Maine Geological Survey
Robert G. Doyle, State Geologist

Reconnaissance and Economic Geology of the Northwestern Knox County Marble Belt

by Eric S. Cheney

Bulletin No. 19

Special Economic Studies Series
Number 7
Reconnaissance and Economic Geology of the Northwestern Knox County Marble Belt

by Eric S. Cheney

Bulletin No. 19

Special Economic Studies Series

Number 7
TABLE OF CONTENTS

Abstract .......................................................... 3
Introduction .......................................................... 4
Geography .......................................................... 4
Geology .......................................................... 4
    Stratigraphy ..................................................... 4
    Igneous Rocks .................................................. 12
    Structure ........................................................ 13
Regional Correlation ............................................... 16
Structural Reinterpretation of Rockland Quadrangle .............. 16
Geologic History ................................................... 18
Economic Geology ................................................... 18
Recommendations .................................................... 22
Bibliography ........................................................ 23
Appendix I .......................................................... 24
Appendix II .......................................................... 32

LIST OF ILLUSTRATIONS

Figure 1 Index of Geologic Mapping in northwestern Knox County .......... 6
Figure 2 Unnamed gneiss of Barrett Hill ........................................ 5
Figure 3 Geology of the Middle Road antiform .................................. 8
Figure 4 Structure of Union Marble Belt ........................................ 10
Figure 5 Vaughn Neck member of Appleton formation .......................... 11
Figure 6 Undifferentiated Appleton formation on 640-foot hill ............... 11
Figure 7 (a & b) a.) Boudinaged metadolerite on 150-foot level of Union Quarry .......... 12
b.) The boudin line trends N 24° E with a plunge gently to the north
Figure 8 (a, b & c) a.) Union marble in western overturned limb of the Middle Road antiform .... 14
b.) Overturned metasediments in quarry on western limb of Middle Road antiform
c.) Minor antiform near crest of Middle Road antiform
Plate I Reconnaissance Geologic Map ........................................  back cover envelope
Plate II Geologic map of Union Marble Belt .................................. back cover envelope
Reconnaissance mapping in northwestern Knox County indicates that the metasedimentary rocks are divisible into the lithologically variable St. George formation and a younger, more monotonous sequence of chiastolite schists and sillimanite gneisses, here named the Appleton formation. These formations may be underlain by two older formations. Gabbroic rocks, including the East Union norite, intrude the St. George formation; the Waldoboro granite and associated dikes intrude both the St. George and Appleton formations.

Chiastolite-bearing phyllites and schists of the Appleton formation can be traced southward toward the Waldoboro granite into gneisses containing sillimanite, feldspar, and muscovite pseudomorphic after chiastolite metacrysts. These rocks and a sillimanite-bearing gneiss in Warren outline the nose of a southerly plunging antiform three miles wide, at least 16 miles long, and overturned to the northwest.

The inferred stratigraphic sequence is based on the assumption that this regional antiform is upright. The marble belts of Union and North Appleton occur on the overturned northwestern limb, and the marbles at Warren and East Union-Hope are believed to be on the eastern limb. All of the marble is within the St. George Formation.

The St. George and Appleton formations are probably pre-Silurian and thus broadly correlative with those of eastern Knox County. A structural reinterpretation of Bastin's 1908 mapping strengthens the possibility that the St. George formation and the Appleton formation may be correlative with the Rockland and Penobscot formations respectively.

The Union marble belt was studied in detail and the local stratigraphy and structure established. The reserves of high-calcium marble are at least four to five times the amount already quarried, but two highways and the St. George River hinder exploitation of the belt.

The structure and stratigraphy of the three outcrop belts of marble in the East Union-Hope area are not well known. Tremolite is common south of old Route #17 near the East Union norite. Preliminary assays indicate the marbles are somewhat magnesian.

The exposed crest and eastern limb of an overturned antiform in Warren are recommended as a future source of magnesian marble. Elsewhere the Warren belt is covered, quarried out, cut by numerous granite dikes, or contains tremolite.

The North Appleton belt is probably structurally similar to the Union belt, but the marble is magnesian and contains some tremolite and thin siliceous beds. The rock is probably suitable for agricultural lime. Intraformational folding has thickened the belt enough to permit economical quarrying.
INTRODUCTION

Northwestern Knox County, Maine, is an area of valuable limestone deposits which are being quarried. In addition, several base metal sulfide deposits have been explored, providing a stimulus for more detailed geologic investigations. The Maine Geological Survey sponsored a mapping and sampling program of the four known local marble belts during the summer of 1963. A month was devoted by the writer to reconnaissance mapping of the poorly exposed bedrock of the northwestern portion of the townships of Warren and Union, the northeastern corner of Washington, and the southeastern two-thirds of Appleton, as well as a small part of the southeast comer of Searsmont in Waldo County (Fig. 1). Some additional mapping was done on weekends during 1964 and 1965.

GEOGRAPHY

The northward trend of the smooth ridges of the southern half of the area changes to northeastward in Appleton. The low elevation of 30 feet along the St. George River in Warren and high elevation of 810 feet at Coggans Hill on Appleton Ridge in Union provide a total relief of 780 feet. Altitude, local relief, and topographic complexity or ruggedness generally increase northward.

The St. George River flows through the central part of the study area and the Medomak River is in the northeastern part.

GEOLOGY

STRATIGRAPHY

Unnamed gneiss. An unnamed gneiss underlyng the crest of Barrett Hill in Union, near the southeast corner of Appleton. This unit is rusty weathering, fine grained, and contains abundant biotite and quartz. A few andalusite metacrysts up to 1.5 cm square were observed. No garnet was found (from limited observation, these metacrysts are neither as abundant, as elongated, nor as zoned as those of Appleton formation described below). The gneiss contains both rusty, red weathering, coarse grained folded quartz stringers one to two inches thick, and a few feet long and isoclinally folded and boudined quartzite interbeds two to four inches thick (Fig. 2). As explained in the section of geologic history, this gneiss is assumed to be Cambrian (?) in age.

Figure 2
Unnamed gneiss looking southward along the summit of Barrett Hill at southward plunging synform of quartzitic beds with the gneiss.

Unnamed biotite and sulfide-rich schists and gneisses. The stratigraphic interval between the unnamed quartz-stringer gneiss just described and the basal Seven Tree quartzite of the St. George

1University of Washington, Seattle, Washington, April 1965.
Fig. 1
INDEX OF GEOLOGIC MAPPING IN NORTHWESTERN KNOX CO.
formation is poorly exposed. In northern Union it is composed of biotite schists and gneisses. Just south of Union Center these rocks contain abundant arsenopyrite; the biotite gneisses on the southern end of Barrett Hill, next to the inferred continuation of the Seven Tree quartzite, are very rusty on weathered surfaces. These rocks are assumed to be Cambro-Ordovician in age.

Unnamed greenstones. Exposures of fine grained greenstones occur along the eastern margin of Sennebec Pond near the Union-Appleton town line. Their extent, age, and relationship to the other rocks in the area could not be determined in the time available.

St. George formation. The St. George formation underlies most of the southeast portion of the map area and in a central swath in the northern part, parallel to and slightly east of the St. George River. The St. George formation consists of the basal Seven Tree quartzite member, the Union marble member, and biotite schists and biotite-quartz gneisses above and below the marble. In the southern part of the area the biotite-rich metasediments are characterized by cranberry red almandite. In the North Appleton area the biotite-rich metasediments are represented by black argillites with minor amounts of tan and green phyllites.

Seven Tree quartzite member of the St. George formation. Metaquartzite underlies the ridge between the Union Town Green and Route #17. On the hill underlyng the town cemetery at the northwest corner of Seven Tree Pond, metaquartzites contain occasional greenish-yellow to brown weathering pyritiferous, graphite-rich schistose interbeds; similar interbeds occur in the quartzites at Union Center and on Route #17 east of the Junction with Route #131. On the cemetery hill, individual beds are tightly folded, and the thicker quartzite beds are boudinaged; deformation has been so severe on the southwestern corner of the hill that pieces of a boudinaged metadolerite dike (?) at least 13 feet thick have been rotated out of the line of strike.

Quartz gneisses crop out on Seven Tree Island in Seven Tree Pond, and fine grained gray and white somewhat feldspathic thinly banded quartzite rocks containing a few percent sulfides and other dark minerals occur along the southeast shore of the pond. Despite different deformational textures and a slightly variable mineralogy, the quartzitic metasediments from Route #17 to Seven Tree Pond are considered correlative and are here named the Seven Tree quartzite.

Along the southeast side of Sennebec Pond the Seven Tree quartzite is fine grained, gray and white, somewhat feldspathic, contains a few percent sulfides and calc-silicate minerals, and has 1 mm banding. In the North Appleton area a 400-foot sequence of quartzite and intercalated black phyllitic rocks have been traced along strike for 2.3 miles. The white to buff weathering aphanitic gray quartzite units are 7 to 200 feet thick. The stratigraphic sequence at North Appleton (consisting of this quartzite interval, a 75- to 100-foot thick marble 1,000 to 1,500 feet to the west, and lustrous phyllites west of the marbles) is similar to the more metamorphosed sequence in Union, thus inferring that the North Appleton and Union marble belts are correlative (Plate 1).

Sufficient mapping was not done to define the stratigraphy and structure of the East Union belt. A quartzite 100 feet thick with 5- to 10-inch thick beds occurs along the western edge of the middle marble unit instead of 1,000 to 1,500 feet away as in the Union and North Appleton Belts.

The absence of the Seven Tree quartzite in the Warren marble belt could be attributed to southward thinning of the unit, but is more likely due to folding.

Union marble member of the St. George formation. The type locality of the medium to coarse grained Union marble is the quarry within the bend of the St. George River west of Union Center (Plate 2). The true thickness of the marble is unknown because units of this marble have been tectonically thinned. Plates 1 and 2 show the stratigraphy and structure of the Union belt.

Instead of one thick interval of marbles as at Union, the other three marble belts of northwestern Knox County have two or more outcrop belts of marble. At least two of the four belts in Warren are related by folding (Fig 3) and the same could be true of the multiple belts in East Union-Hope. The southeasternmost outcrop in the area of Figure 3 is an impure calcic marble.
FIG. 3    GEOLOGY OF THE MIDDLE ROAD ANTIFORM

EXPLANATION
(same as Plate I)
contour interval = 20 ft.
Blocks of the same rock type were seen in 1963 in the waste piles of the quarry along the abandoned railroad bed in Warren, so another thin marble unit probably exists in this area. In the North Appleton area a thinner marble occurs between the Seven Tree quartzite and the extensively quarried thicker marble. Perhaps this thin marble is equivalent to the stratigraphically lowest "paper rock" marble or the calc-silicate units along the western side of the St. George River at Union (Plate 2 and Fig. 4).

The regional structure outlined by the Appleton formation and described below suggests that despite the somewhat different local stratigraphies of the four belts, they are all correlative with each other. On the geologic map (Plate 1) the Union marble member is shown as a calcitic facies, magnesian facies, or as parts mapped by Bastin (1908b) that were not rechecked in the field. The geology and causes of dolomitization of each of the belts is discussed in more detail under economic geology.

**Appleton formation.** The Appleton formation underlies Appleton Ridge. The eastern contact coincides with the St. George River and associated ponds. The Appleton formation consists primarily of dark colored metasediments, some of which contain chiastolite or sillimanite metacrysts.

**Round Pond facies of the Appleton formation.** The Round Pond facies is known to extend from Round Pond northward to Sennebec Pond. The facies is characterized by finger-sized white chiastolite metacrysts that commonly have intermediate pink zones around black cruciform cores. The metacrysts are usually arranged at right angles to each other in the foliation planes of gray fine grained muscovite-biotite quartz schists, with the biotite forming 1 mm long tabular black metacrysts in an otherwise gray ground mass. In thin section only the biotite within the slightly cataclastic chiastolite has escaped partial alteration to chlorite. These chiastolite-bearing units are intercalated with chiastolite-free metasediments 5 to 10 inches thick.

Although unmapped, the western shore of Sennebec Pond is known to be underlain by the Round Pond facies. Farther north beneath the bridge at Appleton the Round Pond facies has become a phyllite, but the very large chiastolite metacrysts persist.

**Ghent phyllite facies of the Appleton formation.** A lustrous, gray phyllite, here named the Ghent phyllite, crops out at Ghent on the St. George River in southern Searsmont and along Route #131 west of North Appleton. No such phyllite occurs in the nearby marble belt southeast of the St. George River so the Ghent phyllite is inferred to be equivalent to the chiastolite-bearing lustrous gray phyllite of the Round Pond facies in the river bed at Appleton Center.

**Altered Round Pond facies of the Appleton.** On the hill south of the cemetery hill and the St. George River in Union, chalky feldspathic prisms approximately the same size as chiastolite metacrysts form distinctive solution pits in metasediments otherwise similar to the Round Pond facies. Approximately 1,500 feet north of the Warren-Union town line is a fine grained slightly garnetiferous biotite gneiss with coarse poikilitic muscovite. The bedding that has not been obliterated is thin and folded in the same style as the beds on the aforementioned hill and the Round Pond facies to the north, but here the prisms are filled with chalky white feldspars and some biotite surrounding a cruciform core of muscovite, pseudomorphic after the chiastolite cores. Some of the pseudomorphs contain tan to nearly transparent needles of sillimanite. The chiastolite-bearing Round Pond facies grades southward into a sillimanite-bearing gneiss.

**Vaughan Neck sillimanite gneiss facies of the Appleton formation.** A rusty weathering sillimanite-bearing fine grained biotite gneiss is well exposed on the median ridge of Vaughan Neck and extends southwestward to North Pond. The sillimanite occurs as transparent to tan needles up to 2 cm long or as brown fan-shaped grains up to 0.5 by 3.0 cm. The member is also characterized by isolated doleritic and meta-quartzitic boudins (Fig. 5).

The southward increase in metamorphic grade and the southward alteration of the Round Pond facies into a sillimanite-bearing biotite gneiss implies that the Vaughan Neck gneiss is the stratigraphic equivalent of the Ghent phyllite and the chiastolite-bearing phyllites and schists of the Appleton formation. Furthermore, the Vaughan Neck gneiss has the same stratigraphic rela-
**EXPLANATION**

- Overburden
- Schists and gneisses
- Sugary dolomitic white marble
- Pyrrhotiferous black quartzite
- Paper rock marble
- Red (hematite?) marble
- Paper rock marble; b = basalt sill
- Green diopsidic marble
- Red (hematitic?) marble
- Paper rock marble
- Rusty, black amphibolite
- Schists and gneisses

**Fig. 4a** STRUCTURE OF UNION MARBLE BELT IN UNION QUARRY

DRAWN ALONG A-A' OF PLATE 2

**Fig. 4b** STRUCTURE OF UNION MARBLE BELT THROUGH KNOX LIME COMPANY DRILL HOLES.
tionship to the Warren marble belt as the Round Pond facies does to the Union marble belt. Additional mapping would indicate whether the sillimanite-bearing units are restricted to an aureole around the Waldoboro pluton.

Undifferentiated Appleton Ridge units. Appleton Ridge has not been mapped thoroughly enough to delimit the extent of the Round Pond facies or to discover what other rock types are present. Along the Union-Appleton town line south of Pease Corner at an altitude of 400 to 500 feet, a biotite quartz schist contains stubby pink andalusite metacrysts up to 5 cm by 2 cm by 3 cm.

On the southeast side of the 640-foot hill on the south end of Appleton Ridge there are folded muscovite-biotite schists which contain abundant and beautiful chiastolite metacrysts with pink cores around dark cruciform centers; the largest metacrysts are 5 cm by 1 cm. Graded beds in similar but chiastolite-free rocks are folded into a small syncline on the north side of the 640-foot hill (Fig. 6). The syncline occurs in a practically unmapped area so it cannot be used to verify the regional structure inferred below.

Unnamed gneiss on Clarry Hill. Cursory reconnaissance of the southeastern part of Clarry Hill one mile southwest of Round Pond failed to disclose either sillimanite-bearing or chiastolite-bearing rocks. The hill is underlain by a coarse grained garnetiferous biotite-muscovite gneiss containing broken veinlets and 2 to 3 inch square blocks of muscovite granite. The foliation is locally variable. Although the muscovite of the gneiss is coarse and poikolitic like the altered Round Pond facies, the gneiss does not appear to be conformable with the Round Pond facies and its inclusion in the Appleton formation may not be justified.

Washington quartzite. Metaquartzite approximately 1,200 feet thick forms small ridges in eastern Washington and in Appleton northwest of Appleton Ridge. The formation here named the Wash-
ington quartzite is a gray weathering grayish to greenish fine grained calc-silicate-rich metaquartzite with biotite commonly along the bedding planes. It is characteristically even bedded (3 to 5 inches thick) and slabby weathering; patches of similar lithology crop out in a northeast trending belt from Fuller Brook in Warren through White Oak Pond to the east side of Seven Tree Pond. The outcrop at Fuller Brook on the Union-Warren road is a tightly folded synform.

**IGNEOUS ROCKS**

*Gabbroic rocks.* No attempt was made to study the East Union norite (Bastin 1908a), but fine to coarse grained gabbro occurs in at least three localities; on the northeast side of the 120-foot hill 1.5 miles south of the Union-Warren town line within the bend of the St. George River; 0.75 mile southwest of East Union; and on the 240-foot hill on the southeast side of Sennebec Pond.

The age of the gabbro is uncertain because its apparent absence in the Appleton formation may be due to a lack of detailed mapping. Northeast of Crawford Pond in East Union the gabbros are cut by coarse grained muscovite granite dikes which elsewhere intrude both the St. George and the Appleton formations. On the 240-foot hill southeast of Sennebec Pond meta-gabbro that contains square pyroxenes up to 5 mm square grades outward into, and is rimmed by, gray fine grained amphibolite, indicating that the gabbro was emplaced prior to metamorphism of the surrounding St. George formation. Thinner ultrabasic intrusives such as the dike described on the Union cemetery hill and the thin dolerite sill in the thickest “paper rock” unit of the Union marble belt (Fig. 7) are boudinaged and folded with the country rock.

Figure 7

7a. Boudinaged metadolerite (dark) in middle paper rock unit (white and gray) of the Union marble, 150-foot level of Union quarry, looking south.

The boudin line shown in Figure 7b trends N 24° E, with a plunge gently to the north.
Amphibolites also occur on the west side of the river at North Appleton, in the marble pit near the north end of Vaughan Neck (sample #165)*, as the hanging wall of the marble quarry along the old railroad bed on the east side of the St. George River in Warren (sample #90), and 1.6 miles southeast of Appleton Center. The origin and age of these rocks are not known. At the latter two localities the amphibolites are tourmalinized, and the Appleton occurrence contains chalcopyrite.

**Biotite granites.** Fine grained biotite granites appear to be largely restricted to the biotite rich metasedimentary units of the St. George formation and may represent local granitization of these metasediments.

**Waldoboro granite.** The Waldoboro granitic pluton underlies the southwest corner of North Pond in Warren. West of the map area in a quarry on the north side of U. S. Route #1 just east of Waldoboro it is a medium grained buff colored biotite granite, but near the contact on the southeast shore of North Pond it contains muscovite.

Coarse grained muscovite granite dikes that often contain small grains of black tourmaline frequently cut the Warren marble belt between North Pond and the St. George River. Elsewhere these granites intrude the East Union norite, the Appleton formation, the Union marble belt and the rest of the St. George formation. These granites are unmetamorphosed and probably intrude all of the other formations as well. However, on the small knob west of the southwestern bay of Round Pond, a granite dike within the Round Pond facies has been deformed into 5- to 6-foot long boudins and ruptured veinlets of this granite also occur in the unnamed gneiss on the southeastern part of Clarry Hill. The muscovite granite is therefore inferred to be syntectonic.

Although Hurley and others (1958) obtained a preliminary minimum potassium-argon date of 205 million years for the granite near Waldoboro Village, the geographic distribution of dates shown by Faul and others (1963) suggests that the Waldoboro granite may be Acadian in age.

**STRUCTURE**

**Regional structure.** The areal distribution of the three facies of the Appleton formation in Union and Warren defines the limbs of a southerly plunging antiform at least three miles wide. The dips on both limbs are easterly, indicating an overturned fold. If the Ghent phyllite in Appleton is correlative with the Round Pond facies of the Appleton formation in Union, the western limb of this fold, here named the Watten antiform, is at least 16 miles long. The Vaughan Neck sillimanite gneiss occurs east of the marbles in Warren on the eastern limb, and the Round Pond and Ghent phyllite facies lie west of the marbles at Union and North Appleton on the western limb. The absence of the Seven Tree quartzite in Warren can be attributed to its interior position within the Warren antiform (Plate 1).

The Appleton formation on the western limb is partially repeated by folding and therefore appears to be much thicker than the Vaughan Neck gneiss. However, the area immediately southeast of Vaughan Neck has no outcrops, and the presence of sillimanite-bearing gneisses at Warren Station on South Pond ¾ mile south of U. S. Route #1 suggests that the thickness of the southeastern limb is comparable to the northwestern limb.

The marble belt within the bend of the St. George River in Warren confirms the regional antiformal structure. The steep southeasterly dip and phacolithic structure of the magnesian marble in the quarry along the old railroad bed on the west side of this belt were visible in 1963 (Fig. 8). Figure 9 shows the overturned metasediments of the footwall. The more gently dipping marble belt near the crest of the hill defines the crest and eastern limb of the herein named Middle Road antiform, the quarry being in the overturned western limb. A folded tremolite layer at the crest of the hill (Fig. 10) is believed to be a small scale example of this style of folding. An equal-area projection of 16 measurements of foliation and bedding from these two marble quarries gives

*See Appendix for sample descriptions.
a poorly defined girdle indicating a southerly plunge of about 30 degrees, confirming the antiformal nature of the southerly plunging Warren antiform.

Figure 8

8a. Union marble in western overturned limb of the Middle Road antiform. Note the phacolithic structure of the marble and the overturned metasediments below it. The hanging wall is composed of tourmalinized amphibolite.

8b. Overturned meta-quartzites and pyrite-rich biotite metasediments below the footwall of quarry in western limb of Middle Road antiform.

8c. Minor antiform near the crest of the Middle Road antiform. Thick gray units are gray tremolite. Thin dark units caused by weathering of Mg-marble.
The northern end of the Warren marble belt and the southern end of the East Union-Hope belt are on strike and are probably correlative, thereby defining the eastern limb of the Warren antiform. The East Union norite occupies the interval between the two belts, and tremolite becomes increasingly abundant in both belts near the norite.

The southward plunging minor synform of quartzitic beds in the unnamed quartz-stringer gneiss on the summit of Barrett Hill (Plate 1), the unusually large northeasterly strikes of the foliations surrounding and in the marble outcrop on Route #235 north of the Union-Hope town line, and the reported presence of marble in a drill hole on the small peninsula in the southeastern corner of Alford Lake suggest that the marble belt and associated rocks may re-curve southward at Alford Lake, thus making the Alford Lake area the nose of a regional synform.

Stratigraphic considerations. If the Warren antiform is upright though overturned northeasterward, then the Appleton formation is younger than the St. George formation. These relative ages may also be inferred by intrusion of ultrabasic rock into only the St. George formation whereas the Waldoboro granite intrudes both the St. George and Appleton formations. No evidence was found along the northwestern border of the map area to indicate that the Washington quartzite overlies the Appleton formation, but the presence of the quartzite at Fuller Brook in Warren and at White Oak and Seven Tree ponds indicates that it unconformably overlies both the St. George and Appleton formations.

Other evidence compatible with a regional antiform. The following evidence is compatible with the hypothesis that western Knox County is underlain by a large antiform.

1) The structure of Lime Products Corporation’s Union quarry (Fig. 4) is monoformal. The key to the structure in the quarry is the thin basalt exposed in the westernmost bay of the quarry (summer, 1964). The orientation of this basalt is similar to the dips observed in the quarried area and is parallel to the foliation of the marble which is in turn parallel to the bedding; this basalt is therefore inferred to be a sill. The basalt is folded into a synform on the westernmost wall of the quarry, indicating that the structure of the quarry is monoformal. The monoformal structure is interpreted as being the overturned western limb of the regional antiform.

2) The alternative to the monoformal hypothesis is that the Union and North Appleton belts are the exposed cores of smaller anticlines (Allen, 1953, 1955). However, neither the marble nor the Seven Tree quartzite have been identified on the western side of either of these marble belts.

3) The quartz-stringer gneiss at the summit of Barrett Hill has not been found to the south, suggesting that it is the core of the regional Warren antiform.

4) A fresh greenish gray weathering fine grained dense greenstone or amphibolite at least 23 feet thick underlies the western abutment of the ruins of the original bridge across the St. George River northwest of Union Center (Plate 2), and a garnet-rich green schist crops out along the eastern shore of Seven Tree Pond southwest of South Union. Rusty weathering graphic schists are exposed in a borrow pit between the river and Route #131 northwest of Union Center and also along Route #17 at the south end of Barrett Hill. The repetition of these units west and east of belts of the Seven Tree quartzite indicates that the northern part of Seven Tree Pond occupies the axial trace of the Warren antiform.

Faults. A northerly trending, steeply westward dipping normal fault with a throw of 10 feet was exposed along the base of the western wall of the Union quarry in 1963 (Fig. 4). The only other evidence for a fault is drill hole KL 1 (Plate 2).

A northwestern projection of this fault could account for the eastward offset of the otherwise normal sequence (“ep” paper rock and structurally lower units) encountered in KL 6 (Plate 2). Projection of this fault southward from KL 1 provides an explanation for the contorted biotite schists on the southeast corner of the Union Center hill, the topographic break between this hill and the cemetery hill, and the contorted schists between this hill and the cemetery hill and Seven Tree Pond. The contorted quartzites at cemetery hill and the northwesterly strike of the quart-
zites on the northern end of Seven Tree Pond could be interpreted as drag folding along the fault. Relative movement along the fault would have been east block down and southward (Plate 2).

The tentative identification of kyanite in the folded and faulted quartzites of the cemetery hill which is next to the chiastolite-bearing Round Pond facies suggests tectonic "over pressure".

REGIONAL CORRELATION

Penobscot Bay—Knox County area. Bastin (1908b, p. 3) was able to trace the more metamorphosed facies of the Penobscot formation from Rockland nearly to the western border of Knox County; thus the rocks of northwestern Knox County may be broadly correlative with those of eastern Knox County. On the islands of Penobscot Bay further to the east, rocks similar to those in the Rockland area are unconformably overlain by fossiliferous strata at least as young as Middle Silurian (Smith and others, 1965).

If the angular unconformity separating the St. George and Appleton formations from the overlying Washington quartzite is the same unconformity recognized by Smith and others to the east, the Washington quartzite is Silurian and Knox County is an anticlinorium of pre-Silurian metasedimentary rocks (intruded by younger intrusives). D. S. Barker (oral communication, 1963) has suggested that the Washington quartzite possibly may be part of the Vassalboro formation which is the basal unit of the Siluro-Devonian sequence of west-central Maine, and J. M. Trefethen (oral communication, 1965) thinks that it may be part of the Bucksport formation which he has mapped as far south as Belfast. The Vassalboro and Bucksport are thicker than the Washington quartzite, but the quartzite may be a basal member of one or both of them.

Rockland-Rockport area. The marbles at East Union are so similar to the Rockport limestone that Bastin (1908b) mapped the East Union-Hope belt as Rockport limestone. He also considered the Warren belt, despite its obviously magnesian composition, as part of the Rockport limestone. Basic igneous rocks, which appear to be confined to the St. George formation in northwestern Knox County, occur as boudins in both the Rockport limestone (Bastin, 1908b, p. 4) and the Union marble, further suggesting that the marbles are correlative. Bastin also reported that the Penobscot formation is often andalusite-rich, especially the more metamorphosed facies of the formation. These andalusite-bearing rocks may thus be correlative with the chiastolite-bearing Appleton formation. In the Rockland area the grade of metamorphism is apparently somewhat less, for muscovite is the dominant mica.

Although the rocks of northwestern Knox County and the Rockland quadrangle appear to be similar in age and lithology, the stratigraphic sequence compiled by Bastin (1908b) in the Rockland area is not similar to the inferred sequence of northwestern Knox County (Table 1). As mapped by Bastin, the Rockport and Rockland marble belts are oddly discontinuous; he obviously did not believe that one could be traced into the other. In suggesting the Rockport belt to be a syncline, he had to assume that the greenish siliceous limestone member and the Weskeag quartzite along the eastern margin of the belt were basal members that pinched out beneath the belt, for they do not reoccur along the western limb of the proposed syncline.

He did not map these basal units in the Rockport belt; instead, all thin quartzites and all thin marbles are shown as massive facies of the Battie quartzite conglomerate and Coombs limestone respectively. In the Rockport area he shows an interval of "Penobscot" rocks between the Rockport limestone and the thin massive quartzite and thin limestone. The siliceous limestone and quartzite members of the Rockland formation were not mapped in the Rockport area, nor were the Coombs limestone and Battie quartzite recognized in the Rockland area.

Structural reinterpretation of the Rockland quadrangle. The three members of the Rockland formation mapped by Bastin as a minor northward plunging anticline south of Blackington Corners suggest a structural reinterpretation that solves the above mentioned problems. It is suggested that the Rockland marble belt is the western limb and the Rockport marble belt the northward plunging nose of a larger antiform. The belts are continuous but may be so tectonically thinned
<table>
<thead>
<tr>
<th>Bastin (1908) Rockland quadrangle</th>
<th>This Report NW Knox County</th>
<th>Proposed Revision of Bastin (1908b) Rockland quadrangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{$or}$</td>
<td>$\text{$s}$</td>
<td>$\text{$w}$</td>
</tr>
<tr>
<td>ROCKLAND FORMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>white to purple crystalline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>limestone, limestone conglomerate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and shaly limestone comprising</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROCKPORT LIMESTONE member, $\text{$or}$ with greenish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>siliceous limestone member, $\text{$s}$, and WESKEAK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QUARTZITE member, $\text{$w}$, locally at base.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{$p}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PENOBSCOT FORMATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>regionally metamorphosed rocks,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chiefly slate and schist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{$b}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BATTIE QUARTZITE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>quartzite and quartzite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>conglomerate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{$c}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{$i}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISLESBORO FORMATION &amp; COOMBS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIMESTONE MEMBER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>slate &amp; schist with shaly and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>occasionally pure limestones,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{$c}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Correlation Chart for Knox County, Maine

See explanation of Plate 1 for description of NW Knox County units.

that the marble is covered in the valleys and swamps of southern Rockport. The eastern limb
would lie off the present coastline east of small areas mapped as Battle quartzite. The Battle quart-
zite at Mt. Battie, instead of being a dome (Bastin, 1908b, p. 2), is the nose of the anticline. The
thin Coombs limestone east of the Rockport belt on Deadman Point east of Rockport Harbor then
becomes correlative with other small patches of limestone scattered along the western margins of
the Rockport and Rockland marble belts.

This interpretation makes the Rockland formation older than the Penobscot formation. The
Penobscot formation would correlate with the lithologically similar Appleton formation which over-
lies the St. George formation. The Islesboro formation (represented by the Coombs limestone) and the Mt. Battie quartzite are thin, and are between the Rockland formation and the Penobscot formation. They do not reoccur in the northwestern part of Knox County. The position of the Rockland formation below the Islesboro would explain why it is not found in the Penobscot Bay area which is underlain by the Islesboro and younger rocks.

The Weskeag quartzite member of the Rockland formation would be correlative with the narrow band of “massive Battie” quartzites of Rockport and the Seven Tree quartzite member of the St. George formation. The greenish siliceous limestone member of the Rockland formation in Rockland would be equivalent to the Coombs limestone and argillites in the Rockport area, and both of these sequences in Rockland and Rockport would correlate with biotite schists and gneisses, phyllites, calcsilicates, and thin marbles between the Seven Tree quartzite and the Union marble. The Union marble is considered to be equivalent to the Rockport limestone.

Because of the tentative nature of the above correlations, the local stratigraphic nomenclature of northwestern Knox County should be retained until all of Knox County is thoroughly mapped.

GEOLOGIC HISTORY

The geologic history of northwestern Knox County is undoubtedly more complex than the preliminary field work indicates. No fossils and few distinctive primary sedimentary features were found to indicate the environment or the sequence in which the original sediments were deposited. The stratigraphic sequence is based upon the assumption that the regional Warren antiform is actually an anticline.

The unnamed quartz-stringer gneiss on the summit of Barrett Hill is assumed to be Cambrian on the basis of its position in the core of the inferred antiform and its apparently higher metamorphic grade with respect to juxtaposed extremely rusty weathering biotite gneisses and schists. The overlying rocks are inferred to be Cambro-Ordovician.

The restriction of ultramafic rocks to the St. George formation suggests that these rocks (including the East Union norite) were intruded prior to the deposition of the Appleton formation. In order to form sillimanite and chiastolite-rich rocks with metamorphism, the original sediments of the Appleton formation were probably very aluminous shales. Assuming an average dip of 60 degrees and no repetition due to folding between Barrett Hill and the Washington quartzite the maximum possible thickness of the pre-Washington formations is about 22,000 feet.

The Appleton, St. George, and older formations were folded, uplifted, eroded, and submerged before deposition of the thin bedded calcareous sediments now preserved as the Washington quartzite. If this angular unconformity is correlative with the Taconic unconformity of eastern Penobscot Bay, the Washington quartzite is probably Silurian, and the Appleton and older formations are Cambro-Ordovician to upper Ordovician.

The boudinaged granite dike at Round Pond and the disrupted granitic veinlets in the unnamed gneiss on Clarry Hill might be evidence for a single period of metamorphism, although the Taconic (?) unconformity indicates at least two periods of folding and the norite and granites indicate two periods of intrusion. The Acadian (?) Waldoboro granite and its syntectonic, coarse grained, muscovite granite facies are unmetamorphosed, indicating that they are the youngest rocks of the area; however, the granites have not been found in the Washington quartzite.

Pleistocene till and outwash, locally overlain by green marine silts, cover most of the crystalline rocks.

ECONOMIC GEOLOGY

Sulfide Ores. Perhaps the greatest economic potential of the area is the nickel and cobalt-bearing pyrrhotite of the East Union norite body (see Bastin, 1908a), but an evaluation of this deposit is beyond the scope of this study; a gossan occurs on the northwestern shore of Crawford Pond.
Little can be said about the chalcopyrite-bearing tourmalinized amphibolite on the Roland Gushee farm in Appleton because the area was not mapped, and in 1963 the old shaft was full of water. Grab samples from rubble around the shaft were forwarded to the State Geologist1. A newspaper account of this prospect was published some years ago in the Rockland Gazette. Time permitted neither verification nor sampling of a copper prospect reported on the Everett Crabtree property on the southwest corner of Fish Pond near South Hope.

*Mullite ores.* The Vaughan Neck facies of the Appleton formation contains 10 to 11 percent sillimanite which is easily liberated (but not separated) from the remainder of the rock when crushed to 30 or 50 mesh (Forsyth, 1955).

A better source of mullite ore would seem to be the Round Pond member of the Appleton formation that is composed of 10 to 15 percent by volume as finger length chiastolite metacrysts. Preliminary mapping suggests that this facies is best developed between Route #17 and the west side of Sennebec Pond.

*Marble.* Although all of the marble belts of northwestern Knox County are thought to be correlative, they vary in thickness, local stratigraphy, impure interbeds, and purity (Table 2). Each belt is discussed below; the problem of dolomitization is discussed last.

*Union marble belt.* The largest known reserves of high calcium marble in northwestern Knox County occur in the Union belt. The belt is about 275 feet thick, of which approximately 200 feet in three different units are nearly pure carbonate. The stratigraphically oldest (i.e., eastern-most) marble (hp of figure 4) and the thick middle marble (ep) are locally called “paper rock” because their large grain size and very high calcite content make them suitable for the paper industry. The chemical assays for the middle “paper rock” in Rand’s cross section along the new Route #17 (Fig. 4) are noticeably lower than assays from the same unit in KL 5 and KL 6, indicating some variation along strike. The unit in the bottom of the quarry (ad) is a massive fine grained slightly dolomitic marble and might be used for building or ornamental stone as well as magnesian agricultural lime. The other impure marbles are suitable for agricultural lime when blended with “paper rock”.

The belt is known to extend at least 2,900 feet northward beyond the main quarry where “paper rock” has been assayed from rubble in an old test pit near the river (sample #293) and encountered 4 to 19 feet below the surface (Plate 2). The high CaO assays of the rubble and the 100-foot width of apparently similar rock encountered in drilling to bedrock suggest that this is the thick middle “paper rock” (ep). The regional geology indicates that the belt may be inferred to extend parallel to or beneath the river both north of the test pit and south of the main quarry. New reserves of marble may be found south of the quarry area within the bend of the St. George River between the cemetery hill and Round Pond, but overburden or water problems may render this marble inaccessible.

The structure of the Union marble in the main quarry is shown in Figure 4. The monoformal structure of the belt, modified by a slightly faulted gentle antiform crest and a tightly folded synform in the quarry area (stratigraphically these are a synclinal crest and anticline respectively), changes northward along strike to a more gently dipping homoclinc in KL 6. Although KL 6 indicates a simple homoclinc (32° SE) structure, the area north of new Route #17 in Plate 2 must be affected by the fault in KL 1. The structure shown in Plate 2 is only the simplest that is consistent with the fault in KL 1, the section in KL 6, and the presence of exceedingly pure “paper rock” rubble around the northern test pit. Many other interpretations are possible.

The greatest amount of “paper rock” that could be recovered per linear foot of quarry extends from the northwest side of the present quarry to the middle of the segment between the old road to Union Center and new Route #17 (Plate 2). The total amount of high calcium marble that could be recovered from this area may be conservatively estimated at 4 to 5 times the amount

1Prospected in 1965 with detailed geologic mapping, sampling and three shallow diamond drill holes. (ed.)
<table>
<thead>
<tr>
<th>Belt</th>
<th>Known Length (Feet)</th>
<th>Description</th>
<th>Thickness</th>
<th>Chemical Purity</th>
<th>Physical Impurities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Union</td>
<td>3,000</td>
<td>sugary dolomitic marble&lt;br&gt;impure marbles and quartzites&lt;br&gt;“paper rock” marble&lt;br&gt;impure marble&lt;br&gt;“paper rock” marble&lt;br&gt;impure marbles&lt;br&gt;“paper rock” marble</td>
<td>50'</td>
<td>medium CaO, medium MgO</td>
<td>waste&lt;br&gt;These units could be used for agricultural lime when sweetened with high CaO rock.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12'</td>
<td>very high silica</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6'</td>
<td>high CaO</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4'</td>
<td>high in calc-silicates</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>90-100'</td>
<td>high CaO</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70-80'</td>
<td>high in calc-silicates</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>40-60'</td>
<td>high CaO</td>
<td></td>
</tr>
<tr>
<td>North Appleton</td>
<td>11,000</td>
<td>Two units separated by 500-600' of silicate rocks.&lt;br&gt;upper marble&lt;br&gt;lower unit</td>
<td>31-46'</td>
<td>high CaO north of Rt. # 105?</td>
<td>many thin siliceous units; several marble units contain 2-10% tremolite crystals; other units contain 4-20' knots of tremolite.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(thickness may be increased to 200-400' south of Rt. # 105 due to intraformation folding)</td>
<td>95-100'</td>
<td>variable CaO and MgO</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warren</td>
<td>11,000</td>
<td>One or two units exposed as four belts due to folding.&lt;br&gt;The thicknesses vary from 100-120' and 25-37'.&lt;br&gt;Each belt is separated from the next by 200 to 1,000' of silicate rocks.</td>
<td></td>
<td>high MgO</td>
<td>South of the southward bend of the St. George River, granite dikes cut the marble into uneconomically small intervals. Isolated tremolite crystals and knots become more plentiful north-east of Middle Road.</td>
</tr>
<tr>
<td>East Union-Hope</td>
<td>21,000</td>
<td>2 or 3 marble belts separated by 300 to 1,000' of silicate rock.&lt;br&gt;western unit&lt;br&gt;middle unit&lt;br&gt;eastern unit</td>
<td>probably 30-40'</td>
<td>high MgO but perhaps some high CaO north of Union-Hope Townline</td>
<td>Tremolite crystals and knots common south of Rt. # 17 western unit contains many siliceous interbeds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>approx. 75'</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>45'</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Comparison of the marble belts of northwestern Knox County
that has already been removed from the present quarry. A roughly equal amount of red, brown, and green impure marble could be mined and “sweetened” with high calcium marble for agricultural lime. If a market could be developed for MgO in the paper industry, the double width of the sugary dolomite in the northern part of the belt would increase the economic importance of the Union belt.

Quarrying will be complicated by overburden, roads, and the river. The overburden consists of Pleistocene marine clay more than 12 feet thick in some places overlying a variable and unknown amount of glacial till or outwash. Next to the river at the northern end of the belt the overburden is only 4 to 19 feet thick. The Union marble belt and the neighboring East Union-Hope belt probably contain enough marble to support a cement industry. The marine clay might be used as a source of aluminous silicate for the cement.

**East Union-Hope belt.** The stratigraphy and structure of this belt is unknown, but the extensive exploratory drilling for nickel in the area should provide some subsurface information. On the Wentworth farm on the south side of Route #17, the magnesian tremolite-bearing marble is 65 to 70 feet thick (samples #453 and #457). This unit apparently retains this thickness and nearly vertical dip at least as far north as Route #235 north of the town line, so quarrying may prove economical. Another promising area is the eastern belt that crops out on the E. L. Bean property (sample #184) and probably extends north-northeastward along the brook into Hope. Granite dikes more than 20 feet wide cut a third thin marble belt to the west and also occur along the strike of the middle belt. If these dikes are extensive, they may cut the western two belts into segments that are too small to work economically. The thin westernmost belt (sample #435) has too many impure biotitic schistose interbeds to be of economic value.

The total reserves of Mg-marble are unknown, but the presence of thin tremolite veinlets in the central marble belt south of old Route #17 (samples #453 and #457) suggests that the southern end of the East Union-Hope belt is worthless. If high calcium marble does exist in this area, the high MgO assay of sample #431 indicates that it lies northeast of the Union-Hope town line.

**North Appleton belt.** Allen (1955, page 14) recognized the en echelon arrangement of quarries south of Route #105 and concluded that the belt is a doubly plunging anticline, presumably by comparison with the Union belt which he considered a doubly plunging anticline (1953). The North Appleton belt is inferred in the present paper to be part of the overturned limb of the regional Warren antiform.

The structure of the Magog quarry is similar to the Union quarry in the Union belt. Throughout most of the quarry the rocks and foliation dip steeply eastward, but in the southwestern corner the metasediments are synformal. An equal-area projection of two marble-argillite contact measurements combined with two foliation measurements in the marble show that the fold axis trends S 72° W, plunge 58°, but the foliation along the fold axis within the underlying marble is antiformal (samples #350 and #351).

Tectonic thickening and thinning of the marble make an estimate of its original thickness difficult. The minimum thickness of the southeastern limb of the Magog quarry synform is 80 feet, and northward along strike the belt is 75 feet wide in Jam Black Brook. A small fold occurs in the brook, and at both localities additional folding may be obscured. The original thickness of the marble could also have varied along strike. The original thickness of the marble was probably less than 100 feet since folding is present on both sides of Route #105 where the belt is about 200 feet wide.

If the belt is to be developed, it should first be systematically sampled across strike. A trench through the 180-foot knoll, 800 feet northeast of Route #105 (sample #386) where the belt is only about 200 feet wide, would sample the entire belt and may permit an evaluation of its structure. The marbles of North Appleton variably contain magnesian and some are tremolite bearing. The presence of thin siliceous units, marble units containing tremolite crystals and knots
of tremolite, and the apparent dolomitization of some of the marble indicates that any future quar- 
rying operations will require close assay and stratigraphic control. However, the potential reserves 
of this belt may be several times those of the Union belt. Since the marble is steeply dipping and 
200 to 400 feet wide in the vicinity of Route #105 in North Appleton, large quarries could be 
opened. The marble probably is suitable for agricultural lime.

Paralleling the main marble belt to the southeast is a thinner belt (samples #264, 290, and 
363) 31 to 46 feet thick. This belt has been quarried only slightly. North of Route #105 it 
seems to contain higher calcium marble (sample #363) than the main belt to the west but it is 
probably too thin and contains too many impure units to be worked profitably.

Warren belt. The four marble belts in Warren are believed to be one unit repeated in two anti-
forms (see cross section A-A' of Plate 1). These belts have not been mapped in detail south and 
east of the St. George River so that the structure shown for this area on Plate 1 is only assumed 
to be similar to the Middle Road antiform (Fig. 3). All of the marble in this area is magnesian.

Tremolite veinlets are too common in the northeastern limb of the Middle Road antiform to 
permit economical quarrying. Between Middle Road and North Pond numerous coarse grained 
muscovite granite dikes cut the southeastern limb of the eastern antiform; the former marble quar-
ries are seldom more than 75 feet long. In these quarries the white magnesian marble is usually 
very coarse grained and without visible impurities. The area of Vaughan Neck near Middle Road 
has already been extensively quarried. The western limb of this eastern antiform is probably not 
suitable for quarrying because it borders the river and is tectonically thinned to 25 feet (sample 
#162). The eastern limb of this eastern antiform (samples #161 and #165) may be more suit-
able but cannot be evaluated without drilling or mapping of the flooded abandoned quarries on strike 
to the southwest.

The most promising prospect is the large former quarry 220 feet wide and 1,500 feet long 
trending approximately N 15° E on the crest of the Middle Road antiform on the Wallace farm 
(Fig. 3). The marble belt extends another 1,100 feet north-northeast across Middle Road but be-
comes progressively tremolite-rich (samples #127, 458, 459, and 460).

The foliation in the quarry generally dips 28 to 39 degrees southeast indicating that the mag-
nesian marble is approximately 120 feet thick. In the exposure southwest of Wallace's barn the 
base of the quarry is 18 feet below the crest of the hill, and the working face would increase as 
quarrying progressed eastward toward the crest of the hill because the marble dips 28° to 58° SE 
(see cross section B-B' of Fig. 3). Overburden is thin or nonexistent up to the inferred eastern 
contact of the belt. Gray tremolite zones 1 to 2 feet thick parallel the foliation of the marble (Fig. 
10) but appear to be widely enough spaced to be easily discarded. The 58° SE dip of the eastern-
most exposure of marble indicates that the quarry would not endanger the small cemetery next to 
Middle Road, Middle Road itself, or the Hill farm on the east side of the road.

Cause of dolomitization. It is not known whether dolomitization of the marbles of northwestern 
Knox County is a diagenetic, regional metamorphic, or contact metasomatic effect related to the 
emplacement of the East Union norite or the Waldoboro granites. Dolomitization in the Union belt 
is selectively restricted to the sugary white dolomitic marble in the footwall.

Emplacement of the East Union norite is inferred to have caused the talcose schists in the 
roadcuts for new Route #17 in East Union and tremolitization of the northern end of the War-
ren marble belt and the southern end of the East Union-Hope belt. Accurate mapping of the 
norite and assays of the marble samples from both belts at various distances from the norite might 
indicate whether dolomitization is also related to the norite.

RECOMMENDATIONS

Geology. Additional marble reserves and sulfide deposits might well be discovered between Union 
and Rockland and elsewhere in the pre-Silurian terrane on the mainlands of Knox and Waldo coun-
ties if detailed mapping indicates that the St. George formation is correlative with the Rockland for-
Chemical assays and additional mapping may clarify the cause of dolomitization and the existence of high calcium marbles.

Complete detailed mapping of the area would solve several geologic problems, including correlations with Bastin's work in the Rockland quadrangle and correlations with the Bucksport and Vassalboro formations. Specifically, it is recommended that (a) the metamorphic and mineralogic facies of the Appleton formation be studied, and the possible repetition of the Appleton formation east of the map area should be investigated; (b) the detailed structure and stratigraphy of the North Appleton, East Union-Hope and Warren marble belts should be mapped; (c) the Washington quartzite should be traced northward; and (d) the unknown significance of the greenstones east of Sennebee Pond and the tourmalinized chalcopyrite-bearing amphibolites of east Appleton should be clarified.

It is recognized that most or all of the rock units described in this paper may eventually be shown to be correlative with previously mapped and named rock units nearby. Until such time as all of both Waldo and Knox Counties is geologically mapped, the names used herein should be considered informal.

BIBLIOGRAPHY


APPENDIX I

A total of 164 samples were collected and described by the writer. Of these, 48 were analyzed for CaO and MgO. Only the analyzed samples are described in this appendix. The remaining sample locations and descriptions are available in mimeographed form from the Maine Geological Survey, Augusta, Maine. The rock samples are also on file with the Geological Survey.

The sample localities are subdivided into the following sections:

NORTH POND SECTION: from North Pond in Warren northeastward to the Warren-Union road.

VAUGHAN NECK SECTION: The Vaughan Neck area in Warren northeast of the Warren-Union road and south of the St. George River.

MIDDLE ROAD SECTION: astride Middle Road on the north side of the St. George River in the prominent bend of the river in Warren.

FAST UNION SECTION: between new Route #17 and Route #235 in Hope.

UNION SECTION: the marble belt just west of Union Center.

GUSHEES CORNER-NORTH APPLETON SECTION: eastern Appleton south of Route #105.

ROUTE #105 SECTION: astride Route #105 in eastern Appleton.

NORTH APPLETON-KNIGHTS CORNER ROAD: northeasternmost Appleton and southeastern Searsmont.

Appendix II lists the samples that may duplicate samples previously submitted by Allen (1955).
APPENDIX I

<table>
<thead>
<tr>
<th>Specimen Number</th>
<th>SAMPLE DESCRIPTION</th>
<th>Chemical Assays</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MIDDLE ROAD SECTION</strong></td>
<td></td>
<td>CaO%</td>
</tr>
<tr>
<td>90</td>
<td>Hanging Wall of Lime Product's Warren quarry just east of the old railroad bed on east bank of St. George River immediately north of prominent bend in the river.</td>
<td>40.03</td>
</tr>
<tr>
<td>90-2</td>
<td>Medium grained gray and white Mg-marble which is more characteristic than 90-1 of the marble stratigraphically within 10 feet of the hanging wall.</td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>Large shallow quarry 1,000 feet long N 15° E, 220 feet wide and 20 feet deep immediately southwest of Wallace farm house and northeast of 90.</td>
<td>31.81</td>
</tr>
<tr>
<td>99-1</td>
<td>Medium grained, pure white, Mg-marble overlying 2-foot thick, rusty weathering, pyritiferous gray tremolite unit. The marble-amphibolite contact is N 17° E, 28° SE. Similar thin amphibolites are uncommon but conspicuous elsewhere along the northeast edge of the quarry and in the southwest corner. Locality is 8.5 feet above old quarry floor and Wallace's barn is approximately 250 N 55° E.</td>
<td>13.84</td>
</tr>
<tr>
<td>127-1</td>
<td>Road bed of Middle Road northeast of Wallace farm where road is unpaved, 55 feet north of 126. Medium grained, white and gray banded Mg-marble, fine grained gray bands might be undolomitized original limestone. Width of outcrop approximately 50 feet, foliation dips 44° SE, 5 feet south of northermost exposure.</td>
<td></td>
</tr>
<tr>
<td>144</td>
<td>Pit #2 (50 feet northwest of Pit #1); Pit #2 is about 150 feet long N 20° E, 20 feet wide and 15 feet deep.</td>
<td>31.11</td>
</tr>
<tr>
<td>144-2</td>
<td>Coarse grained, white, Mg-marble with scattered rusty weathering pyrite impurities. Sample is 2 feet below hanging wall (southeast wall) contact, and evidently was the rock quarried. Foliation is N 18° E, 44° SE.</td>
<td></td>
</tr>
<tr>
<td>149</td>
<td>Pit #6, 50 feet east of Pit #5; Pit #6 is about 60 feet long N 70° W, 20 feet wide, and 18 feet deep.</td>
<td>31.46</td>
</tr>
<tr>
<td>149-2</td>
<td>Medium grained, white, Mg-marble with scattered rusty weathering pyrite in irregular greenish bands 2-3 mm thick. From middle of 3-foot unit quarried along hanging wall at north side of pit. Foliation is N 58° W, 32° NW, suggesting that marble plunges northward.</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>Pit #4, 100 feet N 10° E of Pit #2; Pit #4 is 40 feet long N 10° E, 20 feet wide, and 12 feet deep.</td>
<td>31.81</td>
</tr>
<tr>
<td>150-1</td>
<td>Coarse grained, white, Mg-marble with faint brown banding, from north end of pit within 1 foot of coarse grained, quartz-feldspar dike that is 2-3 feet wide forming the north wall of Pit #4 and the south wall of Pit #5. Medium grained, biotite granite forms the foot wall of the entire belt containing Pits #1-11.</td>
<td></td>
</tr>
<tr>
<td>152</td>
<td>Pit #8, 50 feet north of Pit #5, Pit #8 is 20 feet long N 00° E, 6 to 10 feet wide, and 8 feet deep.</td>
<td></td>
</tr>
</tbody>
</table>
Specimen Number | SAMPLE DESCRIPTION | Chemical Assays
--- | --- | ---
152-2 | Medium grained, gray, Mg-marble with greenish black Ca-silicates and greenish brown grossularite; sample is from a plaque left upon coarse biotite granite wall trending N 30° W; plaque is 45 cm long northwest, 28 cm wide northeast and 25 cm high. | CaO% | MgO%
 | | &multiplied by| &multiplied by|
 | 161 | Ralph E. Crockett farm: 40 feet by 40 feet test pit about 15 feet deep, about 600 feet S 20° E. of farm house. | 28.67 | 18.54
 | 161-1 | Medium grained, light gray, Mg-marble with irregular black bands containing pyrite and unknown black mineral. Marble is cut by 38 cm wide, coarse grained pegmatite dike (striking N 50° W, 69° SW); fine grained muscovite, calcite-tremolite contact zone is 5 to 12 mm wide and is marked on the sample. Marble is greenish gray in an irregular 2 to 5 cm zone parallel to the contact zone. Attitude of marble cannot be determined, but sample comes from massive plaque of dolostone 3.6 feet high, 3.9 feet long, and 1.6 feet wide remaining on pegmatite dike. | 31.11 | 21.13
 | 165 | Medium grained, pure white Mg-marble unit 5 feet thick, 10 to 15 feet stratigraphically above 165-1 below 5- to 10-foot thick amphibolite dike at northwest corner of main pit; Amphibolite trending N 37° W, 61° SW forms west wall of main pit. | 29.19 | 15.35
 | 165-3 | 100 feet by 100 feet test pit about 30 feet deep about 700 feet north of farm house. | | |
 | | 165 | Medium grained, pure white Mg-marble unit 5 feet thick, 10 to 15 feet stratigraphically above 165-1 below 5- to 10-foot thick amphibolite dike at northwest corner of main pit; Amphibolite trending N 37° W, 61° SW forms west wall of main pit. | 29.19 | 15.35

**CHEMICAL ANALSYS**

<table>
<thead>
<tr>
<th>Specimen Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>152-2</td>
</tr>
<tr>
<td>161</td>
</tr>
<tr>
<td>161-1</td>
</tr>
<tr>
<td>165</td>
</tr>
<tr>
<td>165-3</td>
</tr>
</tbody>
</table>

**EAST UNION BELT**

**GUSHEE'S CORNER—NORTH APPLETON SECTION**

<table>
<thead>
<tr>
<th>Specimen Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>264</td>
</tr>
<tr>
<td>264-1</td>
</tr>
<tr>
<td>264-7</td>
</tr>
<tr>
<td>264-9</td>
</tr>
</tbody>
</table>
NORTH APPLETON—KNIGHT'S CORNER ROAD

290
In stream bed approximately 700 feet northwest of dirt road that stream crosses 2,000 feet northeast of Route #105 at North Appleton.

290-1 Medium grained, gray and white banded, soft, pyrrhotite-bearing marble. Marble bands are 5 to 13 cm wide and separated by gray sulfide-rich quartzitic interbands 1 to 10 cm thick. Width of outcrop is 3 feet. Foliation (or bedding) N 47° E, 87° NW.

290-2 Fine grained, greenish-white, pyrite-bearing marble; thinly laminated, foliation: N 47° E, 87° NW; in shaley weathering sequence 12 feet northwest of 290-1 in which the weathering slabs are usually less than 13 mm thick. Width of outcrop is 10 feet.

290-4 Fine grained, greenish white, tremolite marble 1 to 2 cm thick interbedded with fine grained rusty weathering, black phyllite. Unit is 15 feet thick and weathers into slabs 5 to 10 cm thick. Entire 290 outcrop belt is about 46 feet wide.

UNION LIMESTONE BELT

293 Rubble around test pit north of Route #17 and approximately 450 feet south of transmission line.

293-1 Medium grained, gray, banded, “paper rock” marble.

293-2 Medium grained, gray, banded, “paper rock” marble.

293-3 Medium grained, gray, strongly banded, “paper rock” marble. All of the rubble around this pit appears to be high-grade “paper rock”.

NORTH FOND SECTION

297 Approximately 1,500 feet N 45° W of Elbert L. Starrett’s farm house; Pit #1 is 80 feet long N 70° E, maximum of 50 feet wide, and 12 feet deep but floored with brush.

297-1 Medium grained, hard, light gray, Mg-marble with occasional black impurities and a trace of pyrite. From southwest corner of pit and, therefore, the stratigraphically highest unit quarried.

302 In woods 300 feet northwest of dirt road to E. L. Starrett farm 0.15 miles southwest of Warren-Union Road, Pit #4; pit is 25 feet long N 100° E, 6 to 8 feet wide, 3 feet deep.

302-2 Medium grained, hard, gray and fleshy banded Mg-marble from rubble next to pit.

303 Pit #5, 75 feet north of Pit #4; Pit #5 is 150 feet long N 70° E, the center of the pit is 20 feet wide and 20 feet deep but both ends of the pit are 8 to 12 feet wide and 4 to 8 feet deep.

303-2 Medium grained, light gray and gray banded, Mg-marble from southeast wall of southwest end of pit: Foliation N 78° E, 70° SE, stratigraphically highest sample from pit.

<table>
<thead>
<tr>
<th>Specimen Number</th>
<th>SAMPLE DESCRIPTION</th>
<th>Chemical Assays</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CaO% MgO%</td>
</tr>
<tr>
<td>290</td>
<td>In stream bed...</td>
<td>49.47 0.58</td>
</tr>
<tr>
<td>290-1</td>
<td>Medium grained,...</td>
<td>49.47 0.58</td>
</tr>
<tr>
<td>290-2</td>
<td>Width of outcrop...</td>
<td>15.56 0.43</td>
</tr>
<tr>
<td>290-4</td>
<td>Width of outcrop...</td>
<td>5.24 3.21</td>
</tr>
<tr>
<td>293</td>
<td>Rubble around...</td>
<td>54.98 0.46</td>
</tr>
<tr>
<td>293-1</td>
<td>Medium grained,...</td>
<td>54.98 0.46</td>
</tr>
<tr>
<td>293-2</td>
<td>Medium grained,...</td>
<td>54.81 0.62</td>
</tr>
<tr>
<td>293-3</td>
<td>Medium grained,...</td>
<td>54.63 0.67</td>
</tr>
<tr>
<td>297</td>
<td>Approximately...</td>
<td>31.11 20.28</td>
</tr>
<tr>
<td>297-1</td>
<td>Medium grained,...</td>
<td>31.11 20.28</td>
</tr>
<tr>
<td>302</td>
<td>In woods...</td>
<td>29.54 19.23</td>
</tr>
<tr>
<td>302-2</td>
<td>Medium grained,...</td>
<td>29.54 19.23</td>
</tr>
<tr>
<td>303</td>
<td>Pit #5, 75 feet...</td>
<td>26.97 14.75</td>
</tr>
<tr>
<td>303-2</td>
<td>Medium grained,...</td>
<td>26.97 14.75</td>
</tr>
</tbody>
</table>
### Specimen Numbers and Sample Description

<table>
<thead>
<tr>
<th>Specimen Number</th>
<th>Sample Description</th>
<th>Chemical Assays</th>
<th>CaO%</th>
<th>MgO%</th>
</tr>
</thead>
<tbody>
<tr>
<td>303-4</td>
<td>Medium grained, hard, gray, faintly banded, Mg-marble from the southeast side of the deeper central portion of the pit. Stratigraphically between 303-2 and 303-3. Hanging and footwalls of quarry are sulfide-rich, micaceous gray-blue quartzites. Footwall strikes N 58° E, 64° SE.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>304</td>
<td>Pit #6, 20 feet north of Pit #5. Pit #6 is 40 feet long N 65° E and 3 feet wide.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>304-1</td>
<td>Medium grained, gray and fleshy banded marble. Finer grained gray bands may be original Ca-marble; whereas white and fleshy bands may be more dolomitic.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>305</td>
<td>Pit #7, 10 feet east of northeast end of Pit #5. Pit #7 is 35 feet long N 45° E, narrowing from 15 feet to 6 feet northeast and 5 feet deep.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>305-1</td>
<td>Fine grained, siliceous, Mg-marble along contact on south wall of the middle of the pit. The foliation here is N 65° E, dip 34° SE, but in the northeast corner of the pit it is N 35° E, dip 77° SE, suggesting that this body is either a northward plunging antiform or, more likely, another tear-drop-shaped boudin of Mg-marble.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>308</td>
<td>Pit #2, 130 feet S 45° E of Pit #3. Pit #2 is 40 feet long N 10° E, 20 feet wide, and 10 feet deep.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>308-2</td>
<td>Medium grained, light gray, pure Mg-marble 38 cm stratigraphically below (i.e. northwestward) of 308-1. This is the unit quarried and is at least 5 feet thick.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NORTH APPLETON, ROUTE #105 SECTION

344-348 series are from pits south of Route #105 approximately 1,300 feet to 1,800 feet southwest of Richard Meservey farm house.

**344**
- Pit #1 northeasternmost pit not in woods. Northern 2/3 of pit is 100 feet long N 70° E; southern 1/3 strikes N 30° E and may indicate folding.
- Medium grained, well foliated, gray, marble. Foliation defines chevron folds: axial plane of antiform is N 15° E, 81° SE, axis plunging northeastward. This unit is immediately northwest of 344-3 and may have been the unit quarried; if so, it is 20 feet to 30 feet thick.

**345**
- Pit #2 is 20 feet north of Pit #1. Pit #2 is 200 feet long N 55° E, extending northeastward into the woods; the pit is 20 to 30 feet wide and 8 to 20 feet deep.
- Medium grained, well banded marble without visible impurities 120 feet northeast of 345-1 and 8 feet northwest of the southeast wall of the pit. Foliation is N 45° E, 58° SE. The unit is at least 4 feet thick and surrounds a very fine grained, blue-gray, rusty weathering metaquartzite that is 5 to 10 cm thick. The metaquartzite has been isoclinally folded into a westward plunging synform, the axial plane of which strikes N 90° E, 63° S. If this is the same quartzite described in 345-1, the entire pit is synformal (see figure 3) and 345-1 and 345-2 are from the same unit. To the southeast 345-2 is in contact with the thinly laminated, well folded marble unit represented by 344-3 and 344-4.
<table>
<thead>
<tr>
<th>Specimen Number</th>
<th>SAMPLE DESCRIPTION</th>
<th>Chemical Assays</th>
</tr>
</thead>
<tbody>
<tr>
<td>246</td>
<td>Pit #3, two feet southwest of Pit #1. Pit #3 is 100 feet long N 30° E, 40 feet wide and 20 feet deep.</td>
<td></td>
</tr>
<tr>
<td>346-2D</td>
<td>Aphanitic, gray, hard marble is 4.5 feet wide and more than 8 feet long. 346-2D appears to be a boudin with 346-2C wrapping around it on the southeast side and 346-2E wrapping around the northwest side.</td>
<td></td>
</tr>
</tbody>
</table>

**SEARSMONT SECTION**

<table>
<thead>
<tr>
<th>Specimen Number</th>
<th>WEST SIDE OF KNOll (altitude = 140 feet) between the quarry and the river.</th>
<th>CaO%</th>
<th>MgO%</th>
</tr>
</thead>
<tbody>
<tr>
<td>350</td>
<td>Aphanitic to fine grained, gray marble with medium grained, white marble folded into it: north side of the west end of the tunnel.</td>
<td>46.46</td>
<td>4.05</td>
</tr>
<tr>
<td>350-2</td>
<td>Magog quarry is 500 feet long N 45° E, 160 feet wide and 40 feet deep. The southwestern part of the quarry is filled by a pond 260 feet long and 100 feet wide.</td>
<td>53.14</td>
<td>2.11</td>
</tr>
<tr>
<td>351</td>
<td>Medium grained, gray, crystalline marble intercalated with 351-4A. The total width of these units is greater than 30 feet.</td>
<td>50.86</td>
<td>3.50</td>
</tr>
<tr>
<td>351-4B</td>
<td>Medium grained, gray, hard, moderately banded, isoclinally folded marble at the center of the southwest end of quarry. This was the most extensively quarried unit. Weak foliation N 46° E, 77° NW.</td>
<td>9.79</td>
<td>0.95</td>
</tr>
<tr>
<td>353</td>
<td>Northwest corner of Magog quarry approximately 20 feet southwest of stream.</td>
<td>26.45</td>
<td>36.43</td>
</tr>
<tr>
<td>353-1</td>
<td>Aphanitic, light gray limestone. 20 feet southwest of ford across stream. The northwesternmost exposure of carbonate in the quarry area. The unit is at least 10 feet thick, but no measurable foliation.</td>
<td>46.67</td>
<td>0.20</td>
</tr>
<tr>
<td>363</td>
<td>1,200 feet southwest of Waldo-Knox County boundary and 400 feet northwest of farm house on northwest side of Knights Corner Road.</td>
<td>9.79</td>
<td>0.95</td>
</tr>
<tr>
<td>363-3</td>
<td>Medium grained, gray, well banded marble 10 feet southeast of northwest contact of belt. The exposed thickness of the belt is 40 feet. On the northwest contact is 3 feet of rusty weathering, white, thinly laminated phyllite with foliation N 49° E, vertical.</td>
<td>26.45</td>
<td>36.43</td>
</tr>
<tr>
<td>371</td>
<td>Bed of Jam Black Brook northwest of road from North Appleton to Knights Corner, at westward bend in brook at an altitude of approximately 95 feet.</td>
<td>46.67</td>
<td>0.20</td>
</tr>
<tr>
<td>371-4</td>
<td>Aphanitic, tan weathering, tan limestone breccia with 1-3 mm thick veinlets of more dolomitic carbonate. The outcrop is the crest of a small antiform plunging 12° SW in the middle of the brook. Between 371-2 and 371-4 is 25 to 40 feet of rusty weathering, pyritiferous and garnetiferous fine grained black phyllite.</td>
<td>9.79</td>
<td>0.95</td>
</tr>
</tbody>
</table>

**Chemical Assays**

<table>
<thead>
<tr>
<th>CaO%</th>
<th>MgO%</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.89</td>
<td>17.38</td>
</tr>
<tr>
<td>46.46</td>
<td>4.05</td>
</tr>
<tr>
<td>53.14</td>
<td>2.11</td>
</tr>
<tr>
<td>50.86</td>
<td>3.50</td>
</tr>
<tr>
<td>9.79</td>
<td>0.95</td>
</tr>
<tr>
<td>26.45</td>
<td>36.43</td>
</tr>
</tbody>
</table>

Northwest side of hill 500 feet northeast of Route #105 and 500 feet southeast of St. George River, N 60° E of Vernon L. Pease's farm house.
SAMPLE DESCRIPTION

386-5B  Fine grained, gray, banded marble. This appears to be the unit quarried along the southwest wall of the quarry where the quarry is approximately 15 feet wide. Foliation is N 43° E, vertical. Between 386-5A and 386-5B is medium grained, gray marble with alternating units of marble and siliceous dolomite at 20 to 25 cm intervals, forming a 6-foot thick zone.

387  South side of Route #105 on Alton O. Pease’s farm.

387-3  Medium grained, gray and white marble with 2 to 3 mm bands. Outcrop is a septum of rock 20 feet long and 6 feet wide with bedding parallel to foliation at N 78° E, 59° SE. The foliation of the north end of the septum is N 35° E, 81° NW. Outcrop is 25 feet southeast of 387-2 and half way between the road and Pease’s farm house.

VAUGHAN NECK SECTION

420  Partially filled quarry 75 feet long N 5° E, 20 to 40 feet wide and 15 feet deep, on northeast side of Union-Warren Road altitude 130 feet.

420-4  Medium grained, light gray Mg-marble with sulfide and biotite impurities of less than 2% and occasional very coarse calcite and dolomite crystals. This unit is about 8 feet thick, and the foliation along the east wall of the pit is N 30° E, 79° SE.

EAST UNION BELT

431  Northwest corner of automobile repair shop behind James Moody’s house.

431-1  Aphanitic light gray Ca-marble; rusty band of oxidized cubic pyrite may be bedding or foliation striking N 16° E; if so, this unit is at least 7 feet thick. This outcrop is on strike with 453-457 and yet it is not tremolite-bearing, suggesting that the Mg-rich marble to the south grades northward into comparatively unaltered Ca-rich marble. Unfortunately the thickness of the belt at 431 cannot be determined because the original quarry has been filled and the automobile repair shop erected on its site.

435  Approximately 1,500 feet northwest of 431 at an altitude of 280 feet.

435-2  Fine grained, white marble with tan banding 1 to 10 cm wide N 30° E, 76° NW, and talcose stylolitic folds 3 mm wide. This unit is 2 feet wide to the southeast of the quartzite described in 435-1.

453  Quarry on Wentworth farm 100 feet southwest of barn on south side of Route #17 is 50 feet long N 25° E, 20 to 40 feet wide and partially filled (but more than 15 feet deep).

453-3  Fine grained, white marble with irregular splottes of tan and gray calcite occurs 25 feet east of 435-2 so that the marble belt is at least 65 feet wide.

455  Approximately 200 feet north of power line on north side of new Route #17 and 200 feet southeast of 456.
SAMPLE DESCRIPTION

455-2 Medium grained, white, Mg-marble with faint gray banding and occasional coarse tremolite crystals; foliation is N 05° E, vertical, and the trace of the bedding is N 10° E. 455-2 is 3 feet wide and 2 feet east of 455-1.

456 Quarry on crest of knoll 50 feet north of telephone line and 200 feet northwest of 455. The quarry is about 30 feet in diameter and at least 15 feet deep.

456-2 Medium grained, white, Mg-marble with faint gray banding plunging northward. This sample is probably near the western contact of the marble belt, whereas 455 is probably the eastern contact; if so, the belt is approximately 100 feet wide.

457 Half way between 454 and 456.

457-1 Fine grained, white, Mg-marble with vague light gray bands 1 cm thick that may be more Ca-rich; foliation is N 10° E, vertical. 457-1 is 45 feet southwest of the southern end of pit 454 and is on the western contact of the marble belt in contact with quartzites.

MIDDLE ROAD SECTION

458 On east side of small but conspicuous ridge (altitude of 110 feet on Hills farm east of road, west of St. George River and 100 feet south of woods.

458-3 Medium grained, white, Mg-marble with faint foliation N 15° W, 68° NE delimited by pyritiferous fine to coarse grained tremolite. 458-3 is 6 feet wide and contains 5% tremolite, of which 458-4 is an example.

459 Pit, 130 feet N 17° W of 458 on west side of ridge; pit is 20 feet long northward and 15 feet wide.

459-2 Medium grained, white, Mg-marble with occasional rusty spots. This unit is 20 feet wide and was the unit quarried, but it too contains occasional white tremolite stringers. Foliation is N 10° W, 55° NE. The width of the marble belt from 459-2 to 458-1 is approximately 100 feet.

VAUGHAN NECK SECTION

464 Quarry #12 on northwest side of road at bend in the road as it turns from northeast to north. The quarry is filled with water, is 150 feet long N 30° E, 75 feet wide and 10 feet deep to water level.

464-4 Medium to coarse grained, white Mg-marble with sulfide impurities causing faint foliation 15 feet southeast of edge of quarry in triangle of marble between metasediments on rim of pit striking N 30° E and coarse grained muscovite granite dike east of pit striking N 25° E, the base of the triangle opposite the southeast corner of the pit is 30 feet long.
APPENDIX II

Samples that may duplicate samples previously submitted by Allen (1955) in the Route #105 section of the North Appleton belt.

<table>
<thead>
<tr>
<th>Sample number of this study</th>
<th>Sample number of Allen's study</th>
</tr>
</thead>
<tbody>
<tr>
<td>344-3</td>
<td>L53</td>
</tr>
<tr>
<td>344-4</td>
<td>L53</td>
</tr>
<tr>
<td>345-2</td>
<td>L53</td>
</tr>
<tr>
<td>345-3</td>
<td>L53</td>
</tr>
<tr>
<td>345-4</td>
<td>L53</td>
</tr>
<tr>
<td>346-1</td>
<td>L53</td>
</tr>
<tr>
<td>346-2</td>
<td>L53</td>
</tr>
<tr>
<td>347-1</td>
<td>L53</td>
</tr>
<tr>
<td>347-4</td>
<td>L53</td>
</tr>
<tr>
<td>348-1</td>
<td>L53</td>
</tr>
<tr>
<td>390-1</td>
<td>L53</td>
</tr>
</tbody>
</table>

BeD4 15
BeD4 16
BeD4 18
BeD4 19
BeD4 20
BeD4 12
BeD4 13
BeD5 28
BeD5 26
BeD5 30
BeD4 10