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Dolomite in the Vicinity of Lee, Massachusetts as an available source of Metallic Magnesium.

by E. T. Apfel

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Dolomite marble in the vicinity of Lee, Massachusetts as an available source of Metallic Magnesium.

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Earl T. Apfel

Introduction

The recently developed process for producing metallic magnesium from dolomite has made it desirable to review known occurrences of dolomite formations with specific reference to their possible use as magnesium ore. Among the well-known areas in which dolomite beds are known to occur is the so-called "Stockbridge Valley" of western Massachusetts where, in the vicinity of Lee, dolomite marble has been quarried as building and monumental stone for many years. This paper constitutes a preliminary report on suitability of the "Lee marble", a formation known to geologists as the Stockbridge limestone, as a possible source of dolomite for the production of metallic magnesium; other uses for the marble are given only incidental attention. The general character and resources of the marble are considered, but many specific questions and details are left for further study if and when active interest is shown in the use of "Lee marble" as a source of metallic magnesium.

The field work upon which this report is based was performed during parts of August and September, 1942, and was restricted to the vicinity of Lee where dolomite marble has been quarried at several places. The writer was assisted in the field by A. J. Bodenlos. The project was done under the cooperative geologic program of the Massachusetts Department of Public Works and the United States Department of the Interior, Geological Survey. The geologic maps by Emerson[1/] and Dale[2/] were used to compile the general geologic base map, figure 1.

1/ Emerson, B. K., Geology of Massachusetts and Rhode Island; U. S. Geol. Survey, Bull. 597, 1917, plate X

2/ Dale, T. Nelson, The Lime belt of Massachusetts and parts of eastern New York and western Connecticut; U. S. Geol. Survey, Bull. 744, 1923, plates I and II.

The quarries of the district were studied in some detail; channel samples were taken across the exposed faces, and these samples were analyzed in the laboratories of the Geological Survey in Washington, to determine whether the bulk of the material closely approximates the theoretical composition of dolomite. Also specimens taken from these samples were examined by polishing and staining to discover the textural relationships between the dolomite grains and other minerals, chiefly calcite, and to determine approximately the sizes of grains. Further and more comprehensive sampling and analysis would be necessary before the deposits are exploited as magnesium ores, but these preliminary results appear to demonstrate that the material is suitable as to texture, composition, and gross resources. The data given herein, therefore, should serve as a guide to further and more detailed investigations.

General geology of the region

The beds of limestone and dolomite that constitute the Stockbridge limestone are exposed at many places along the Housatonic and Hoosic Valleys of western Massachusetts, and they extend into adjacent parts of Connecticut, New York, and Vermont. Both the limestone and dolomite beds are less resistant to erosion than the rocks associated with them, and therefore generally underlie low land. Because the belt underlain by the Stockbridge limestone is several miles wide the depression in which it lies is one of the principal physiographic features of western Massachusetts. The name "Stockbridge Valley" has been given to this area, in which are located the cities and towns of Stockbridge, Pittsfield, Williamstown, North Adams, Adams, Lee, Great Barrington, and others.

The formations that underlie the Stockbridge Valley are composed almost entirely of beds that were of sedimentary origin, namely sandstones,

shales, and carbonate rocks (limestones and dolomites). By processes of metamorphism the sandstones were transformed into quartzites, the shales into schists, and the limestones and dolomites into calcitic and dolomitic marbles respectively. Present interest centers in the dolomite marble beds of the Stockbridge limestone.

Pronounced folding of the formations in the Stockbridge Valley and subsecuent erosion have resulted in roughly parallel belts of outcrop of the various formations that trend in a general north-by-east or east-northeast direction. In the vicinity of Lee, however, the formations locally trend northwestward (see figure 1). The larger local valleys were developed along the belts of the softer carbonate rocks, so that the Stockbridge Valley as a whole follows and is confined to the broad area in which outcrops of the Stockbridge limestone occur. The beds of the more resistant quartzites within the folds or interbedded with the carbonate rocks have formed ridges and local divides within the Valley; the widely separated and steep walls of the Valley are also composed of highly resistant rocks and stand high above the general level of its floor. The development of the Valley along the limestone belt was doubtless aided greatly by the solubility of the carbonate rocks as well as by the inferior resistance of these rocks to mechanical abrasion.

The structure of the Stockbridge limestone is so complex (figure 4) that the general pattern of outcrop as described above is modified in detail, and locally the trends of the outcrop belts depart widely from the general trend of the Valley. This departure is due chiefly to the fact that the axes of the folds into which the beds have been deformed are not horizontal but pitch markedly, some to the north and some to the south; the belts of

outcrop, therefore, swing locally rather sharply around the noses of the pitching folds, and the map pattern displays many local loops rather than complete parallelism of the outcrop belts of the formations. Again, the limestone and dolomite beds are intricately folded within themselves, many of these minor folds being tightly compressed and overturned, so that within an exposure beds may be found with various angles and directions of dip. This deformation was accomplished in part by actual flowage of the beds under the stresses of general regional folding, in consequence of which individual beds vary in thickness. Finally, the beds have been faulted in places, and the marble as well as other beds are abruptly cut off or wedged out.

Where the underlying, more resistant quartzite and schist beds have been brought above the level of the Valley floor, either by folding or overthrusting, their greater resistance to erosion has caused them to form hills and ridges within the Valley. Thus, the morphologic pattern of the Valley as well as the pattern of the belts of outcrop within it, shows numerous trough-like depressions partly separated by quartzite ridges from which the once overlying carbonate beds have been eroded. Some of the conspicuous topographic features, such as Mount Greylock and the ridges between Pittsfield and Great Barrington, consist of schist and quartzite beds that probably overlie the Stockbridge limestone.

The Stockbridge Valley, together with the surrounding area, was intensely glaciated during the Pleistocene ("Glacial") epoch. Deposits left by the ice now largely cover the limestone and dolomite beds and limit the bedrock exposures to small areas on the hills and to those uncovered along the stream channels.

The lack of extensive exposures and the consequent impossibility of tracing the Stockbridge limestone continuously for long distances makes it difficult to correlate individual beds from place to place with certainty, and hence to determine the details of structure in many places. It seems clear, however, that there are definite stratigraphic units of carbonate rocks, each characterized by one of two principal minerals, dolomite and calcite. Most of the dolomitic or high-magnesium marble approximates the composition of pure dolomite in which the molecular ratio of magnesium carbonate to calcium carbonate is one to one. The calcitic or high-calcium marbles commonly contain a few per cent of magnesium carbonate, but the proportion of this component is consistently low in them. There are also interbedded calcitic and dolomitic marbles which may, at least in some places, represent transition beds. Dale[3] mapped the distribution of the calcitic and dolomitic marbles not only on the basis of the observed exposures but also on the probable extents of these rocks as inferred from their structural and topographic features.

3/ op. cit.

The Lee Area

The town of Lee is located in the central-western part of the state, near the eastern edge of the Stockbridge limestone area. Emerson and Dale (see references cited before) have recognized five lithologic units as occurring in the vicinity of Lee. Four of these were designated by Dale as Horizons I, II, III, and IV--the two members of the Stockbridge limestone being designated as Horizons II and III, the underlying quartzite as Horizon I, and the overlying micaceous schist as Horizon IV. Emerson recognized also a local quartzite facies in the lower member (Dale's Horizon II) of

the Stockbridge limestone. All these units are shown on the geologic map, figure 1, and are described briefly in the following stratigraphic column.

Formations exposed in the vicinity of Lee, Mass., (according to B. K. Emerson, and T. N. Dale)

Dale's units	Formations (Emerson)	Symbol on fig. 1 of this report
Horizon IV (youngest) 2000 to 2500 feet (est.)	Berkshire schist; mica schist containing variable amounts of quartz and feidspar; of Ordovician age	Ob
Horizon III 200 to 400 feet thick	Upper part of the Stockbridge limestone; a calcite or high-calcium marble; probably of Ordovician age. (Full thickness probably not represented in this area.)	Osu (upper member)
	Quartzite within the Stockbridge limestone (As used in this report it is the separating member between III and IV of fig. I. It is not certainly established, however, that it completely separates high-magnesium from high-calcium beds).	Osm (middle member)
Horizon II 500 to 800 feet thick	Lower part of the Stockbridge limestone; dolomite marble; exact thickness undetermined; probably largely of Cambrian age but part of it may be Ordovician.	€Osl (lower member)
Horizon I (oldest)	Metamorphosed sandstone, quartzitic in places. (Editor's note: may be Cheshire quartzite, but correlation uncertain). Occurs near the base of the Cambrian(?).	€cg

As noted, "Horizons II and III" constitute the formation mapped as Stockbridge limestone. There are thin quartzite layers and schist zones within the marble, especially in Horizon II. These may be mistaken, in small exposures, for the Berkshire schist. They are of value in some places in helping to define structures within the marble. Gray marble beds constitutes a part of "Horizon II," alternating with beds of white marble.

In this report, therefore, the Stockbridge limestone is considered to consist of the three members designated as €Osl, Osm, and Osu on figure 1 (corresponding to Dale's Horizons II and III, and the included quartzite beds) and referred to in the text as the lower, middle, and upper members respectively. The quartzite member (designated as Osm) is believed to be within the Stockbridge limestone, probably between members €Osl and Osu or in the upper part of member €Osl, but the exact stratigraphic relations are yet to be determined through more extensive and detailed areal mapping.4/

4/ Detailed geologic mapping of the entire Stockbridge limestone area in Massachusetts is planned as an early project. (Editor)

On figure 1 this member is shown as it appears on Dale's map.5/

5/ op. cit.

It is worth noting here that Emerson6/ reported a remarkably pure lime-

6/ Emerson, B. K., The geology of eastern Berkshire County, Massachusetts: U. S. Geol. Survey, Bull., 159, 1899.

stone bed in the lower member of the Stockbridge limestone, as occurring just north of Lee. According to the reported analysis of this pure limestone "from cut west side of railroad, north of Lee village" the rock contains 98.13% $CaCO_3$, 0.95% SiO_2, and 0.10% FeO. The extent of this bed has not been determined. The possible presence of such beds in the lower member (member COsl) should be considered with reference both to the further investigation of the dolomite beds as a source of metallic magnesium and to the search for local supplies of high-calcium limestone.

The Stockbridge limestone has been quarried both north and south of the village of Lee. Here it is a good dolomite marble. The principal uses have been for structural purposes, for monuments, and for burning to make

lime. So many excavations have been made that the quality of the marble has been adequately determined; and the supply of high-grade dolomite suitable for the production of metallic magnesium as well as other products seems to be ample. For these reasons the dolomite area around Lee was selected for study, and a reconnaissance was made in a strip extending about a mile from the railroad line, this width being considered a practicable limit within which deposits of proper kind could be conveniently exploited.

The bedrock east of Laurel Lake, 1½ miles northwest of Lee, is, in general, obscured by drift cover except for the ridges where resistant schist and quartzite underlie steep slopes, and for the quarry exposure of dolomite marble one mile north-northeast of Lee (numbered 1 in figure 1). The numbered quarries are described beyond.

Between Laurel Lake and Lee faulting and folding have produced a mixed pattern of outcrop. Dolomite exposures are few and the rock is of questionable quality except just west of the stream that drains Laurel Lake.

West and south of Lee there are many exposures, some of which have been opened by quarrying. These are indicated on the map and numbered for reference in the text of this report.

Zones in the Lee Marble

The beds quarried south of Lee are known to the trade as "Lee marble," and interpreted as belonging to member €Osl, although beds of formation €c may be exposed in small areas. Within member €Osl as mapped several lithologic zones are distinguishable. These are:

Zone F. White dolomite marble with gray bands, some of which contain graphitic carbon; some beds contain much tremolite.

Zone E. Upper white dolomite marble, the principal marble member; white dolomite of high purity; thickness variable due to shearing and

compression particularly on steep limbs of folds; normal thickness probably 120', but may be greater.

Zone D. Upper gray marble; impure, with mica and tremolite as common constituents; thickness 50' to 150'.

Zone C. Lower white dolomite marble, much folded and squeezed, irregular in thickness. Impure gray marble is intricately folded into the white marble in places; thickness variable, 40' to 100'.

Zone B. Lower gray dolomite marble, impurities include abundant mica and some tremolite.

Zone A. (lowermost) Gray, schistose rock possibly representing formation I.

Dolomite Localities in the Lee Area

The descriptions of dolomite in the Lee area, presented in the following pages, refer to several localities where the marble has been quarried and where exposures are extensive enough to permit study of the rock in appreciable detail. These are.

1. Northeast Quarry
2. Lee Marble Works Quarries
3. Marble Street Quarry
4. Lee Lime Corporation Quarries
5. Standard Lime Corporation Quarries
6. Joseph Valenti Quarry

These quarry locations are shown and numbered on figure 1.

No. 1. Northeast Quarry. A small quarry was opened in a low knoll one mile north-northeast of Lee. Rock was removed to a depth of six to eight feet over an area measuring about 60 by 180 feet. A small part of the area was opened

to a depth of about fifteen feet and is now filled with water. The marble also appears in a few low hills in the area, up to twenty feet above the level of the Housatonic River, near the west side of the exposure. The length of the exposure is more than three hundred feet and its width is about 200 feet.

Foliation planes that probably represent bedding planes in the marble dip eastward 30° to 45°. The strike ranges from N 20° W to N 5° E.

Because of the extent of the exposure and the character of the marble, it is probable that the rock belongs to Zone E as described above. However, the thickness of the marble at this place is not known, and the rather slight relief above river level would cause drainage problems if the rock here were to be excavated to any considerable depth.

The rock is a sugary white marble, but contains yellowish brown mica scattered through it and concentrated in some bands that consequently have a yellowish color. Irregular nodules stand in relief on the weathered surfaces of part of the exposure; they range in maximum diameter up to one and one-half inches, several nodules being found on a square yard of the surface at places of maximum concentration.

The rock from this exposure was not studied in the laboratory.

No. 2. Lee Marble Works Quarries. The two large quarries of the Lee Marble Works are located on the west side of the Housatonic river one-half mile south of Lee. The easternmost and older of the quarries is about 75 feet wide and 200 feet long, with the long direction extending N 35° E. This is called the "Philadelphia Quarry", from which one-half million cubic feet of stone was taken for use in constructing the wings of the National Capitol. The second, or main quarry, about 170 feet northwest, is about 250 feet

long and 120 feet wide. The longer dimension lies about N 25° E. An older and smaller pit extends northwest from the present main quarry. The large quarry is here called the "New Quarry", and a part of it was being worked in 1942 to supply headstones for the National Cemetery at Arlington, Va. In addition, broken stone was being hauled to the Lee Lime Company plant where it was burned together with stone quarried near the kilns. Stone from the northeast end of the New Quarry is also used for fluxing stone, but only a small quantity was shipped in 1942; it is reported that several cars per week were shipped formerly to Springfield, Massachusetts, for use in steel production.

Besides the stone exposed in the quarry small scattered exposures are also to be found south and west of the quarry.

The bedding and foliation appear to be parallel and to dip 12° to 25° to the north (figure 4). The strike ranges from N 70° E to N 80° W. Similar strikes and dips are found in the nearby smaller exposures. The structure seems to be rather simple, with only a moderate amount of distortion due to shearing and intricate folding.

Gray marble is said to have been reached at the southwest end of the New Quarry at a depth estimated to be 60 feet from the surface. It is probable that this gray marble belongs to Zone D, and that the main dolomite marble is in Zone E. The thickness of the white dolomite marble is computed to be about 140 feet in the New Quarry. Zone E contains a few lenticular veins of very coarse-grained, gray dolomite in which there are some curved cleavage surfaces up to 1½ inches across. Near the top of the northeast wall there is a band of dolomite containing abundant tremolite and mica. The tremolite and mica zone probably represents the base of Zone F.

The marble, as exposed in the quarry, is white, medium-grained, and distinctly crystalline. At intervals of several feet there are surfaces which are coated with an almost continuous layer of mica flakes and which may represent slip planes. Such slip planes are also indicated on transverse surfaces by Twin mica streaks, and the marble splits readily along these streaks. There are also some bands of mica-rich marble a few inches thick which show some distortion, though intricate folding of them was not observed. In some places the white marble grades into a light bluish-gray marble which may form a zone up to three or four feet thick but is neither continuous along the foliation nor uniformly thick.

The rock of the Philadelphia Quarry and the New Quarry are probably identical and were so assumed for purposes of sampling. A series of ten channel samples was taken from the southeast face of the New Quarry to represent the rock of the stratigraphic section. The locations and numbers of the samples are shown on figure 2. Descriptions of these samples are given in the appendix to this report.

Chemical analyses of the samples were made in the Survey laboratories by Samuel H. Cress. The magnesium carbonate in the analyses was calculated by difference after determining insoluble material, soluble alumina, etc. and calcium oxide. CaO was calculated to $CaCO_3$. Water and minor constituents were not determined. The analyses of the samples are shown in Table I, where they are arranged in their stratigraphic sequence.

Table I

Channel Samples	Length of channel (feet)	Insoluble in hydrochloric acid	Soluble			
			R_2O_3	CaO	$CaCO_3$ (calc.)	$MgCO_3$ (calc.)
A-8 (top)	11	1.90	.90	29.56	52.76	44.44
A-7	17	.32	.36	30.84	55.04	44.28
A-10	18	.58	.24	30.44	54.33	44.85
A-9	17	.92	.30	30.40	54.26	44.52
A-1	15	.50	.30	31.50	56.22	43.29
A-2	15	.77	.32	30.90	55.15	43.76
A-3	15	1.30	.38	30.14	53.79	44.53
A-4	15	1.70	.30	29.40	52.47	45.53*
A-5	15	1.06	.38	30.04	53.62	44.94
A-6 (bottom)	15	1.58	.34	30.04	53.62	44.46

* Probably too high.

No. 3. Marble Street Quarry - a small quarry, now abandoned, is located on the west side of Marble Street, a little more than two hundred yards southwest of the New Quarry of the Lee Marble Works. The quarry is filled with water and only a part of the section formerly exposed is now observable. The quarry is roughly L-shaped and estimated to be 150 feet by 180 feet. The long dimension extends N 70° W. There are a few nearby exposures, though some of these may be exceptionally large boulders. Gray marble is exposed about 250 feet south of the quarry. Another bed of gray marble is found north and northeast of quarry 3, so that its outcrop is indicated between this quarry and the Lee Marble Works quarries.

The Marble Street quarry is probably in the lower white dolomite Zone C, previously described, the gray dolomite north of the quarry is in Zone D, and that south of the quarry in Zone B.

The foliation which apparently is parallel with the bedding is undulated so that the strike varies greatly. The dip, however, is northerly at angles of 30° to 45° (figure 4).

The rock is light-buff colomite, but the color may be due in part to weathering, and thus represent merely a slightly altered or stained white dolomite. Discontinuous streaks of light-gray dolomite tend to follow the foliation. Tremolite and yellowish mica are common, and are abundant in some zones.

Channel samples were taken across the west side and southwest corner of the quarry to get approximately 25 feet of the stratigraphic sequence represented. Chemical analyses of these channel samples were made in the Survey Laboratory, with the results shown in Table II.

Table II

Channel Samples	Length of channel (feet)	Insoluble in hydrochloric acid	Soluble			
			R_2O_3	CaO	$CaCO_3$ (calc.)	$MgCO_3$ (calc.)
E-3 (top)	8	2.92	0.36	30.30	54.08	42.64
E-2	8	1.28	1.28	30.08	53.69	43.75
E-1 (bottom)	9	1.40	.70	30.28	54.04	43.86

No. 4. The Lee Lime Corporation operates a large quarry one mile south of Lee to supply an adjacent lime plant along the New York, New Haven, and Hartford Railroad. The total length of the quarry opening is about 1200 feet, but smaller quarries have been opened as branches of the main quarry and in other parts of the outcrop of this marble. There are 5 quarry faces, which are designated by the letters "a" to "e" on figure 1. A small inactive opening just south of quarry "a" and regarded as part of it is left unlettered.

The quarries lie on the outcropping edge of a marble bed that forms an asymmetrical syncline with southward pitch (fig. 4). The western limb has a northerly strike with easterly dips ranging from 20° to 40°. The eastern limb is vertical or nearly so and swings eastward in an arc which ranges in strike from N 40° W at the northern end to north-south at quarry "e" in a distance of about 2000 feet. In quarrying the outcrop has been followed around the end of the syncline, and both limbs have been quarried for some distance along the strike.

The white and gray dolomite beds in the center of the syncline constitute the youngest present; they represent Zone F of the sequence previously described. The western limb has been quarried for about 1200 feet, and the eastern limb for 750 feet from the extreme northern end of the fold. The main quarry development has been in Zone E. The outcrop on the eastern limb of the syncline has been opened at two other places along the strike. Below the white marble and exposed on the outer quarry walls in the east limb of the syncline is the marble of Zone D. The gray marble of this zone is the oldest rock exposed on the west side limb of the quarry. Owing to the vertical

dip of the eastern limb of the syncline, the zones underlying Zone E appear in parallel outcrops, along the west limb all except Zone D are covered by glacial debris. Quarry "c" has been opened in the lower white marble of Zone C in the east limb.

The characteristic features of several of the quarry openings are shown in following descriptions.

Quarry 4-a. This is the main quarry of the Lee Lime Corporation, and the only one being worked by that company in the Lee area in 1942. The working face at the south end of the quarry extends east-west and is 155' long. As the rock dips about 30° eastward, the stratigraphic thickness represented on the quarry floor is nearly 78 feet. The east wall of the quarry has a maximum height of 90 feet. Only the lower part of this wall is of the same quality as the stone now being quarried at the south face; the upper part contains more tremolite and mica. The best marble exceeds 120 feet in thickness here, including that in the quarry floor and in the east quarry wall.

Channel samples were taken from west to east across the 155 feet of quarry face; they are numbered G-1 (stratigraphically lowest) to G-11. They were analyzed in the laboratories of the Survey, with the results shown in Table III.

Table III

Channel Samples	Length of channel (feet)	Insoluble in hydrochloric acid	Soluble			
			R_2O_3	CaO	$CaCO_3$ (calc.)	$MgCO_3$ (calc.)
G-11 (top)	13	1.26	0.26	30.28	54.04	44.44
G-10	13	.90	.24	30.60	54.61	44.25
G-9	13	1.90	.36	30.80	54.97	42.77
G-8	12	.70	.40	30.66	54.72	44.18
G-7	12	.54	.28	30.66	54.72	44.46
G-6	12	.76	.36	30.44	54.33	44.55
G-5	12	1.46	.24	30.52	54.47	43.83
G-4	12	.80	.40	30.42	54.22	44.58
G-3	12	.54	.24	30.00	53.54	45.68
G-2	12	.40	.20	30.70	54.79	44.61
G-1	13	.50	.28	30.36	54.19	45.03

Quarry 4-b. This quarry was opened southward along the vertical east limb of the syncline for a distance of about 750 feet from the extreme northern end of the outcrop. The quarry face, about 110 feet long, extends across nearly the full width of Zone B, but the beds have been so squeezed that the maximum zone does not appear here in its maximum thickness.

Channel samples were not taken from this face as it is the same rock as that represented insamples G-1 to G-11.

Quarry 4-c. This quarry lies north of the quarry 4-b, and parallel with it. Between the two is a verticalzone of the impure gray marble of Zone D. The marble of quarry 4-c belongs to stratigraphic Zone C.

The walls of quarry 4-c show considerable distortion, though the beds are nearly vertical (figure 4). The marble of zone C has been dragged and folded so that there is some impure marble, perhaps from the walls, now resting within the purer marble that is typical of this zone. The thickness of zone C ranges from about 30 feet to more than 80 feet as shown by the quarry opening in the 325 feet of quarry length. The parting of gray marble (zone D) between this quarry and quarry 4-b ranges from less than 50 to more than 150 feet in thickness.

Near the north end of the eastern limb of the syncline the strata are bent abruptly to an almost horizontal position at a point near the top of the eastern quarry wall. This furnishes, in part, a clue to the structural relations between this quarry and the quarries farther north. Between the two lies an anticline from the top of which all the rocks have been eroded so that zone A is exposed over a small area, shown in figures 1 and 4.

Channel samples D-1 to D-5 were taken across the face of quarry 4-c where the width was 75 feet. These were analyzed in the Survey laboratories with the results shown in Table IV. The table is arranged so that the samples are in stratigraphic sequence.

Table IV

Channel Samples	Length of channel (feet)	Insoluble in hydrochloric acid	Soluble			
			R_2O_3	CaO	$CaCO_3$	$MgCO_3$
D-1 (top)	15	0.36	0.66	30.80	54.97	44.01
D-2	15	.94	.40	30.64	54.69	43.97
D-3	15	1.64	.54	30.40	54.26	43.56
D-4	15	.44	.48	30.40	54.26	44.82
D-5	15	1.00	.60	30.32	54.12	44.28

Quarry 4-d. This quarry is a small opening, now filled with water, along the outcrop of the east limb of the syncline. Some rock has also been removed to lesser depths from the immediate vicinity.

The foliation here is vertical or nearly so. The eastern wall is fairly regular but the detailed structure of the marble of zone E is not determinable from the exposures now available, nor is its full thickness visible. Between this quarry and the southern point of quarry 4-b are several grass and tree covered trenches that apparently were exploratory openings along the strike of the marble. No rock is now exposed in them.

Samples were not collected from this quarry.

Quarry 4-e. This is the most southeasterly quarry on the syncline. It lies about 2000 feet from the northern end of the outcrop of this zone in the syncline, and is at the southern end of the exposures on the eastern limb. It is about 325 feet long and 100 feet wide, with its long axis extending north-south. The southernmost 150 feet of length has been quarried to a depth of more than 55 feet, as a line of that length was lowered in the water-filled hole. The northern part of the quarry has been opened only to water level.

The foliation shows a roughly fan-shaped pattern on the quarry floor and walls. The general attitude of the marble zone appears to be nearly vertical but there is considerable internal deformation within the rock which may have resulted insome local change in its thickness.

There is considerable tremolite in some beds near the northwest corner of the quarry, which may be a part of zone F folded into the marble of zone E.

Channel samples were collected across the beds from east to west in the principal quarry face, and were analyzed in the Survey laboratories with the results shown in Table V. The table is arranged in stratigraphic order.

Table V

Channel Samples	Length of channel (feet)	Insoluble in hydrochloric acid	Soluble			
			R_2O_3	CaO	$CaCO_3$ (calc.)	$MgCO_3$ (calc.)
F-8 (top west)	12	1.42	0.42	30.42	54.22	43.94
F-7	12	1.40	.35	31.90	56.94	41.31
F-6	13	2.40	.26	31.28	55.83	41.51
F-5	13	.50	.20	30.26	54.01	45.29
F-4	13	.62	.20	30.69	54.81	44.37
F-3	13	.80	.58	30.70	54.79	43.83
F-2	12	.50	1.14	30.70	54.79	43.57
F-1	12	.60	.26	30.96	55.26	43.88

No. 5. Standard Lime Company Quarry. This quarry is located on Fairview Street about .45 mile west-southwest of the Lee Lime Company quarry 4-a. A shallow quarry was opened on this site and worked down to water level. The opening is 10 to 15 feet deep and somewhat less than an acre in area.

The quarry is composed of two parts, separated by an unquarried wall 10 to 15 feet wide (figure 3). The rock in this wall is much deformed and is thought to represent the axial part of a much compressed syncline. South of the dividing wall, the beds show nearly vertical foliation, but north of the wall the foliation is arched in an asymmetrical anticline with a gently dipping north limb as exposed in the quarry.

The rock in this quarry cannot at present be correlated with that in the quarries to the east. White marble is exposed on the hillside east of the road from this quarry but there are no other exposures between the two areas. The high purity of the marble and its thickness, known to be in excess of 75 feet, suggest that it may belong to zone E, and may therefore be equivalent to that quarried by the Lee Lime Company.

Channel samples were taken from this quarry to represent as much of the stratigraphic section as was accessible. The locations of the samples are shown on figure 3. The analyses of the samples are given in Table VI.

Table VI

Channel Samples	Length of channel (feet)	Insoluble in hydrochloric acid	Soluble			
			R_2O_3	CaO	$CaCO_3$	$MgCO_3$
C-1	11	0.40	0.56	30.76	53.90	45.14
C-2	16	.32	.40	30.60	54.61	44.67
C-3	13	.60	.80	30.92	55.19	43.41
C-4	12	.69	.37	30.85	55.06	43.90
C-5	12	.34	.36	30.82	55.01	44.29
C-6	14	.56	.36	30.16	53.83	45.25*
C-7	14	.70	.42	30.90	55.15	43.73
C-8	15	.54	.20	31.14	55.58	43.68
C-9	30	.64	.40	30.70	54.79	44.17

*Probably too high.

No 6. Joseph Valenti Quarry. A small quarry, now filled with water, lies on the Joseph Valenti farm. It is the southernmost opening in the Lee area. The relationship of the rock here to that farther north is not clear. There is considerable impurity in this marble and just southeast of the quarry pond an exposure of gray marble contains much pyrite.

A series of three samples was taken across 43 feet of stratigraphic section. The results of the analyses of the samples are given in Table VII.

Table VII

Channel Samples	Length of channel (feet)	Insoluble in hydrochloric acid	R_2O_3	CaO	$CaCO_3$ (calc.)	$MgCO_3$ (calc.)
B-1	15	3.86	0.28	29.66	52.94	42.92
B-2	15	3.92	.82	29.70	53.01	42.25
B-3	13	2.88	.34	30.30	53.07	43.71

Composition of the Lee Marble

The Lee marble is a dolomite of high degree of purity. The average composition of the marble in zone C, shown below, is the approximately weighted average of channel samples taken from the Marble Street quarry (No. 3) and quarry 4-c on the Lee Lime Company property. Possibly other channel samples also represent this zone, but they cannot be certainly identified as such.

Average composition of marble from Zone C.

Insoluble in HCl	1.1%
R_2O_3	.6
CaO	30.4
$CaCO_3$ (calc.)	54.3
$MgCO_3$ (calc.)	44.0

The average composition of the marble from zone E given below is the computed, approximately weighted average of the analyses from the Lee Marble Works main quarry (No. 2) and the Lee Lime Corporation quarries (4 a, b, c, and e) on both the east and west limbs of the syncline.

Average composition of marble from Zone E.

Insoluble in HCl	1.1%
R_2O_3	.4
CaO	30.5
$CaCO_3$ (calc.)	54.5
$MgCO_3$ (calc.)	44.1

The marble having the lowest amount of impurities was found in the quarry of the old Standard Lime Company on Fairview Street, (Quarry No. 5 on figure 1) where the approximately average composition of the rock is as shown below, judging from analyses of nine channel samples, some of which cover duplicate parts of the stratigraphic section at different places in the quarry.

Average composition of marble from abandoned Standard Lime Company quarry on Fairview Street

Insoluble in HCl	0.5%
R_2O_3	0.4
CaO	30.8
$CaCO_3$ (calc.)	54.8
$MgCO_3$ (calc.)	44.3

Four channel samples which cross 73 feet of unduplicated stratigraphic section have the following average composition:

Insoluble in HCl	0.6%
R_2O_3	.3
CaO	30.7
$CaCO_3$	54.8
$MgCO_3$	44.2

A few minerals predominate as impurities in the dolomite marble near Lee. The principal ones are calcite, mica (phlogopite), tremolite and pyrite. Lesser quantities of quartz, graphite and chlorite are found; galena has been reported by local quarrymen, but was not seen by the writer.

Some calcite forms thin stringers or films along fractures, but most of it forms interstitial grains among the dolomite grains of the marble or minute halos around them.

The mica, which is distributed widely through the marble, is a light-brown to colorless mineral, and probably includes both the muscovite and phlogopite varieties. It forms small "books" and also disseminated flakes. Some pockets of mica up to one-eighth of an inch across consist of several mica "books" intergrown, making star-shaped stellate masses.

Surfaces along which movement appears to have occurred are in many places so nearly covered with thin mica scales that they provide planes of separation in the rock. There is some mica all through the marble but it seems to be concentrated principally in certain very thin bands and layers where it may form several per cent of the rock.

Tremolite is found both as radiating, crystalline masses and as individual euhedral crystalline blades. It is widely distributed through the marble, but is most abundant in certain zones which, however, do not seem to be continuous enough to be used for purposes of stratigraphic correlation. Near the upper surface of zone E the tremolite occurs in such abundance as to make the rock worthless for some purposes. This tremolite-bearing marble is believed to belong to zone F. Most of analyses that show the higher percentages of insoluble material represent marble containing relatively large quantities of tremolite.

Pyrite is scattered through the marble, usually as very small grains, many of which show crystal faces. Where mica is abundant pyrite is also likely to occur in conspicuous amounts. Some of the darker-gray bands in the marble owe their color in part to the presence of pyrite, especially in zones other than zone E.

Some of the pyrite has been oxidized with the consequent staining of the surrounding marble, but there are also pseudomorphs of iron oxide after pyrite which show no stain around them. These pseudomorphs are commonly 1/2 mm or less in diameter.

Minute grains of carbon, presumably in the form of graphite, are disseminated through the darker-gray beds. They are commonly inclosed within grains of dolomite. It is so potent a coloring agent that even the darkest-gray beds contain only small fractions of one per cent.

Of somewhat similar coloring effect is a soft, green mineral, tentatively identified as chlorite. The quantity is small and it is not so widely distributed as most of the other minerals.

Quartz is commonly associated with veins of very coarse grained, gray dolomite; it was most clearly displayed at the north end of the New Quarry of the Lee Marble Works. Quartz also forms skeletal nodules in the marble at a few places; these nodules do not appear to be distributed widely enough in zone E to prevent the cutting of that rock into structural shapes.

Reserves

Without greater areas of exposure, and drilling to determine the extent and structure of the marble below the concealed bedrock surface, it is not possible to make a close estimate of the amount of marble that might be available if the area south of Lee were to be developed to the economic limit. The following tentative estimates have been made for two areas, i.e., the east limb of the syncline, in the vicinity of quarries 4b, 4d, and 4e, and the area in the vicinity of the Lee Marble Works.

The west limb of the syncline is not included in the estimate because it is assumed it will be required for other purposes by the Lee Lime Corporation. Moreover, near the south end of the exposures on the west limb the dips are about 20 degrees east, which suggests that the structure may flatten to the south and east and that the outcrop of zone E may swing eastward to cross the south end of the ridge, as indicated by the questioned boundary on figure 1.

East limb of Syncline:- The estimate for this area is limited to the undeveloped ground in the vicinity of the quarries, because the south end of the ridge may be under too thick a cover of glacial drift to permit economic development. In general, the glacial drift is thickest on the south slopes

of ridges, and the area south of quarries 4d and 4e is believed to have a drift cover of rather great but unknown thickness. However, exploration of the southern extension of the mapped area here, to determine the thickness of the cover and the continuance and structure of favorable marble, might materially increase the potential resources.

The east limb of the syncline has undeveloped marble indicated for a length of approximately 1500 feet and to a width of at least 100 feet. Assuming that it could be quarried to a depth of 100 feet, the prism of marble available would be about 15,000,000 cubic feet in volume. Assuming an average weight of 165 pounds per cubic foot, a figure which makes reasonable allowance for porosity and fractures, this would supply 1,237,500 tons of marble.

Lee Marble Works area:- The area that has been opened by the quarries of the Lee Marble Works is considered to have marble underlying a tract more than 1000 feet long and probably 400 feet wide extending from the bridge at the south end of the village of Lee southeastward to a point beyond the Philadelphia Quarry, in which the average thickness of the marble is 140 feet. The shape of the tract is somewhat irregular and these dimensions are only approximate averages. A block of marble of these dimensions would contain about 56,000,000 cubic feet and weight approximately 4,620,000 short tons.

Thus for the two undeveloped marble areas specified a total of 5,857,500, or approximately 6,000,000 tons is indicated. If it is assumed that half of the indicated marble can be extracted economically, 3,000,000

tons of available marble occurs in this locality and can be classed as "indicated" or probable ore. This estimate seems to be conservative and would be increased either by the development of the east limb of the syncline over a greater length, or by the finding of accessible marble at the south end of the structure.

The marble of zone C is not included in this estimate because of its highly variable thickness and the fact that it averages somewhat higher in impurities.

The high degree of purity indicated by the analyses of the marble at the Standard Lime Company quarry on Fairview Street over an apparent stratigraphic thickness of 75 feet may make that site worth prospecting. No good estimate can be made of the reserve which might be found in that area on the basis of present knowledge, but prospecting both to the east and west of the present openings would doubtless indicate a very substantial tonnage of marble that could be quarried at reasonable cost.

Appendix

Descriptions of channel samples and laboratory specimens.

Channel samples were taken across seven quarry faces in the Lee area. Each sample was lettered to designate the quarry from which it was taken, and the samples from each quarry were also numbered in the order of collection. The length of channel represented by a single sample ranged from 9 to 20 feet. The sample channels were cut across the bedding.

Characteristic specimens were selected from each channel sample for laboratory study. Except for these specimens, the samples were sent to the Washington laboratories of the Geological Survey for analysis. The analyses appear in the text, under the corresponding quarry descriptions.

Specimens retained for laboratory study were polished, and stained to differentiate the calcite from the dolomite.

The channel samples in the following descriptions are lettered and numbered as described above and thus correspond to the designations in the various tables of analyses that appear in the text. The descriptions of Laboratory specimens taken from these samples are similarly lettered and numbered, and are further distinguished by an additional letter as a, b etc., of A 1 a, A 1 b, etc.

Sample A.

Channel samples and laboratory specimen from the Lee Marble Works main quarry (location No. 2 on the map, figure 1). Total length of channel 142 feet.

A 1. - Fifteen feet of channel. Most of material buff, due to some exposure to weathering; usual size of crystals; little phlogopite; small amount of iron oxide. Very little gray dolomite in this sample. Three specimens selected for staining.

A1a - Typical sample. Crystalline dolomite; particles mostly .25 to .5 mm across; interlocking textures; sound marble; small amount of mica.

A1b - Crystalline as A1c; slightly less regularity of grain and size; largest particle size 1 mm.

A1c - Crystalline dolomite; particles .1 to .5 mm; interlocking texture. Staining shows powdery sprinkling of calcite among dolomite particles. Estimate calcite $\pm$ .01 mm.

A 2. - Fifteen feet. White marble with a little buff, and a few streaks of light gray. Crystals usual size; phlogopite rare, iron oxide very rare. Small amount of tremolite.

A2a - Crystalline dolomite; particles .2 to 1. mm; no calcite.

A2b - Similar to A1b, but with minute particles of calcite.

A 3. - Fifteen feet. Material white, with some light gray. Runs much like A 2, but slightly more gray, and less tremolite. Phlogopite and iron oxide very rare.

A3a - Crystalline dolomite; particles .1 to 1. mm across; containing particles of calcite, mostly minute but a few irregular patches up to 1. mm across.

A3b - Crystalline dolomite; particles .05 to .5 mm; thin seam of coarser particles, gray; some minute interstital calcite particles.

A 4. - Fifteen feet. Material white; contains zone with much phlogopite and more than usual amount of iron oxides and pyrite. Little gray material. Galena has been reported from this part of the section.

A4a - Similar to A3b except slightly more uniform in texture.

A4b - Staining shows small number of isolated calcite particles up to 1. mm long and .2 mm wide.

A4c - Crystalline dolomite containing abundant calcite and thin streaks of pyrite; tremolite also present, and mica present in small amounts.

A 5. - Fifteen feet. White dolomite, with zone containing more than usual amount of pyrite. Tremolite and phlogopite are rare. One zone contains a little greenish mineral - chlorite?

A5a - Crystalline dolomite; particles .02 to .5 mm; minute interstitial calcite particles.

A5b - Thin zone of rusty pyrite and tremolite in crystalline dolomite; minute calcite particles.

A5c - Crystalline dolomite with small irregular mass of coarser crystals to 2. mm; small amount of tremolite and pyrite; calcite particles small except in coarse dolomite where they reach 1. mm across.

A5d - Crystalline dolomite, little or no calcite.

A 6. - Fifteen feet. White dolomite, little impurity; tremolite, iron oxide, phlogopite, chlorite. Not as much impurity as A-5. Stratigraphically lowest bed.

A6a - Crystalline dolomite; particles .2 to .5 mm; minute tremolite needles and calcite to .2 mm.

A6b - Crystalline dolomite; particles .2 to .8 mm; numerous calcite particles as large as the dolomite particles.

A 7. - Seventeen feet. Buff dolomite (color due to exposure), pure, with a little iron. Some gray bands.

A7a - Pure marble, little impurity.

A7b - With iron stains, and micaceous streaks.

A 8. - Eleven feet. Extremely weathered surficial zone.

A 9. - Seventeen feet. White marble with considerable gray. Impurities same, with usual iron, but no tremolite.

A9a - Crystalline dolomite; particles .1 to .5 mm; one calcite grain .2 mm. and an irregular, very thin seam of calcite which approximately follows a crack.

A9b - Crystalline dolomite; particles .02 to .5 mm; very few small grains of calcite.

A 10. - Eighteen feet. White marble with thin gray banding, apparently very pure.

A10a - Typical white marble, staining showed no calcite.

A10b - Gray phase, no calcite shown.

Sample B.

Small abandoned quarry on Fairview Street on top of hill, the farthest south of the quarries (location No. 6 on figure 1), Joseph Valenti property. Strike variable, generally NW, dips 12° to 22° SW. Channel sample cut across 43 feet of stratigraphic section, bottom to top.

B 1. - Fifteen feet. The dolomite is gray, and contains considerable impurity; pyrite and phlogopite.

B1a - Light gray dolomite. Very little calcite in minute grains.

B1b - Slightly darker gray dolomite, pyrite specks. Very little calcite.

B1c - Darker gray dolomite. Pyrite grains are numerous and cause some of the darker color.

B 2. - Fifteen feet. The gray dolomite grades upward into white dolomite, which contains much less iron and phlogopite. The gray may still be part of the underlying gray material seen under the "upper" dolomite.

B2a - White dolomite. Few pyrite grains, fewer calcite grains.

B2b - Gray dolomite, pyrite and calcite grains small but common.

B 3. - Thirteen feet. White dolomite, with considerable phlogopite, and more pyrite than the average Lee Marble quarry sample.

B3a - White, typical sample. Minute calcite stringers. Little pyrite.

B3b - Similar to above, slightly more mica.

B3c - Dolomite containing small cavity. Mica, tremolite and small calcite veins in this specimen.

Sample C.

Abandoned quarry on Fairview Street, formerly worked by Standard Lime Company (location No. 5 on figure 1). Now locally called "Mrs. Dooley's quarry". The quarry is 10 to 15 feet deep with a narrow ridge of unquarried material separating two chambers. Strike about N 60° W. Channel samples taken as indicated on figure 2, totalling 135 feet.

C 1. - Eleven feet. Dolomite, light gray to cream color with much gray dolomite.

C1a - Typical light gray marble. Staining shows many areas of calcite with some up to one mm across.

C1b - Darker gray phase, calcite particles numerous.

C 2. - Similar in appearance to C 1.

C2a - Typical light gray marble. Few impurities, including calcite.

C2b - Light phase, few impurities.

C2c - Gray phase, small amount of staining by iron oxides.

C 3. - Thirteen feet. Similar to C 1, but with brownish gray bands.

C3a - Typical light gray marble. Impurities few.

C3b - Gray phase. Little mica or calcite.

C 4. - Twelve feet. White and buff marble.

C4a - White phase, rather pure.

C4b - Buff phase, minute needles of tremolite. Calcite scarce.

C 5. - Twelve feet. Fairview St. quarry, southwest wall. Stratigraphically below, or equal to C 1. Uniform gray marble.

C5a - Typical dolomite marble, pure.

C5b - Typical, a few tremolite needles of small size.

C 6. - Fourteen feet. Section across west chamber (C 6 to C 10 are across 73 feet of section). Light gray dolomite, mostly white, some gray mottling.

C6a - Typical white dolomite. A few minute calcite grains.

C6b - Gray mottling, very light color. Appears similar to C6a.

C 7. - Fourteen feet. Fairview St. - Similar to C 6, but includes a gray band which contributed an estimated 20% of the sample.

C7a - White, typical dolomite marble of high purity.

C7b - Gray. Numerous minute calcite grains.

C7c - Little calcite but contains groups of small tremolite needles. Gray.

C 8. - Fifteen feet. Dolomite, a gray band with one darker gray streak.

C8a - Typical of the gray band. Impurities minor in amount.

C8b - From darker band. A little calcite, small amount of mica and tremolite.

C 9. - Thirty feet. Dolomite, gray.

C9a - Typical, pure.

C9b - Typical, a few minute calcite grains.

Sample D.

Unused chamber of Lee Lime Corporation quarry, lying northeast of the main quarry and connection with it. It is marked 4-c on the map, figure 1. Channel sample taken west to east across the face of nearly vertical beds, representing 75 feet stratigraphically. This does not represent the full or true thickness, however, as the marble has been much distorted and squeezed. The samples are numbered from top (D 1) to bottom of the stratigraphic section.

D 1. - Fifteen feet. Light gray dolomite marble with some mottling of slightly darker gray. Appears to be quite pure except for mica which is uniformly present.

D1a - Typical, pure dolomite marble.

D1b - Pure dolomite marble, minor amount of mica.

D1c - Darker gray marble, shows some calcite streaks under staining.

D 2. - Fifteen feet. Similar to D 1, a light gray dolomite marble with some darker gray banding. Some mica appears in zones and very thin layers.

D2a - Appears uniform, but staining shows calcite to be present in streaks or very thin broken bands.

D2b - Medium gray marble, with numerous calcite grains showing on stained surface.

D2c - Light gray marble, with mica as small books scattered through the specimen.

D 3. - Fifteen feet. Light to medium gray marble. More darker marble than in D 1 or D 2.

D3a - Gray phase, typical of 75 to 80% of the channel sample. Mica is common.

D3b - Darker gray phase, abundant mica. Not all of darker phase has mica in such abundance.

D 4. - Fifteen feet. Light gray dolomite marble, uniform, with streaks of mica.

D4a - Typical, pure.

D4b - Typical.

D 5. - Fifteen feet. Light gray marble with micaceous streaks, some of which are in darker gray marble. Tremolite in fibrous masses an inch or more across occur scattered through this zone.

D5a - Gray marble with abundant impurities, including pyrite.

D5b - Dolomite, with a few pyrite grains. Calcite rare.

Sample E.

From abandoned, water-filled quarry along Quarry street between Lee Marble Company and Lee Lime Corporation quarries. Channel sample across 25 feet stratigraphic section exposed above water, bottom to top. This quarry is marked No. 3 on the map, figure 1.

E 1. - White marble with some gray bands (5% ±) all with small amount of mica. 9' of channel.

E1a - White phase 95% of sample. Pure dolomite.

E1b - Gray phase 5%. Appears to have few impurities.

E 2. - Similar to E 1, 8' of channel.

E2a - White phase, 80% of sample. Sugary texture.

E2b - Gray phase, 20% of sample. Few impurities.

E 3. - Gray and buff marble, considerable mica in both phases, 8' of channel.

E3a - White phase, contains both mica and tremolite blades.

E3b - Gray phase, with both mica and tremolite present.

Sample F.

From southeastern quarry (abandoned) on Lee Lime Corporation property. This is on the east limb of a syncline, the west limb of which constitutes the main Lee Lime Corporation quarry. Channel samples across 100 feet face, east to west, therefore bottom to top stratigraphically. The limb is apparently nearly vertical here. This quarry is 4-e on the map, figure 1.

F 1. - Twelve feet. Light buff and gray marble. Mica in spots and streaks, minute grains of pyrite in small number.

F1a - Buff phase, 90% of sample. Appears to be pure, but staining shows considerable calcite present in small irregular grains.

F1b - Gray phase, 10% of sample. Mica is present in small amount.

F1c - Fragments showing impurities, chiefly mica and pyrite.

F 2. - Twelve feet. Uniform buff marble, with some mica.

F2a - Typical, pure dolomite.

F2b - Dolomite, pure.

F 3. - Thirteen feet. Similar to F 2.

F3a - Typical buff marble, with some mica books and micaceous surfaces.

F3b - Typical but with more mica.

F 4. - Thirteen feet. Light buff marble with bands of light gray. Impurities minor.

F4a - Buff phase, typical, pure dolomite.

F4b - Buff phase, typical, pure dolomite.

F4c - Gray phase, typical.

F4d - Gray phase, typical, pure dolomite.

F 5. - Thirteen feet. Light buff marble with thin light gray bands. Impurities, chiefly mica, locally found.

F5a - Buff, typical, but with abundant mica.

F5b - Gray, typical.

F5c - Buff, impurities include mica and pyrite.

F 6. - Thirteen feet. Light gray marble with some mica and tremolite both in bladed crystals and radiating fibrous masses. Some small pyrite specks.

F6a - Gray, typical. Calcite streaks and specks.

F6b - Gray, with radiating tremolite.

F6c - Gray, with tremolite blades.

F6d - Gray, with streaks of mica. Staining shows abundant calcite in a banded pattern.

F 7. - Twelve feet. Similar to F 6, but more buff color. Somewhat less impurity but with some tremolite and mica.

F7a - Buff, typical pure dolomite.

F7b - Buff, typical, with tremolite blade. Staining shows calcite to be common.

F 8. - Twelve feet. Light buff marble with a few grayish streaks. Some tremolite blades in both buff and gray phases.

F8a - Typical, with calcite grains common.

F8b - Typical with tremolite blade, and numerous calcite grains.

F8c - Typical, unstained.

Sample G.

On west limb of Lee Lime Corporation syncline, from face of main working quarry. Channel sample west to east across 150 feet stratigraphic section, from bottom to top. Beds here dip 25°-35° eastward and strike north-south. This is marked 4-a on the map, figure 1.

G 1. - Thirteen feet. Light gray marble, a few medium gray bands, containing mica streaks and a few pyrite grains up to 1/2 mm diameter.

G1a - Gray, typical, pure dolomite.

G1b - Medium gray, with mica. 2% of sample is of this rock.

G 2. - Twelve feet. White and light gray banded; few pyrite specks, little mica or tremolite.

G2a - Typical white, unstained.

G2b - Typical gray dolomite with a few calcite streaks.

G 3. - Twelve feet. Light gray and white marble with a few narrow gray streaks and thin mica layers with which minute pyrite grains occur. One medium gray streak. This sample contains powdered dolomite, but probably from shooting on the face from which collected.

G3a - White, pure dolomite.

G3b - Gray, with pyrite and mica.

G 4. - Twelve feet. Gray and white banded marble. Some slip surfaces show oriented mica on them.

G4a - White, typical dolomite marble.

G4b - Micaceous surface.

G4c - Slip surface.

G4d - Gray, typical, showing a few smallpyrite grains.

G 5. - Twelve feet. White marble; some bands of mica. A few blades of tremolite.

G5a - Typical white, with blade of tremolite.

G5b - From micaceous band.

G 6. - Twelve feet. White marble with some thin gray, coarsely crystalline streaks. Some gray and buff banding.

G6a - Typical, buff, pure dolomite.

G6b - Buff and gray gradational. Gray somewhat coarser texture.

G6c - Gray with veins of coarse dolomite.

G 7. - Twelve feet. Light gray and buff marble, banded. Includes some thin streaks of mica and small specks of pyrite.

G7a - Buff, typical, with small calcite grains.

G7b - Gray, typical, pure dolomite.

G7c - Streaked with mica and pyrite. (worst contamination in sample)

G 8. - Twelve feet. White marble, some gray bands. A few shear zones with oriented mica on the slip surfaces.

G8a - No specimen.

G8b - White, showing mica spots and a few grains of pyrite.

G8c - Gray phase.

G 9. - Thirteen feet. Light gray and white banded marble. Small amounts of mica in seams. Very few pyrite grains, all small.

G9a - White, typical. A few small streaks of calcite.

G9b - Gray phase, typical.

G9c - White, typical. Unstained.

G 10. - Thirteen feet. White marble, some light gray bands. A few thin micaceous seams.

G10a - White, typical. Unstained.

G10b - Gray, typical, pure dolomite.

G10c - White with mica seams, including small pyrite grains.

G 11. - Thirteen feet. Gray and white banded marble; mostly light gray. Local zones contain mica and small pyrite grains which are not abundant.

G11a - No specimen.

G11b - Gray phase. Unstained.

G11c - Gray, with mica streaks and associated pyrite grains of small size.