A TRAVERSE ACROSS THE SOUTHERN CONTACT OF THE MARCY ANORTHOSITE MASSIF, SANTANONI QUADRANGLE, NEW YORK

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INTRODUCTION

The 15' Santanoni quadrangle is located between 44°00' and 44°15' north latitude and 74°00' and 74°15' west longitude in what is known as the High Peaks region of the Adirondack Mountains of New York State (Figure 1). The nearest towns of any size are Lake Placid, which is northeast of the quadrangle, and Saranac Lake, which is north of the quadrangle (Figure 2).

Approximately 80% of the quadrangle is underlain by anorthosite or anorthosite-related rocks. The remainder of the area is underlain by pyroxene syenite gneisses (commonly ascribed to a mangerite-charnockite series), amphibolites, granitic, pelitic and calc-silicate gneisses, marbles and quartzites. All of these rocks have been affected by the approximately one billion year old Grenville metamorphism and form the southeastern part of the Grenville province of the Canadian shield. Bedrock geologic mapping of the Santanoni quadrangle at a scale of 1:62500 was carried out between 1978 and 1982 under the direction of Howard Jaffe from the University of Massachusetts.

Metamorphism

A number of workers have attempted to estimate metamorphic conditions for the area surrounding the Santanoni quadrangle. The quadrangle lies entirely within the 750° C isotherm of Bohlen et al. (1980). This isotherm is based on both magnetite-ilmenite and feldspar thermometry. Valley (1980) suggested maximum temperatures of just under 700° C for the area immediately south of the Santanoni quadrangle (northern part of Newcomb quadrangle) on the basis of the assemblage tremolite-calcite-quartz. Jaffe et al. (1978) estimated metamorphic temperatures between 760 and 790° C in the Mt. Marcy quadrangle on the basis of coexisting orthoferrosilite-ferroaugite compositions, and Valley and Essene estimated temperatures to be 750° C ± 30 ° based on akermanite bearing assemblages at Cascade Slide (Mt. Marcy quadrangle).

Pressure estimates based on the stability or iron-rich orthopyroxene suggest metamorphic pressures of approximately 8 kbar (Jaffe et al. 1978, Bohlen and Boettcher 1981). Reinterpretation of textures of iron-rich pyroxenes of Ollila et al. (1984) suggests that these may be igneous as well as metamorphic pressures. Valley and Essene (1980) estimated metamorphic pressures of 7.4 ± 1 kbar based on akermanite bearing assemblages at Cascade Slide in the Mt. Marcy quadrangle.

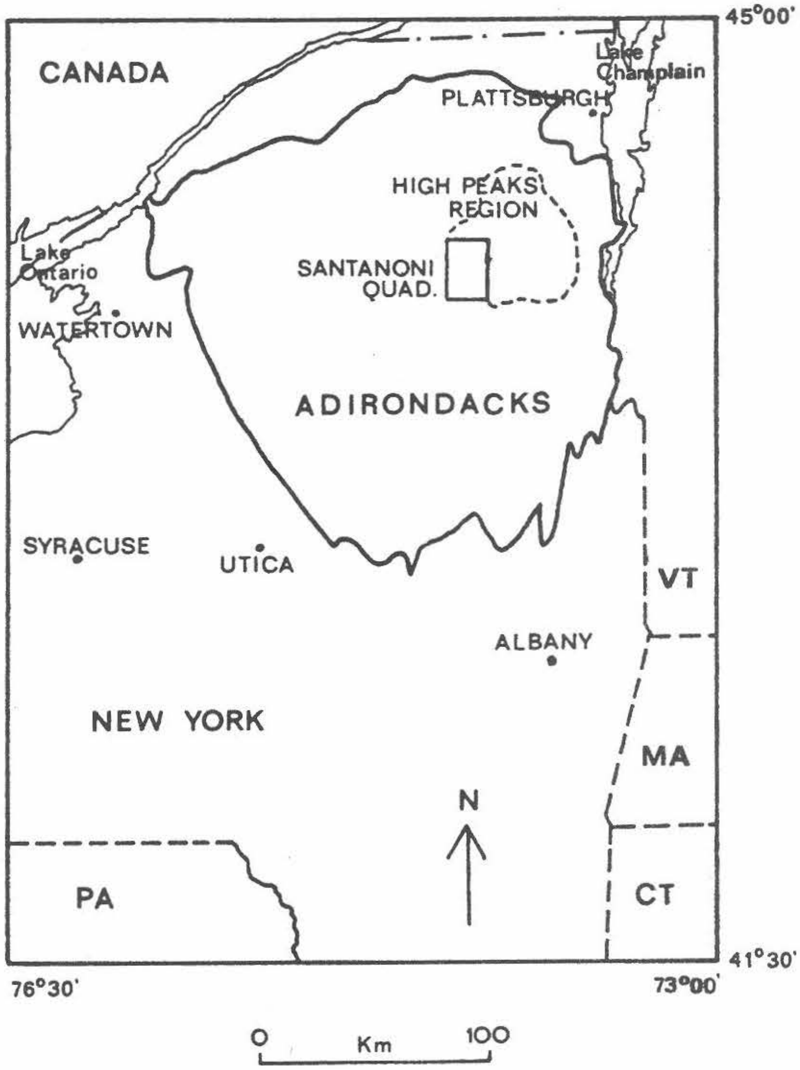


Figure 1. Index map showing location of the Santanoni quadrangle (modified after Buddington, 1953).

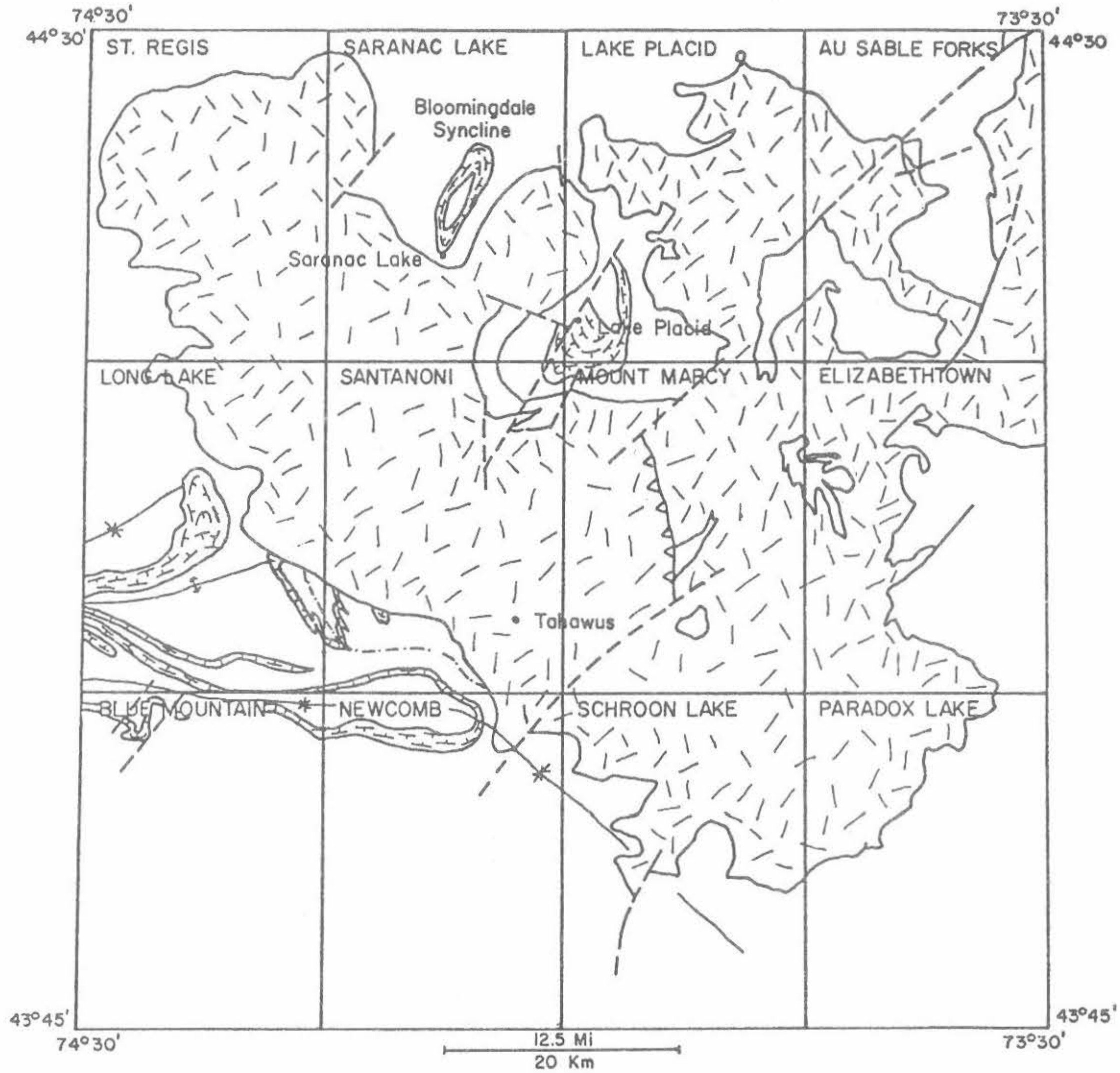


Figure 2. Generalized geologic map showing anorthosite, patterned, calc-silicate rocks [pattern] and other gneisses [blank box]. Axial traces of third phase synclines from Wiener et al., 1984, a third phase anticline and the second phase Wolf Pond syncline —·—·—·— are also shown.

Use of the Newton and Perkins (1982) garnet-plagioclase-orthopyroxene quartz geobarometer on mineral compositions from the Mt. Marcy and Elizabethtown quadrangles published by Kretz (1981) gives pressures of approximately 9 kbar. Although these pressures are slightly higher than those given by Valley and Essene or Bohlen and Boettcher, the uncertainties are such that they are not significantly different.

Metamorphic assemblages in the Santanoni quadrangle are consistent with a regional metamorphic maximum occurring near or below 750° C. This conclusion is based upon the common occurrence of biotite + quartz and the single occurrence of tremolite + calcite + quartz in the southern part of the quadrangle. These assemblages place upper limits on metamorphic temperatures whereas the occurrence of orthopyroxene, both in granitic gneisses and amphibolites and the occurrence of sillimanite + potassium feldspar place minimum limits on the temperature of metamorphism. The temperatures at which biotite + quartz or muscovite + quartz react to produce orthopyroxene + potassium feldspar or sillimanite + potassium feldspar respectively are highly dependant on the composition of the fluid phase but it is perhaps reasonable to assume that the temperatures (650° C to 750° C) determined for muscovite-absent rocks in central Massachusetts by Robinson et al. (1982) are reasonable minimum estimates for metamorphic conditions in the Santanoni quadrangle. A single specimen from the southwestern part of the quadrangle contains both wollastonite and calcite + quartz. This is consistent with a high-grade regional metamorphism but suggests variable fluid compositions over short distances.

High-grade metamorphism of anorthositic rocks has produced garnet, hornblende and scapolite. These minerals are most common in highly deformed anorthositic rocks and all of these minerals could have formed during the same high-grade regional metamorphism that has affected all Adirondack rocks. The possibility, however, that garnet formed during isobaric cooling of anorthosite cannot be ruled out. Locally retrograde assemblages characterized by minerals such as prehnite, pumpellyite and chlorite can be found in anorthositic rocks.

Geochronology

Ashwal and Wooden (1983) have reviewed the various age determinations for Adirondack anorthosite and other rock types and provide evidence that Adirondack anorthosite may be as old as 1288 ± 36 Ma. This age is based on Sm-Nd data from mineral separates and whole rock samples from a layered sequence of rocks near Tahawus in the Santanoni quadrangle. Metamorphic ages based on whole rock and mineral separate data using both Sm-Nd and Rb-Sr range between 995 and 915 Ma. Ashwal and Wooden conclude that the most likely explanation for these ages is that anorthosite intrusion and crystallization was followed by distinctly later prograde metamorphism.

Basu and Pettingill (1983) concluded that anorthosite crystallization in the Snowy Mountain dome in the south-central Adirondacks took place at approximately 1100 Ma. This age is based on Sm-Nd data from whole rocks and mineral separates. The age is heavily dependent on garnet which is a metamorphic mineral in anorthositic rocks.

Basu and Pettingill's age corresponds closely with ages determined by Silver (1969) on zircon separates from a variety of Adirondack rocks. According to Ashwal and Wooden these ages represent metamorphic rather than igneous crystallization ages. The degree to which Basu and Pettingill's age depends on garnet supports the argument of Ashwal and Wooden.

The deposition age of metamorphosed sedimentary rocks in the Adirondacks is uncertain, but Grant et al. (1981) determined an age of 1265 ± 25 Ma for leucogneisses in the northwest lowlands of the Adirondacks. These rocks are interpreted to be metamorphosed felsic volcanics, are the oldest rocks in the Northwest Lowlands stratigraphy and were interpreted to be basement by Wiener et al. (1984).

Structural Geology

The Marcy anorthosite massif is roughly heart shaped and covers approximately 5000 km^2 (Figure 2). There are several hypotheses concerning the general shape of the massif. Bowen (1917) suggested that the main body of the Adirondack anorthosite massif is a laccolith. Buddington (1939) believed that what he called the St. Regis-Marcy anorthosite unit is a northwest-southwest elongate domical structure. He did not believe that the floor of this unit was exposed and suggested that it everywhere dipped underneath overlying metamorphosed sedimentary rocks. A similar hypothesis was presented by Davis (1971), who stated that foliated anorthosite dips under overlying syenitic rocks and metamorphosed sedimentary rocks in the St. Regis quadrangle. He described the anorthosite as a layered sheet with the more mafic portions at the top and reported that a few hills show upward increase in mafic minerals. Folding complicates these relations so that leucocratic anorthosite forms topographic highs in anticlinal areas and gabbroic anorthosite is found in synclinal topographic lows.

The domal hypothesis has most recently been re-expressed by Whitney (1982, p. 68) who suggests that anorthosite rose as "relatively rigid domes through the supracrustal rocks sweeping them into pseudoconformity with the anorthosite contact and disrupting earlier structural trends." Whitney's hypothesis differs significantly from Buddington's, however, in that he suggests that the anorthosite domes were emplaced in the solid state.

Crosby (1966) presented a different interpretation for anorthosite in the Jay-Whiteface sheet in the Lake Placid and Ausable Forks quadrangles. He interpreted anorthosite here as being in northerly to northeasterly transported nappes that emplace anorthosite over metamorphosed sedimentary and syenitic rocks. Jaffe et al. (1983) have described a similar nappe or thrust in the Mt. Marcy quadrangle that emplaces undeformed anorthosite over syenitic and anorthositic gneisses.

Balk (1930, 1931) believed the Adirondack anorthosite massif to be a lenticular sheet 10 to 12 miles thick tilted to the northeast at 20° to 30°. Balk believed the roof of this sheet was exposed in the north and south and the floor in the east. Buddington (1939) disagreed with this. He suggested that the features Balk observed in the east were sills of anorthosite and that the floor of the main body was never exposed.

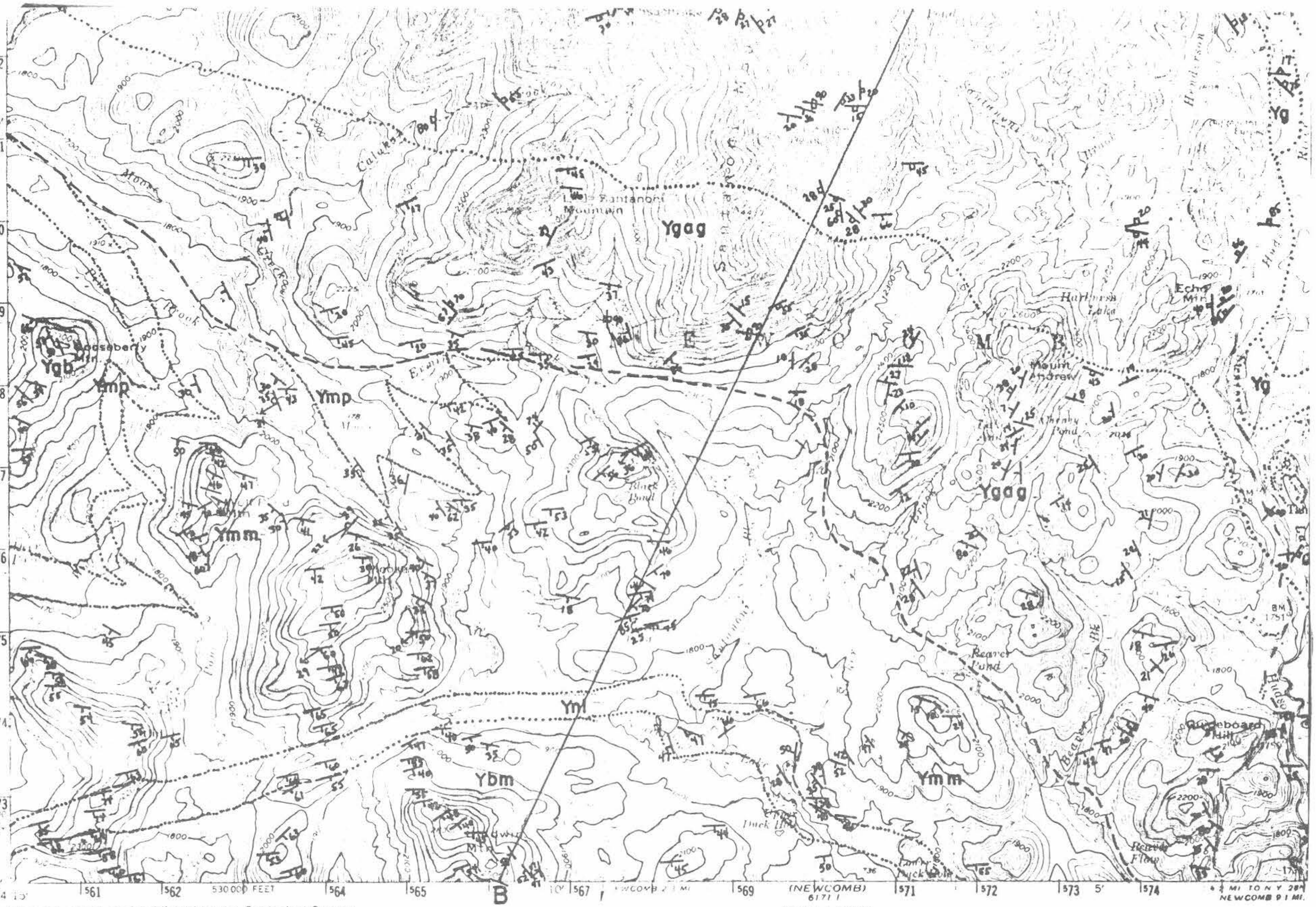
Simmons (1964) used gravity measurements to model possible size and shapes of the anorthosite massif. He concluded that the anorthosite is a slab 3 to 4.5 km thick with two roots extending downward to 10 km or more. Simmons' model is based on a density contrast of .010 between anorthosite and country rocks. The average density for country rocks of 2.82 implies a higher percentage of amphibolites in the country rocks than has been observed in the Santanoni quadrangle. The density contrast used by Simmons, however, is supported by the half width of the anomaly associated with the anorthosite body.

A more detailed gravity survey by Mann and Revetta (1979) detected five gravity lows within the anorthosite massif. They suggest that gravity highs between the lows may either represent thinning of the anorthosite or bodies of gabbro or amphibolite within the anorthosite.

As can be seen from this summary, there is no consensus on the shape, depth or extent of anorthosite in the Adirondacks. Most recent mapping, however, suggests that Buddington was correct in concluding that the floor of the main body of anorthosite is not exposed. This conclusion is supported by mapping in the Mt. Marcy quadrangle (Jaffe et al. 1983) and by relationships in the Santanoni quadrangle. Jaffe et al. (1983), Crosby (1966), and Buddington (1939) all have recognized anorthosite bodies that overly metamorphosed sedimentary rocks but interpret these as either thrust sheets, nappes, or sills.

One critical problem yet unsolved, is the exact nature of the contact of anorthosite with surrounding rocks. Davis found that the contact to be parallel to foliation in anorthosite and surrounding rocks. While this may be locally true, the foliation is secondary and need not be parallel to contacts. Detailed mapping of large areas combined with geophysical studies may be needed to delineate the shape of the anorthosite massif.

Within the Santanoni quadrangle, foliated anorthosite (gabbroic anorthosite gneiss) dips under other gneisses in the southwestern part of the quadrangle. In the northeastern part of the quadrangle, gabbroic anorthosite gneiss is limited in extent and has only been observed as sills or layers separated from the main anorthosite body. The main anorthosite body in the northeast corner of the quadrangle retains igneous textures up to its contact with pyroxene monzonite granulites which are intrusive into anorthosite. Foliated rocks away from the contact do, however, dip away from the anorthosite and imply



(BLUE MOUNTAIN)
6171 IV

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by photogrammetric methods
Aerial photographs taken 1952. Field check 1953

Polyconic projection. 1927 North American datum
10,000-foot grid based on New York coordinate system, east zone
1000-meter Universal Transverse Mercator grid ticks, zone 18, shown in blue

Entire area lies within the Adirondack State Park

Unchecked elevations

14°
249 MILS

0°37'
11 MILS

UTM GRID AND 1953 MAGNETIC NORTH

SCALE 1:62500

1 ½ 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 .5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

QUADRANGLE LOCATION

AB-2

Figure 3. Geological map of the southwestern part of the Santononi quadrangle.

EXPLANATION

Intrusive Igneous Rocks

Ypqs — Pyroxene quartz syenite gneiss; tan-weathering, brown on a broken surface, hornblende-pyroxene-quartz-microperthite gneiss.

Ypmg — Pyroxene monzonite granulite; tan-to pink-weathering, gray to brown on a broken surface, fine grained granulite. Commonly contains bluish gray plagioclase megacrysts.

Ygag — Gabbroic anorthosite gneiss; Hornblende-garnet-pyroxene-plagioclase augen gneiss, includes minor amounts of anorthosite, gabbro, pyroxene quartz syenite and monzonite gneiss.

Yg — Gabbro; medium to coarse grained sub-ophitic gabbro and fine grained rusty-brown-weathering gabbro granulite. C.I. > 35

Yga — Gabbroic-noritic anorthosite; medium to coarse grained sub-ophitic, C.I. between 10 and 35, includes minor amounts of anorthosite and gabbro.

Ya — Anorthosite; medium to coarse-grained, C.I. < 10, includes minor amounts of gabbroic-noritic anorthosite and gabbro.

Metamorphosed Sedimentary and Interlayered Igneous Rocks

Ybm — Baldwin Mountain Gneiss; gray-to pink granitic gneiss, amphibolite, thin calc-silicate rocks, and rusty-brown to gray-weathering sillimanite or biotite-garnet-sillimanite quartzite.

Ynl — Newcomb Lake Formation; coarse grained marble, calc-silicate rocks, calcareous quartzite, minor interlayered granitic gneiss, amphibolite and rusty-brown granulites.

Ymm — Moose Mountain Gneiss; gray-to brown-weathering hornblende granitic gneiss with thin (< 1m) amphibolite layers, hornblende (locally orthopyroxene) granite gneiss, minor interlayered pink granitic gneiss, calc-silicate rocks, biotite-quartz plagioclase gneiss and rusty-weathering plagioclase rich granulites.

Ymp — Moose Pond Formation; coarse grained marble, calcareous quartzite, rusty-brown weathering diopside quartz-microperthite granulites, and fine grained biotite-quartz-microperthite gneiss.

Ygb — Gooseberry Mountain Gneiss; pink-weathering medium-grained granitic gneiss containing 1 to 3 mm thick layers rich in sillimanite or sillimanite, biotite and quartz and thicker (1m) amphibolite layers.

Geological contact (dashed; approximate, dotted; inferred)

Fault (solid; approximate, dashed; inferred

Strike and dip of foliation

Strike and dip of plagioclase megacryst foliation

Strike and dip of compositional layering

Strike and dip of axial surface

Fold hinge line

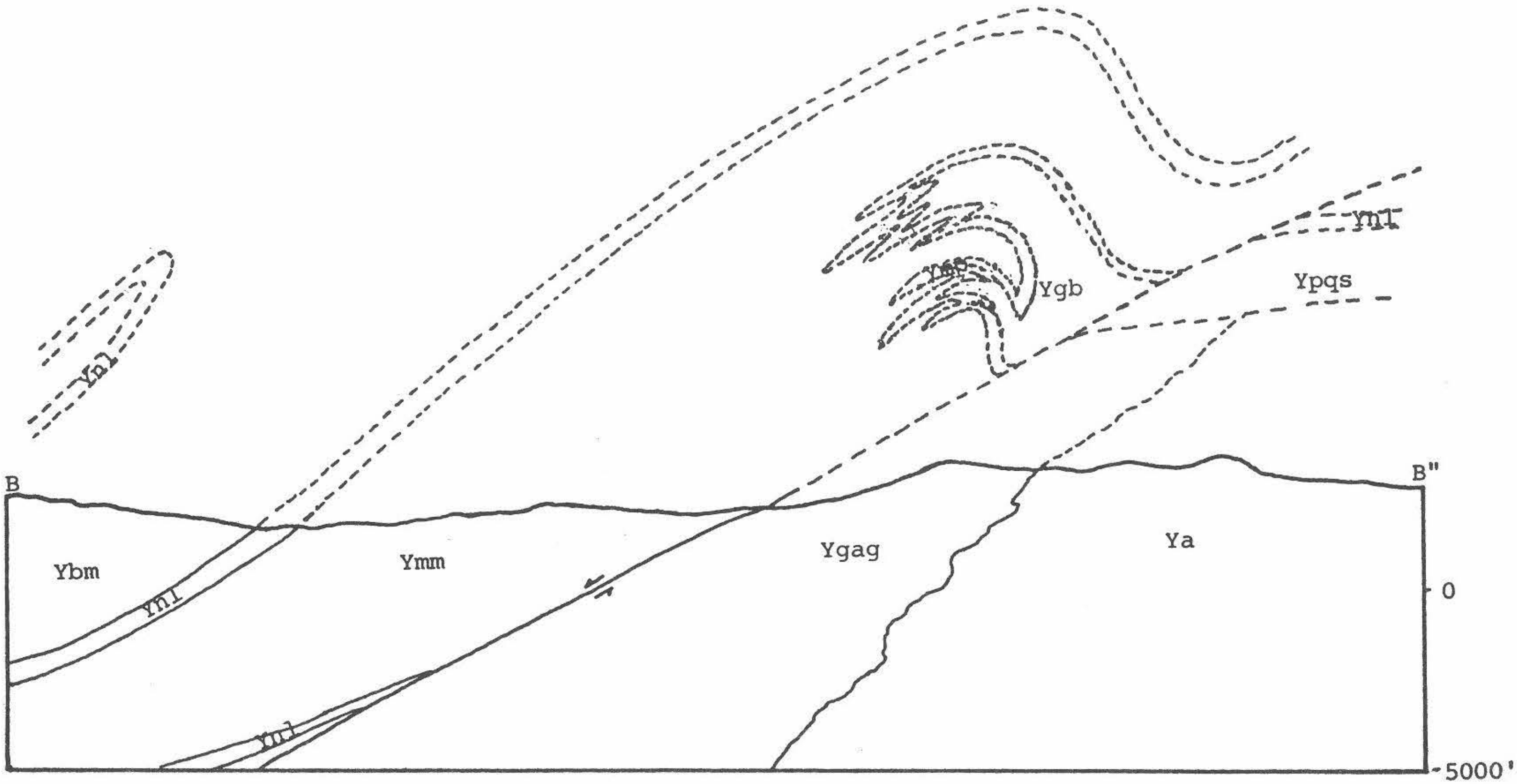


Figure 4. Schematic cross section along B-B'(Figure 3) illustrating the relationship between second and third phase folds and the Ermine Brook fault.

that the anorthosite dips beneath the surrounding rocks so that only the upper contact of the anorthosite is present in the Santanoni quadrangle.

Gneisses surrounding the major northwest trending lobe of the Marcy massif (Figure 2) define an open northwest trending doubly plunging anticline. A saddle in this anticline, caused by a northeast trending open syncline, occupies most of the Santanoni quadrangle. The part of this syncline that is located near the boundaries between the Santanoni, Mt. Marcy, Lake Placid and Saranac Lake quadrangles (Figure 2) was named the Newman syncline by Buddington (1953).

Northwest and northeast trending open folds refold three earlier phases of folding. Map scale folds related to two of these earlier phases of folding are evident in and around the southern part of the Santanoni quadrangle. The earliest map scale folds (F_2) are tight to isoclinal in nature and fold a foliation related to earlier isoclinal folds. Axial surfaces of second phase minor folds trend E-W to SE-NW and dip to the S. The Wolf Pond syncline (Figures 2 and 3) is a second phase fold. Other map scale second phase folds occur near Moose Pond.

Second phase folds are refolded by E-W trending folds (Figures 2, 3 and 4) whose axial surfaces dip to the south. Three large scale third phase folds are shown in Figure 2. These are from south to north the Newcomb syncline, Long Lake anticline and the eastern extension of the Loon Pond syncline of Potter (this guide book). The location of the axial traces of the Newcomb and Loon Pond synclines has been taken from the regional synthesis of Wiener et al. (1984). The location of the axial trace of the Long Lake anticline is uncertain. Contacts shown in eastern part of the Long Lake quadrangle in Figure 2 are highly speculative.

One of the principal reasons for mapping the Santanoni quadrangle was to try and constrain the timing of anorthosite intrusion relative to the regional deformation history. A sill of gabbroic anorthosite gneiss lies parallel to and slightly below the contact between the Moose Mountain Gneiss and the Newcomb Lake Formation across the entire southwestern part of the quadrangle. The foliation in the sill is concordant to that of surrounding rocks and this foliation and the sill are folded by third phase folds. Intrusion of the sill must have taken place prior to or during second phase folding. Jaffe et al. (1983) report xenoliths in anorthosite that contain second phase folds. This suggests that anorthosite intrusion was taking place during second phase folding. McLelland and Isachsen (1980) reached a similar conclusion on the basis of anorthosite dikes that are both involved in and cross cut second phase folds.

The gabbroic anorthosite gneiss contact in the southwestern part of the quadrangle cuts across both second and third phase folds (Figures 2 and 3) and at the one locality (Ermine Brook), where rock is exposed near the contact, rocks are intensely foliated and lineated and are finer grained than normal. This evidence and the map pattern has led to the conclusion that the contact is a fault.

The main purpose of this trip is to walk across this fault (named the Ermine Brook Fault). Along the way we will look at some of the gneisses that underlie most of the southwestern part of the quadrangle. These rocks have been subdivided into five units which are briefly described in the explanation for Figure 3.

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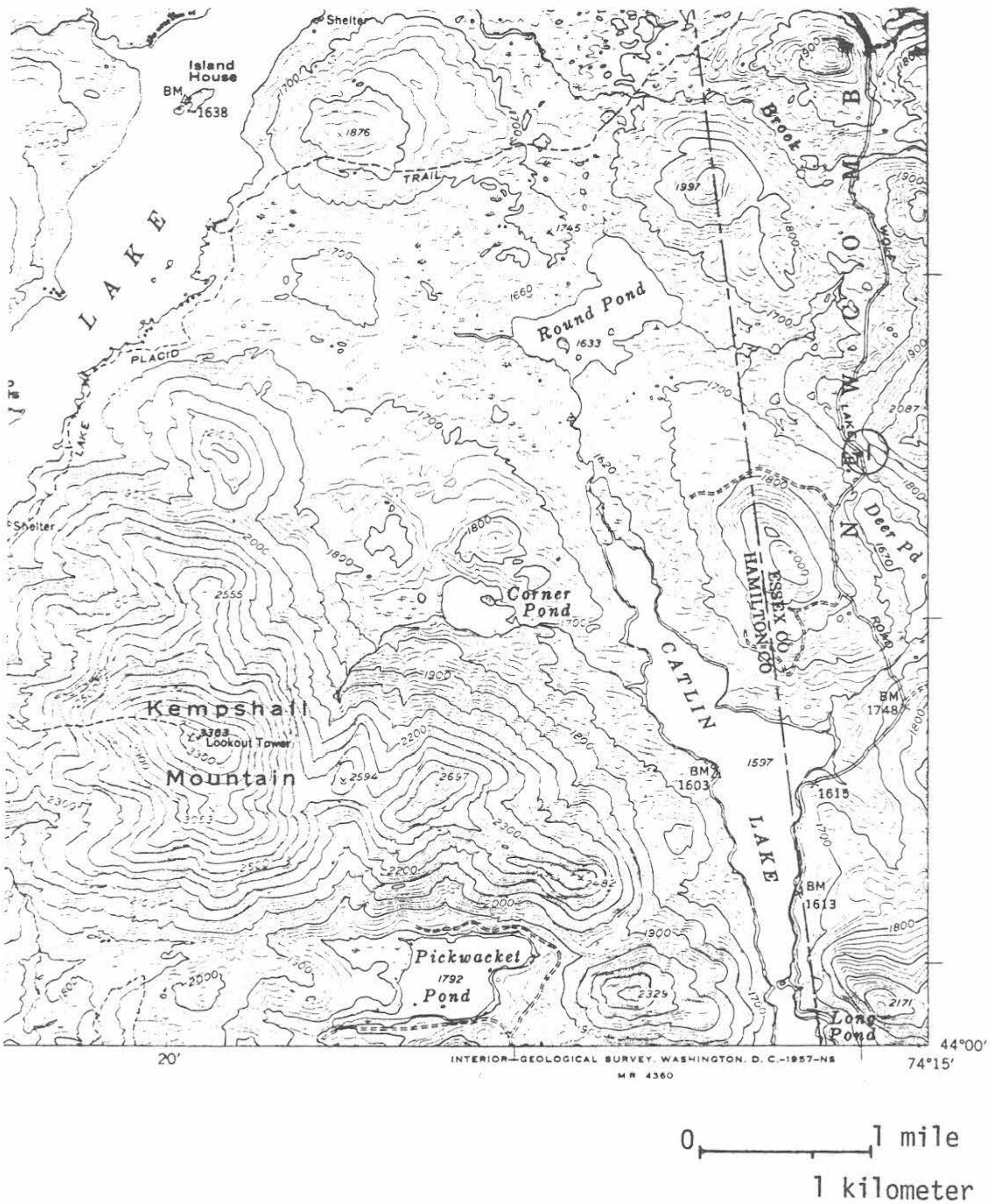

Figure 5. Southeastern corner of the 15' Long Lake quadrangle.
Stop 1 is north of Deer Pond.

ROAD LOG

Mileage

0.0 Depart Long Lake public beach and proceed south on Route 30.

0.7 Turn left on Route 28N towards Newcomb.

11.0 Proceed about 10 miles, turn left into Huntington Forest. From here on we will be traveling on private roads of the Huntington Forest, some of which are not on the topographic maps. We will walk to Moose Pond via the saddle between Moose Mountain and Wolf Pond Mountain. For those interested in visiting these localities at some other time, an excellent trail leaves from the Santanoni Preserve in the village of Newcomb. It is about a 7-mile walk to Moose Pond and 8 miles to Ermine Brook. Stop locations are shown on the 15' Long Lake (Figure 5) and Santanoni (Figure 6) quadrangle maps.

STOP 1 Gooseberry Mountain Gneiss

The Gooseberry Mountain Gneiss consists of pink-weathering, medium-grained granitic gneiss, black-and white-weathering amphibolites that average 1 m in thickness and gray-weathering layers 1 to 3 mm thick rich in sillimanite, biotite and quartz. Sillimanite gneisses are the key to identifying the Gooseberry Mountain gneiss. Other rocks included within this unit are quite similar to rocks included in the Moose Mountain Gneiss.

Sillimanite gneisses form only a small part of the unit but have been found on the north side of Gooseberry Mountain, on the southern end of a hill just east of Deer Pond, and on the southwestern side of Gooseberry Mountain in the Long Lake quadrangle.

North of Gooseberry Mountain, zones characterized by abundant sillimanite rich layers occur within pink granite gneiss. Within these zones, sillimanite-rich layers are separated by 1 to 2 cm layers of quartz and pink microperthite augen. Granitic gneiss within the Gooseberry Mountain gneiss is typically composed of anhedral quartz, and microperthite, brown biotite, magnetite, and may contain green hornblende and orthopyroxene. Sample 17-1 (Table 1) is fairly representative except that the granitic gneisses commonly contain higher modal proportions of magnetite. Average grain size is 1 to 2 mm and foliation is defined by oriented biotite. Sillimanite rich layers and amphibolite layers parallel foliation. Both weathered and broken surfaces of granitic gneiss are pink to brown. Locally the granite gneiss is garnetiferous and garnetiferous granitic pegmatites are fairly abundant on the southwest side of Gooseberry Mountain.

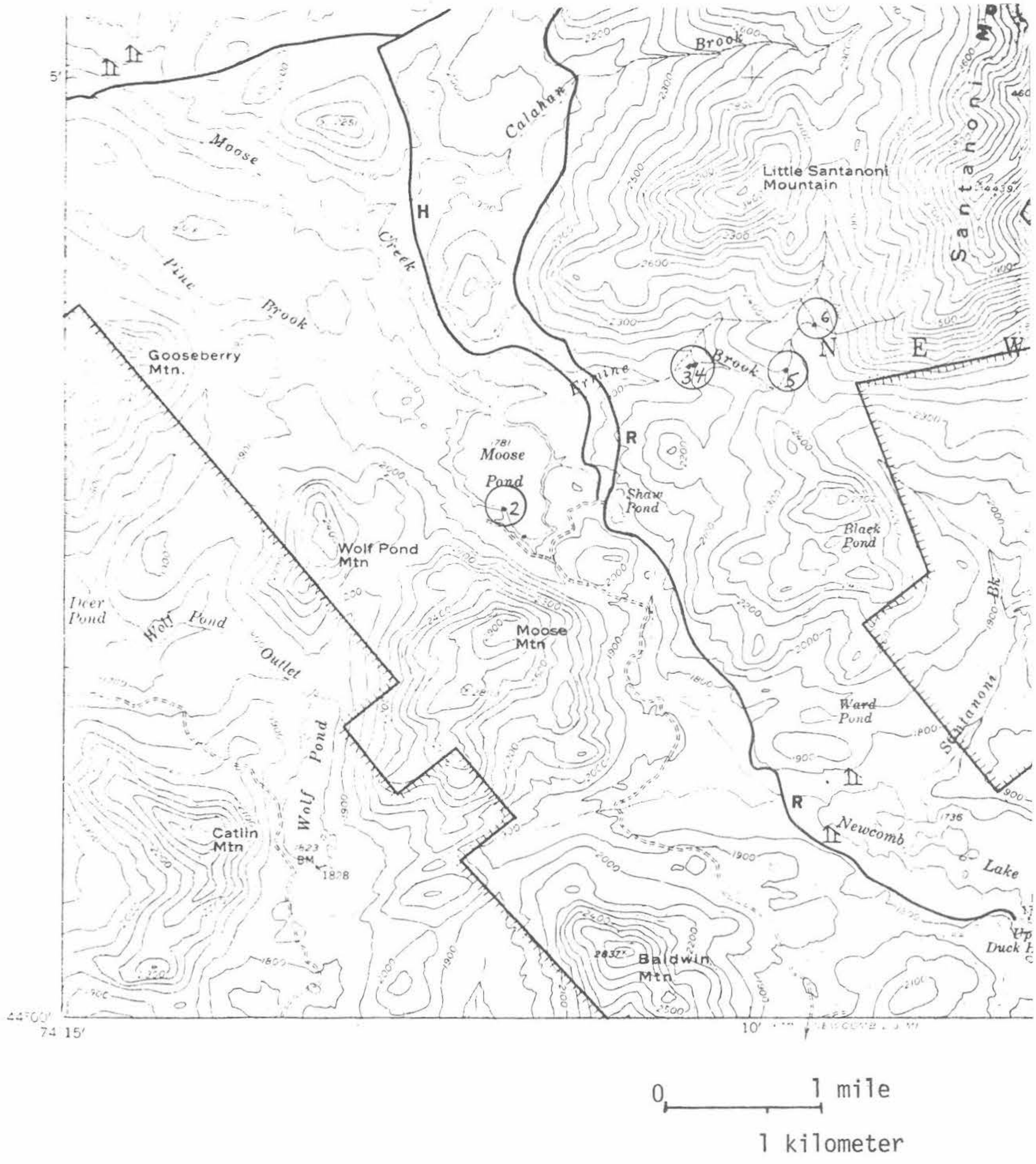

Figure 6. Southwestern corner of the 15' Santanoni quadrangle. Stops 2-6 are at Moose Pond and along Ermine Brook.

Table 1. Mineral Assemblages and Estimated Modes for Rocks within the Gooseberry Mountain Gneiss.

Sample No.	17-1	LL-4	17-21
Quartz	39	X	
Microperthite	57	X	+
Plagioclase	3		X
Hornblende			X
Biotite	1	X	+
Orthopyroxene			+
Sillimanite		X	
Opaques	+		+
Apatite			+

X = Major constituent

+ = Minor constituent

Hand specimen descriptions:

17-1 Medium-grained pink granitic gneiss.
Layer in granitic gneiss rich in sillimanite biotite and quartz.

LL-4 Sillimanite + biotite + quartz rich layers in granitic gneiss.

17-21 Medium-grained, amphibolite gneiss.

STOP 1 (cont'd)

Amphibolite layers are abundant at low elevations on the northern side of Gooseberry Mountain and also north of Deer Pond in the Long Lake quadrangle. The amphibolites are medium-grained but range in texture from well-foliated to granular. They are black-and white-weathering and typically have a color index near 50. Hornblende and plagioclase are the dominant minerals but amphibolites also contain brown biotite, orthopyroxene and oxides. Both garnetiferous and non-garnetiferous varieties have been observed. At location 17-22, granitic gneiss and amphibolite layers average 1 m in thickness and granitic gneiss forms about 60% of the outcrop. Going south from this location, the amount of amphibolite decreases, until near the summit of Gooseberry Mountain, the rock is almost entirely granitic gneiss. This sequence is reversed down the south side of Gooseberry Mountain. This repetition, and the occurrence of sillimanite gneisses on the north and south side of Gooseberry Mountain, suggest that this unit has been doubled by folding.

STOP 2 Moose Pond Formation-Ymp

The Moose Pond formation is extremely poorly exposed. One probably loose block of coarse-grained calcite marble (sample 17-6, Table 2) is located at the south end of Moose Pond. A mixture of rusty-brown medium-to-fine-grained diopside-quartz-microperthite granulites (17-7, Table 2) and fine-grained biotite-quartz-microperthite gneisses cropsout along the western shore of Moose Pond at location 17-7. Although there is abundant quartzite and diopsidic quartzite float northwest of Shaw Pond a nearby outcrop northwest of Shaw Pond contains only a few thin diopside-rich layers. Most of the rock at this location is a medium-to fine-grained brown augite-biotite-quartz-plagioclase-microperthite gneiss.

No outcrops were observed in the region between Gooseberry Mountain and Wolf Pond Mountain. The Moose Pond marble is inferred to go through this region on the basis of topography and the geometry of folds in the Moose Mountain gneiss and the Gooseberry Mountain Gneiss. The aeromagnetic map (1978) shows a magnetic low east of Gooseberry Mountain which is consistent with the presence of marble in this valley. Mineral assemblages in rocks from the Moose Pond marble are listed in Table 2.

Ermine Brook

This is the only place in the quadrangle, yet found, where rock is exposed near the gabbroic anorthosite gneiss contact. We will walk upstream along Ermine Brook and see the sequence of rocks shown at Stops 3, 4, 5, and 6.

Table 2. Mineral Assemblages from the Moose Pond and Newcomb Lake formations.

	Moose Pond		Newcomb Lake						
Sample No.	17-7	17-6	21-28	21-18	22-53	21-40	22-56	22-59	22-54
Calcite		X				+	X	X	
Clinopyroxene	X	X	X	X	X	X	X	X	
Tremolite							X		
Wollastonite						X			
Biotite	X								X
Phlogopite		X					X		
Quartz	X	X	X	X		X			X
K-feldspar		X	X	X	X	X		X	
Plagioclase	X	X				X			
Scapolite		X						X	
Sphene	X	X	X	X	X	X		X	
Apatite	X	X		X		X			
Graphite		X	X				X		
Tourmaline							X		
γ Cpx.	1.723	ND	1.697	ND	1.718	ND	1.697	1.697	

X = Major constituent

\+ = Minor constituent

ND = Not determined

STOP 3 Calcereous quartzites of the Moose Pond Formation.

These rocks contain quartz, diopside, calcite, sphene, microcline and scapolite. The scapolite is partially altered to prehnite.

The dominant foliation in these rocks trends 276°, 26 s and a strong lineation defined by trains of diopside trends 213°, 20°.

The rotation sense of minor folds at this outcrop indicates south side down movement.

STOP 4 Mylonitic pyroxene quartz syenite gneiss.

This rock is more intensely foliated and finer grained than normal for pyroxene quartz syenite gneiss. Foliation trends 90°, 35 s and locally a strong lineation defined by quartz ribbons trends 222°, 25°. A few asymmetric augen and what are possibly S and C foliations (Berthe et al. 1979, Simpson and Schmid, 1984) suggest south side down movement.

The mineralogy of pyroxene quartz syenite gneiss along Ermine Brook is typical of pyroxene quartz syenite gneiss found elsewhere in the quadrangle. Modes of typical pyroxene quartz syenite gneisses are listed in Table 3.

STOP 5 Gabbroic Anorthosite Gneiss (Ygag)

The gabbroic anorthosite gneiss map unit trends NW-SE in a zone across the southwestern corner of the quadrangle (Figure 3). It lies between metamorphosed sedimentary and igneous rocks to the southwest and anorthosite to the northeast. The dominant rock type within the unit has a color index (C.I.) equivalent to gabbroic anorthosite but minor amounts of gneissic anorthosite, noritic anorthosite, gabbro, and syenite are included as well. Forty-four samples from the gabbroic anorthosite gneiss map unit were examined in index of refraction oils or in thin-section. Of these 27 have a C. I. equivalent to gabbroic anorthosite, 7 are monzonites, 5 are anorthosites, 2 are gabbros, 1 is noritic anorthosite and 1 is a quartz syenite. The syenitic rocks and the gabbros generally occur as concordant layers or sills. Most of the rock in the unit has a composition similar to gabbroic anorthosite except that it contains more garnet, hornblende, alkali feldspar and quartz. Modes of four samples of gabbroic anorthosite gneiss (Table 4) are representative of the amount of hornblende, garnet, K-feldspar, and quartz typically found in these rocks. Orthopyroxene, although present in all

Table 3. Modes of Pyroxene Quartz Syenite Gneisses.

Sample No.	3-2	4-13	4-25	Al-4
Quartz	6.5	6.8	5.4	15.9
Microperthite	49.1	53.1	53.7	61.3
Plagioclase[1]	24.0	18.6	19.1	14.8
Augite[2]	6.9	8.6	8.5	2.5
Orthopyroxene[3]	3.4	6.3	2.9	1.4
Hornblende	3.9	3.3	6.7	3.0
Garnet	3.3	0.9	0.6	0.3
Opaques	1.9	1.5	1.9	0.3
Apatite	1.1	0.6	0.8	0.4
Zircon	+	0.3	0.1	0.1
Biotite	--	--	0.1	--
1 An_{plag}	18	21.9	--	--
2 MG_{cpx}	14	23	13	--
3 MG_{opx}	9	16	13	11
C.I.	20	22	22	8

Table 4. Modes of Gabbroic Anorthosite Gneiss

Sample No.	4-38	17-28	17-13	18-30
Plagioclase[1]	69.4	67.5	64.3	76.8
Alkali-feldspar*	6.3	7.4	5.8	2.7
Quartz	1.2	1.3	0.7	0.4
Augite[2]	7.5	10.3	9.2	4.9
Orthopyroxene[3]	2.0**	3.9	2.1	8.0
Hornblende	4.6	2.7	2.5	1.7
Garnet	3.4	2.5	9.7	3.6
Opaques	5.2	4.2	3.8	1.4
Biotite	--	--	0.1	0.4
Apatite	0.5	0.2	1.9	0.1
1 An	36.9	40.8	36.9	42.8
2 MG	68	58	58	54
3 MG		47	44	48

* Both microcline and orthoclase microperthite.

** Extremely altered.

STOP 5 (cont'd)

four modes, is not commonly present in anorthosite gneiss. At this locality pyroxene is commonly rimmed by hornblende which locally defines a strong lineation that trends 225°, 24°.

Rock at this locality is heterogeneous, consisting of gabbroic anorthosite gneiss with lesser amounts of gabbro, anorthosite, and syenitic gneiss. This is a good area to look at both intrusive relationships between the different rock types and the intense deformation typical of gabbroic anorthosite gneiss. Note also the different response of the various rock types to deformation.

STOP 6 Anorthosite.

This anorthosite is typical of anorthosite in much of the interior of massif. This rock is probably part of a layer or large xenolith of anorthosite in the gabbroic anorthosite gneiss map unit. More gabbroic anorthosite gneiss crops out to the north along the other branch of Ermine Brook and on Little Santanoni Mountain.

Walk down Ermine Brook and return to cars. If there is time, typical outcrops of Moose Mountain gneiss are easily accessible along the way.