 feet near Welsh Run, Pennsylvania. Near Kauffman, Pennsylvania, the New Market is 460 feet thick and the Row Park Limestone is 545 feet thick. The Row Park thins southward and disappears a short distance south of the Maryland-West Virginia State line. Its maximum thickness, 600 feet is reached near Welsh Run, Pennsylvania. In the present study, no complete section of the New Market Formation was measured, because only the upper New Market appeared to contain suitable metallurgical limestone.

ORIGIN OF AND LATERAL VARIATION IN NEW MARKET LIMESTONE

The faunas of the New Market Limestone consist of calcareous algae, the coral *Tetradium*, and both large leperditiid, small leperditellid, and eurychilinid Ostracoda (Swain, 1957, 1962). The Ostracoda are types that probably lived in shallow water and, although all represent extinct families, they probably fed on algal material, judging from the diet of similar modern faunas. The vaughanites are believed by the writers to have been deposited in quiet-water, low-energy environments such as intershoal lagoons or in protected bays similar to the present day Florida Bay environment.

Marked lateral and vertical variations occur in the magnesium and silica contents, especially in the lower New Market and Row Park Limestones. Alternation of dolomitic and nondolomitic beds in the two formations may represent minor oscillations of sea level in which the magnesian layers were formed in somewhat hypersaline water during intervals of low water levels or of higher evaporation rates, or both, whereas the high-calcium layers formed in less saline waters during times of higher sea level or of lower evaporation rate or both. The conclusion that dolomitization is related to hypersaline conditions is consistent with recent studies of modern processes of dolomitization (Deffeyes, Lucia and Weyl, 1964).

The progression of events from late Beekmantown through St. Paul and early Chambersburg time is thought to have included the following sequence. (1) The upper Beekmantown Dolomite was deposited under conditions of high rates of evaporation in a shallow-water marine environment, essentially below wave base (see Osmond, 1954 for discussion of similar deposits in Silurian and Devonian of Nevada). (2) The Row Park magnesian vaughanites represent deposits of a shallow sea in which the evaporation rate was somewhat less than in late Beekmantown time and into which silica, argillaceous material, and organic matter were introduced from terrestrial sources. (3) The Row Park fine- and medium-crystalline limestones represent intervals of shallow water during which carbonates that had been deposited on shoals were reworked into nearby areas of deeper water (Osmond, 1954). There was moderate development of shoal-and-depression submarine topography in the area during this time interval. (4) In New Market time, there was further development of shoal-and-depression marine topography; the purer *Tetradium*-bearing vaughanites formed in depressions, while the more granular ostracodal magnesian limestones represented material that was either deposited on shoals or was reworked from shoals out over the depressional areas. Fluctuation of sea level is implied in this interpretation. Rapid lateral facies changes that characterize the New Market vaughanites can be explained in this way. (5) In Chambersburg time, most of the carbonate deposition of this area took place in shoal environments that were receiving appreciable terrestrial organic and clastic material.

Some of the Row Park and New Market beds exhibit minute laminations as well as large-scale banding (called "tiger-stripe" by Kay, 1943, 1944) in otherwise massive-appearing strata. The laminations and banding are the result of variations in amount of dolomite crystals, amount of organic and argillaceous matter, and intercalation of calcarenite layers. Although most of the dolomite in the St. Paul Group is believed by the writers to be primary or penecontemporaneous, some may have been introduced secondarily by waters moving through the strata. The minute laminae of dolomite in the deposits are considered to be primary concentrations, perhaps formed during periods of high rates of evaporation of the sea water. Thicker and more irregular lenticular laminae may have resulted in part from additions by circulating waters.

STRUCTURE

Several structural features were important in solving the problem of finding commercial limestone in this area. (1) The St. Paul Limestone and adjacent Chambersburg and Beekmantown limestones are nearly everywhere steeply, and more or less isoclinally, folded; most dips are greater than 45 degrees. (2) In the belt south of Chambersburg, faulting of reverse or overthrust type has occurred in several elongate bands within the Chambersburg, St. Paul, and upper Beekmantowns unit. These faults may represent the surface expression of more extensive overthrusts of the kind recently described by Gwinn (1964) in central Pennsylvania. (3) Near the contact with the Chambersburg, the St. Paul Group is in many places overturned; in such places, the Chambersburg is also almost all overturned. (4) In the belt near Shippensburg, and from there northeast through Newville nearly to Carlisle, there is less faulting in the St. Paul Group, perhaps because this is a salient belt, convex westward, wherein some of the stresses in the limestone were absorbed by tensional stretching. (5) Overturning along the St. Paul-Chambersburg contact is common northeast of Shippensburg, and the contact is much more sinuous than south of Chambersburg. The sinuosity may be due to rotation during folding. (6) The tough magnesian limestones of the upper Beekmantown strata form resistant ribs, which evidently aided in uniform transmission of stresses to the northwest. Within themselves, the dolomitic beds were deformed by the development of the imperfect fracture cleavage that now appears strikingly on many weathered surfaces. (7) The contact between the Chambersburg and St. Paul Limestones may be the result of faulting at many of the localities visited; as a result, it is difficult to know, in most places whether variations in the upper St. Paul are due to facies changes or to structural conditions. This problem is important in the exploitation of the limestone.

ANALYSES

Chemical analyses of the New Market Limestone at one locality are given in table 1. Additional analyses are in the files of the Pennsylvania Railroad.

TABLE 1

Partial chemical analyses of limestone from surface sections along the Pennsylvania Railroad 1 mile northwest of Kauffman, Pennsylvania.
[Distance below top of New Market limestone is given.]

Feet below top New Market Fm.	0–5	10–15	20–25	35–40	40–45	45–50	55–60	75–80	85–90	95–100	105–110	110–115
Insoluble residue (including SiO_2)	1.36	2.27	1.92	1.72	1.61	1.09	2.16	1.61	1.41	3.23	2.06	2.12
Total R_2O_3	0.40	0.69	0.75	0.65	0.17	0.10	0.15	0.16	0.17	0.29	0.10	0.52
Total phosphorus	0.01	0.01	0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.03	0.01	0.01
Calcium oxide	54.93	53.72	53.96	53.72	54.22	54.62	53.62	53.40	53.54	49.92	54.00	54.16
Magnesium oxide	0.32	0.24	0.21	0.12	0.50	0.63	0.75	1.20	0.93	4.06	0.58	0.60
Loss on ignition (at 1000° C)	42.81	42.56	43.05	42.33	42.65	42.82	42.50	42.69	43.34	42.26	42.71	42.38
Total	99.82	99.48	99.89	99.54	99.19	99.26	99.18	99.06	99.39	99.78	99.45	99.78
Calculated from above data:												
Calcium carbonate	98.02	95.86	96.29	95.86	96.75	97.47	95.68	95.29	95.54	89.08	96.36	96.65
Magnesium carbonate	0.67	0.50	0.44	0.25	1.05	1.32	1.59	2.52	1.98	8.52	1.22	1.26

RESERVES

On the basis of the limited core drilling that has been done, tentative reserves have been estimated for the area. These data are in the files of the Pennsylvania Railroad.

USES

Nearly all of the stone found in the core holes appears to be suitable for blast-furnace flux. With selective quarrying, open-hearth stone and stone for portland cement and agricultural lime could also be obtained.

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