Trip H

META-ANORTHOSITE OF THE JAY-WHITEFACE NAPPE, AUSABLE FORKS-LAKE PLACID QUADRANGLES, NORTHEASTERN ADIRONDACKS, NEW YORK

by

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GEOLOGIC SETTING AND OUTLINE OF PRECAMBRIAN DEVELOPMENT OF ADIRONDACK META-ANORTHOSITE

The Adirondack Mountains comprise an outlier of the Canadian Shield. They are geographically and geologically subdivided into the Highlands, which are principally underlain by granitic gneisses and anorthosite and the Lowlands, composed mainly of metasedimentary rocks of the Grenville Series (Fig. 1). Table 1 is an outline of two opposing theories on the origin of the anorthosite and related Precambrian rocks of the Adirondack region (from de Waard and Walton, 1967). A principle difference between the two theories is the time of Grenville sedimentation and subsequent metamorphism. Buddington (1939, 1952) considers Grenville sedimentation as the earliest recognizable Precambrian event which was followed by magmatic intrusion of the anorthosite series, and later by metamorphism. DeWaard et al. propose Grenville sedimentation on an older, partly anorthosite terrain.

NOMENCLATURE OF THE ADIRONDACK META-ANORTHOSITE

The Adirondack meta-anorthosite is subdivided into three broad, general groups: 1) The Marcy anorthosite, consisting of massive, porphyroclastic, generally homogeneous meta-anorthosite, which is typical of the Mt. Marcy massif, 2) the Whiteface anorthosite, consisting of more heterogeneous, gneissic, and typically gabbroic variety, which is characteristic of the Whiteface Mountain massif, and, 3) the subordinate Keene Gneiss, a hybrid type of andesine-augen-mesoperthite gneiss intermediate between anorthosite and charnockite. These three types are gradational with each other and are not restricted to the areas from which their names are derived. Plate I shows their general distribution in the Lake Placid and Ausable Forks Quadrangles.

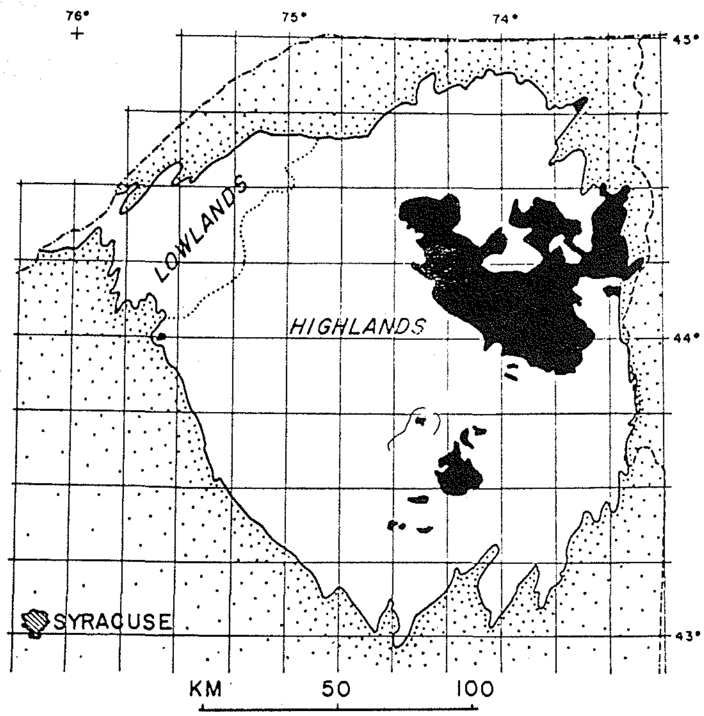


Fig. 1. Highlands - Lowlands division of the Adirondack Mountains, showing meta-anorthosite bodies in black. From deWaard, D. and W. D. Romey, 1963, Boundary relationships of the Snowy Mountain anorthosite in the Adirondack Mountains, Proc. Koninkl. Nederl. Akademie van Wetenschappen - Amsterdam, Ser. B, 66, No. 5

With increasing mafic mineral content, the Adirondack meta-anorthosites (and anorthosites in general) grade into meta-gabbros (clinopyroxene predominant) and meta-norites (orthopyroxene predominant). Intermediate varieties are thus classed as gabbroic or noritic meta-anorthosites, or anorthositic meta-gabbros or meta-norites. Charnockites, in which garnet and hypersthene are principle minerals, are also very common in the Adirondack region.

FIELD STUDY OF ADIRONDACK ANORTHOSITES

Anorthosites generally are very coarse grained. This is particularly true of the Marcy type, in which plagioclase crystals a foot or more in length are not uncommon. The normal procedure of field-and-thin section studies used with finer-grained rocks cannot be strictly applied to study of the Adirondack anorthosite, and some special methods have been devised. Representative modal analyses for instance, are obtained by point counting large areas on the outcrop with a transparent overlay net having evenly spaced points. Field differentiation of the meta-anorthosites without point counting is difficult, but a method used by several Adirondack workers is to differentiate on the basis of 1) percent mafic minerals (color index) and 2) degree of granulation. A third criterion which may be applied either on the outcrop or on the hand specimen in the laboratory is the K-feldspar content (Estimated from hand specimen stained with sodium cobaltinitrite)*.

*This staining technique was extensively used in the Santanoni quadrangle southwest of the Lake Placid quadrangle where Marcy type predominates. High K-feldspar contents were found only in intensely sheared zones, indicating probable metasomatism.

Buddington (1939, 1952)

~ orogenic deformation and metamorphism

intrusion of granites and alaskites

~ orogenic deformation and metamorphism

intrusion of hypersthene diabase

~ orogenic folding

intrusion of quartz syenite and charnockite series

intrusion of olivine diabase or gabbro

intrusion of anorthosite series, anorthosite and gabbroic anorthosite

Grenville series

Walton and De Waard (1963 a, b)

~ Grenville orogeny and metamorphism

intrusion of olivine dolerite - gabbro

- deposition of supracrustal sequences

erosion

~ pre-Grenville orogenic cycle includes:

sedimentation, orogeny, metamorphism, and plutonism, forming an extensive granitic terrain, origin or emplacement of anorthosite-gabbro suite

Table 1. Geologic evolution of the Adirondacks, a correlation of two concepts. (de Waard, D. and M. Walton 1967, Precambrian geology of the Adirondack highlands, a reinterpretation, Geol. Rundschau 56 - 2, 596-629)

FIELD TRIP STOPS

NOTE: THE FOLLOWING NOTES ARE THOSE OF DR. PERCY CROSBY WHICH APPEARED IN THE GUIDEBOOK CONNECTED WITH THE GEORGE H. HUDSON SYMPOSIUM ON THE ORIGIN OF ANORTHOSITE, HELD IN PLATTSBURGH, OCTOBER 9, 1966.

INTRODUCTION

A sub-horizontal to gently northward-dipping sheet of meta-anorthosite and gabbroic meta-anorthosite 24 miles long and up to 12 miles wide lying north of the main High Peaks massif will be visited. It lies entirely within the Ausable Forks and Lake Placid quadrangles. The Jay sheet on the east forms most of the highest peaks of the Ausable Forks quadrangle and the Sentinel Range of the Lake Placid quadrangle. It is bordered on the northwest by the Whiteface sheet which occupies the Mt. Whiteface massif and much of the Stephenson and Wilmington Ranges to the north.

Massive porphyroclastic meta-anorthosite similar to that exposed in the main massif, often referred to in the literature as Marcy anorthosite, composes most of the Jay sheet whereas a typically gabbroic, gneissic border facies of the meta-anorthosite is particularly characteristic of the Whiteface sheet although it is widely distributed elsewhere near the boundaries of the Marcy anorthosite. It is a much more heterogeneous unit and locally contains substantial amounts of non-anorthositic material. It has been traditionally known as "Whiteface anorthosite." The distribution of the two types is shown on the Geologic Map, Plate 1, within the area we will visit, together with a hybrid rock, the Keene (andesine augen-mesoperthite) gneiss intermediate between the anorthosite and charnockite series.

Plate 2 is a northwest-southeast geological cross-section through the long dimension of the sheet which is connected near Lewis to the main anorthosite mass. It is interpreted by me as a meta-anorthosite nappe less than a mile thick rooted in the High Peaks meta-anorthosite. The Jay-Whiteface meta-anorthosite overlies a massive, inverted charnockitic section to the southwest. Similar, but less extensive, charnockites appear on the northeastern normal limb. Bordering the meta-anorthosite is a discontinuous metasedimentary shell which is best developed along the connecting neck to the southeast and also near the leading edge of the nappe within a major digitation east of Franklin Falls. For the sake of simplicity the charnockite- metasedimentary rocks have not been differentiated on Plates 1 and 2 where they are unlabelled.

ANORTHOSITE AND MESOPERTHITE GNEISS OF LAKE PLACID AND AU SABLE FORKS QUADRANGLES NEW YORK

GEOLOGY BY P. CROSBY

EXPLANATION

A MASSIVE PORPHYROCLASTIC META-ANORTHOSITE (MARCY FACIES)

A_2 BORDER FACIES META-ANORTHOSITE AND GABBROIC META-ANORTHOSITE (WHITEFACE FACIES)
Locally includes charnockite and charnockite – anorthosite hybrid rocks in layers

ANDESINE AUGEN MESOPERTHITE GNEISS (KEENE GNEISS)

Other lithologic units omitted for simplicity

25 35 Strike and dip of foliation with strike and plunge of lineation

3 Field trip stops

Plate I

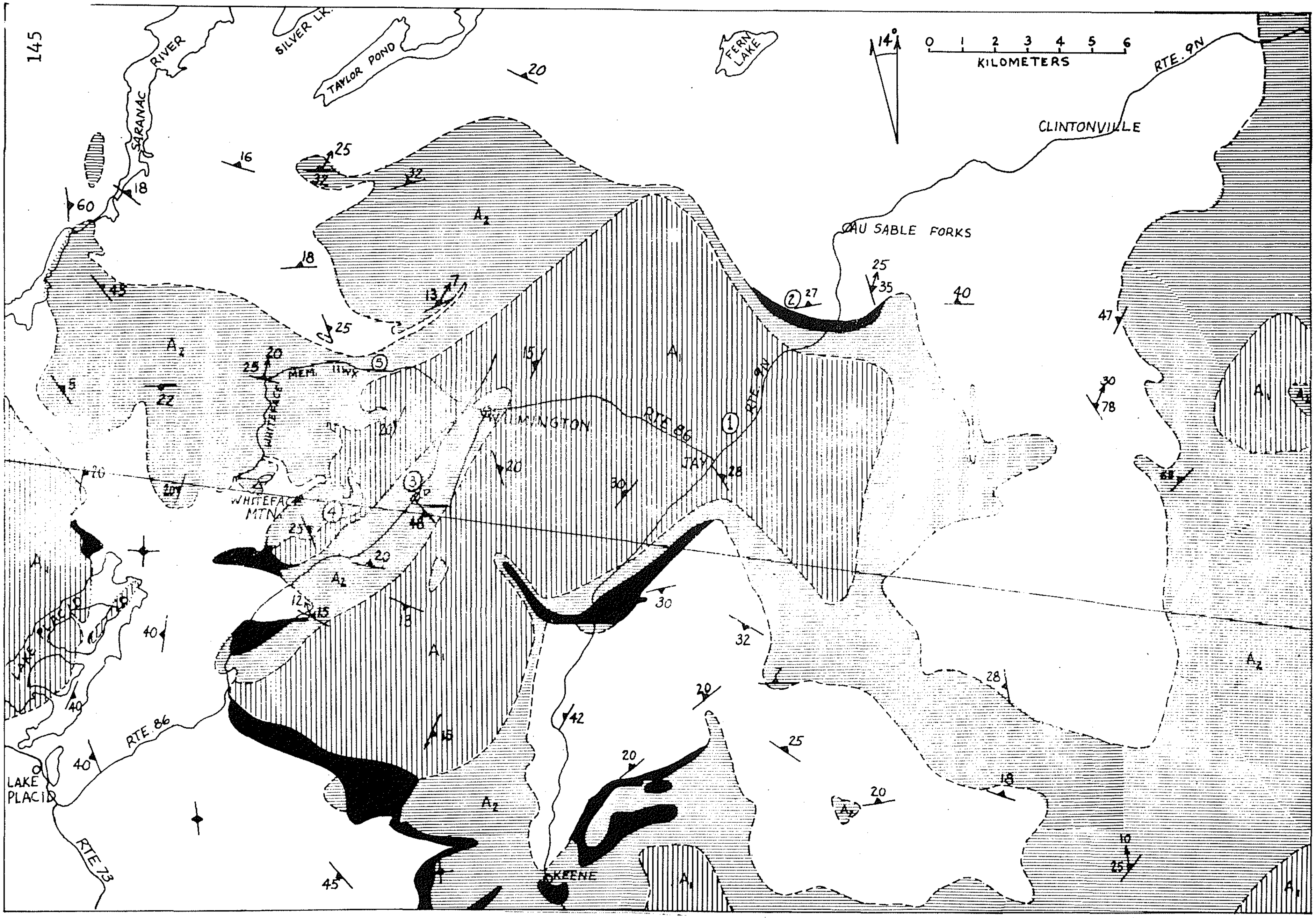

SARANAC RIVER
SILVER LK.
TAYLOR POND
FERN LAKE
14°
0 1 2 3 4 5 6
KILOMETERS
RTE. 9N
CLINTONVILLE
AU SABLE FORKS
A₂
A₁
MEM. HWY.
WILMINGTON
RTE 86
RTE 9N
JAY
WHITEFACE MTN.
LAKE PLACID
RTE. 86
RTE 73
KEENE

Plate I

The nappe was presumably emplaced from the south with minimum apparent displacement 10 to 15 miles. Supporting this interpretation is a pervasive gently-plunging north-northeast mineral lineation which is particularly prominent in the strongly deformed gabbroic anorthosite gneisses on Whiteface Mt. near the base of the nappe. The nappe hypothesis is in general agreement with gravity data. Most of the Jay-Whiteface sheet lies outside the residual anomaly contour corresponding to a 3Km thickness for the anorthosite.

Stop 1. Locality A, Jay, Ausable Forks Quadrangle

Take woods road beginning opposite Tirolerland restaurant, 0.8 miles N. of Jay on Route 9N. Follow woods road to point where it begins to veer sharply south, 0.25 miles from Route 9N. Climb 100 yards south to exposed slabs on hilltop which has been stripped and cleared by Rock of Ages Corp. Professor Brewster Baldwin of Middlebury College prepared base map by plane-tabling on which geology and sample localities have been plotted (Fig. 2).

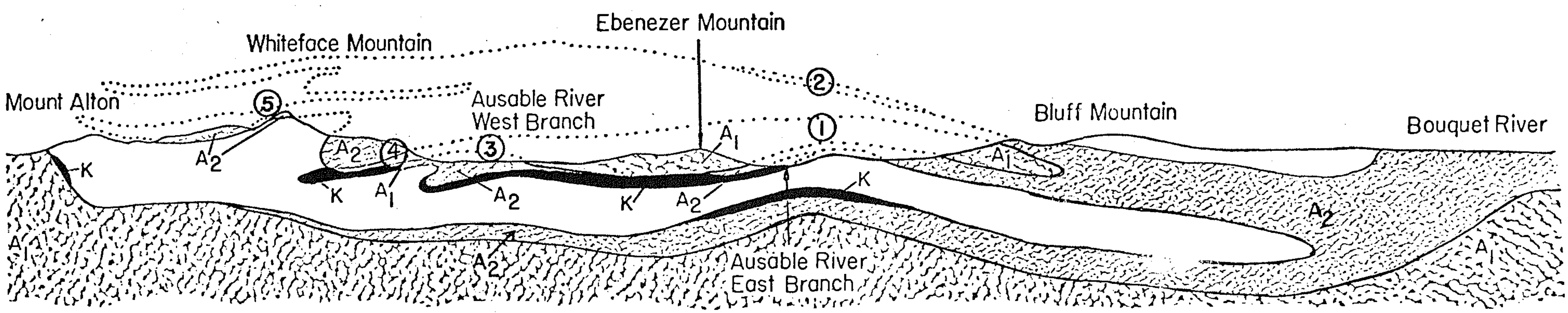
The exposure is representative of massive, generally porphyroclastic, core meta-anorthosite of the "Marcy-type," but shows the considerable local compositional and textural variation encountered in this map-unit. Three local facies have been distinguished here, viz:

Facies I: A fine-to-medium grained granoblastic equigranular gabbroic meta-anorthosite, locally passing into an anorthositic metagabbro, largely confined to the northwestern portion of the outcrop. It shows many analogies with the border facies anorthosite. (Whiteface-type") and perhaps should be so mapped. Clinopyroxene ($Wo_{40}En_{35}Fs_{25}$) takes place of hypersthene in this facies, and garnet is absent.

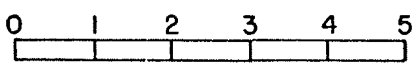
Facies II: This is the predominant lithic type in the exposure and consists of inequigranular meta-anorthosite with plagioclase megacrysts forming from about 25 to 70 per cent of the total rock volume, the proportion of megacrysts decreasing toward the southeast. Hypersthene is the major ferromagnesian constituent, but locally incipient rims of garnet and clinopyroxene are visible. Before concluding that the finer-grained plagioclase matrix between the megacrysts is of protoclastic origin or produced by post-crystallization deformation, examine the hypersthene grains intergrown with the matrix. Many will be seen to be optically continuous as shown by reflections from parallel cleavage surfaces and may indicate an ophitic intergrowth suggestive of a final, possibly eutectic, assemblage.

Plate 2 CROSS-SECTION of JAY WHITEFACE ANORTHOSITE NAPPE

Ausable Forks–Lake Placid New York Quadrangles



SCALE IN MILES



EXPLANATION

A_1 Massive porphyroclastic meta-anorthosite. ("Marcy" facies)

A_2 Border facies meta-anorthosite and gabbroic meta-anorthosite ("Whiteface" facies). Locally includes charnockitic and charnockite anorthosite hybrid rocks in layers

K Andesine augen mesoperthite gneiss ("Keene" gneiss)

② Approximate location of field trip stops (along structural plunge)

TABLE 2
MODES, LOCALITY A, JAY

	FACIES I			FACIES II								
Mineral	1	3	4	2	5	6	8	9	10	11	12	13
Plagioclase (matrix)	81.7	75.0	61.4	50.4	51.2	51.4	31.6	27.4	24.1	30.4	36.4	68.0
Plagioclase (megacrysts)				44.9	46.2	45.2	59.3	68.8	70.7	64.4	57.5	27.1
Clinopyroxene	18.3*	25.0	38.6									
Hypersthene				4.7	2.6	3.4	9.1	3.8	5.2	5.2	6.0	4.9[1]
Garnet				tr.		tr.	tr.		tr.		tr.	tr.
Quartz												
Magnetite						tr.					0.1	
Pyrite		tr.										
Total Plag.	81.7	75.0	61.4	95.3	97.4	96.6	90.9	96.2	94.8	94.8	93.9	95.1
Color Index	18.3	25.0	38.6	4.7	2.6	3.4	9.1	3.8	5.2	5.2	6.1	4.9
Per cent An											56	
Matrix	72						44[2]					
Megacrysts							44[2]					

*Composition approx. $Wo_{40}En_{35}Fs_{25}$
1 also includes probably clinopyroxene
2 from excavated block 25 ft. SSE
(south southeast)

TABLE 2 (continued)
MODES, LOCALITY A, JAY

	FACIES II						FACIES III					
Mineral	14	15	16	17	18	19	7	20	Mean Facies I N=3	Mean Facies II N=15	Mean Facies III N=2	Mean Facies N=20
Plagioclase (matrix)	67.9	40.0	29.2	31.8	48.9	60.9	8.3	15.7	72.7	43.3	12.0	44.6
Plagioclase (megacrysts)	27.8	55.0	62.8	65.9	44.7	35.1	66.9	74.8		51.6	70.8	45.8
Clinopyroxene	tr.		tr.						27.3			4.1
Hypersthene	4.3	5.0	8.0	2.3	6.4	3.8	24.8	8.8		4.8	16.8	4.6
Garnet		tr.	tr.	tr.	tr.	tr.	tr.	0.7			0.4	0.1
Quartz						0.2						
Magnetite					tr.		tr.			other 0.3 (cpx, gar, mag, qtz)	tr.	other 0.8 (mag, Py, qtz)
Pyrite												
Total plag.	95.7	95.0	92.0	97.7	93.6	96.0	75.2	90.5	72.7	94.9	82.8	90.4
Color Index	4.3	5.0	8.0	2.3	6.4	3.8	24.8	9.5	27.3	5.1	17.2	9.6
Percent An	56											
Matrix			48						72	52		57
Megacrysts							50			46	50	47
All plag.										49.6		52.9

EXPLANATION

- Facies I gabbroic meta-anorthosite
- Facies II meta-anorthosite
- Facies II a Anorthositic metanorite to metanorite
- Facies III Pegmatitic meta-anorthosite to anorthositic metanorite
- ·20 Location of field modal analysis
- ◻ 13A Quarried block
- 1080 Contour

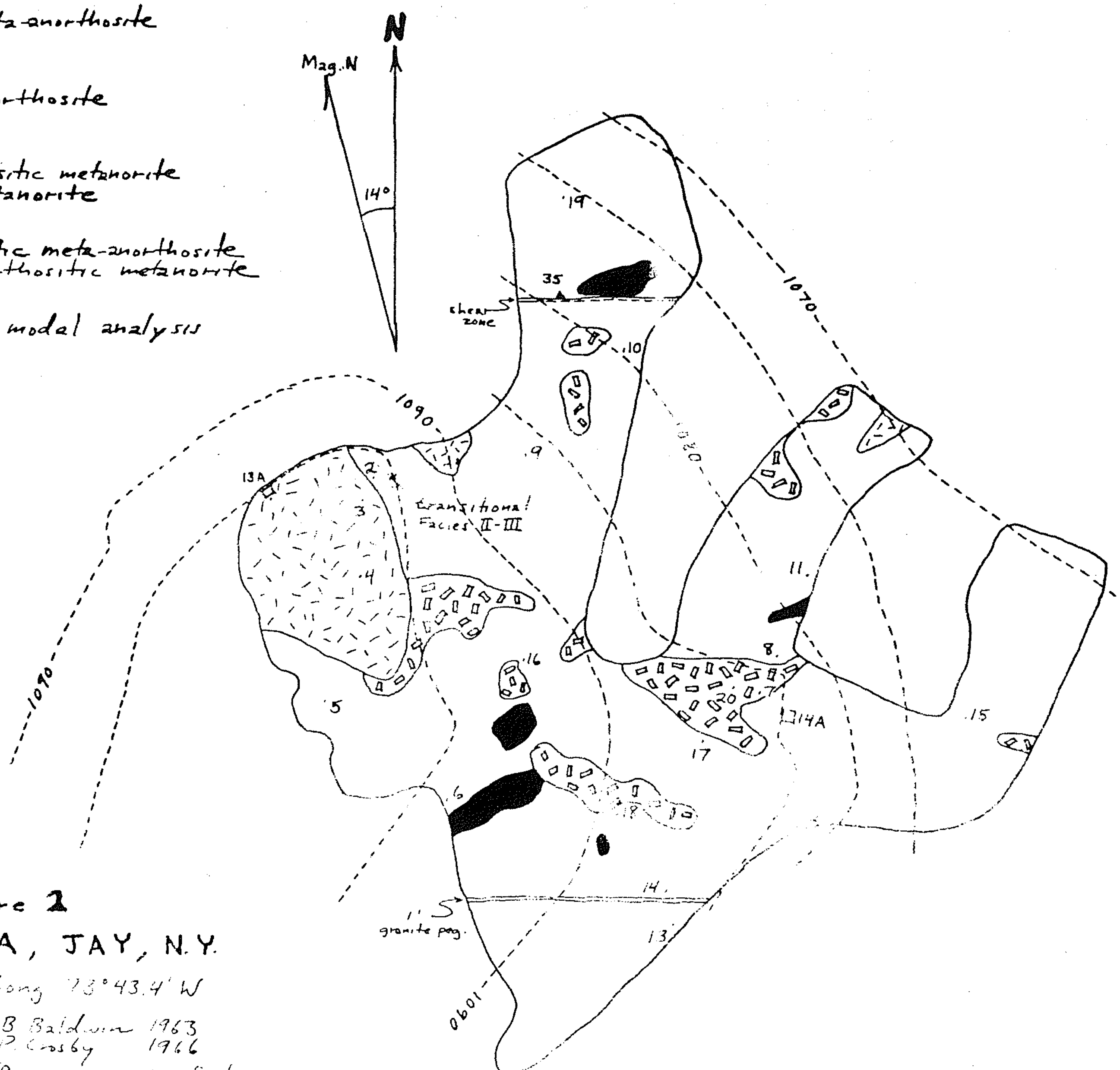


Figure 2

LOCALITY A, JAY, N.Y.

Lat 44°23.1 N Long 73°43.4' W

Plane table map B Baldwin 1963
Geology P. Crosby 1966

0 50 100 feet
SCALE

Contour interval 5 feet

Facies III: Appearing as irregular patches up to 50 feet across in facies II meta-anorthosite is a pegmatitic phase, varying from meta-anorthosite to anorthositic metanorite. A coarse ophitic intergrowth of little-granulated plagioclase crystals and hypersthene, both attaining lengths up to one foot, is characteristic of facies. Garnet rims may be seen around some of the hypersthene.

In Table 2 are given modes measured on the outcrop (numbers painted on outcrop and located on Fig. 2) covering 6.5 feet^2 apiece (619 cm^2) with reticular spacing of one inch (2.54 cm.). Means for each of the facies and a mean for all modes, which have been apportioned among the various facies proportional to their aerial extent, have been calculated. The anorthite content of a limited number of plagioclase samples, both megacrysts and the finer grained matrix, has been determined by refractive indices. The compositional range is from calcic andesine (An_{44}) to sodic bytownite (An_{72}) with the average of all determinations An_{53}. Where both matrix and megacrysts were measured in a single sample, the composition was identical in each. It is likely, however, that many of the megacrysts show compositional zoning. This is indicated by one crystal having a chatoyant core and a non-chatoyant rim.

Stop 2. Omitted.

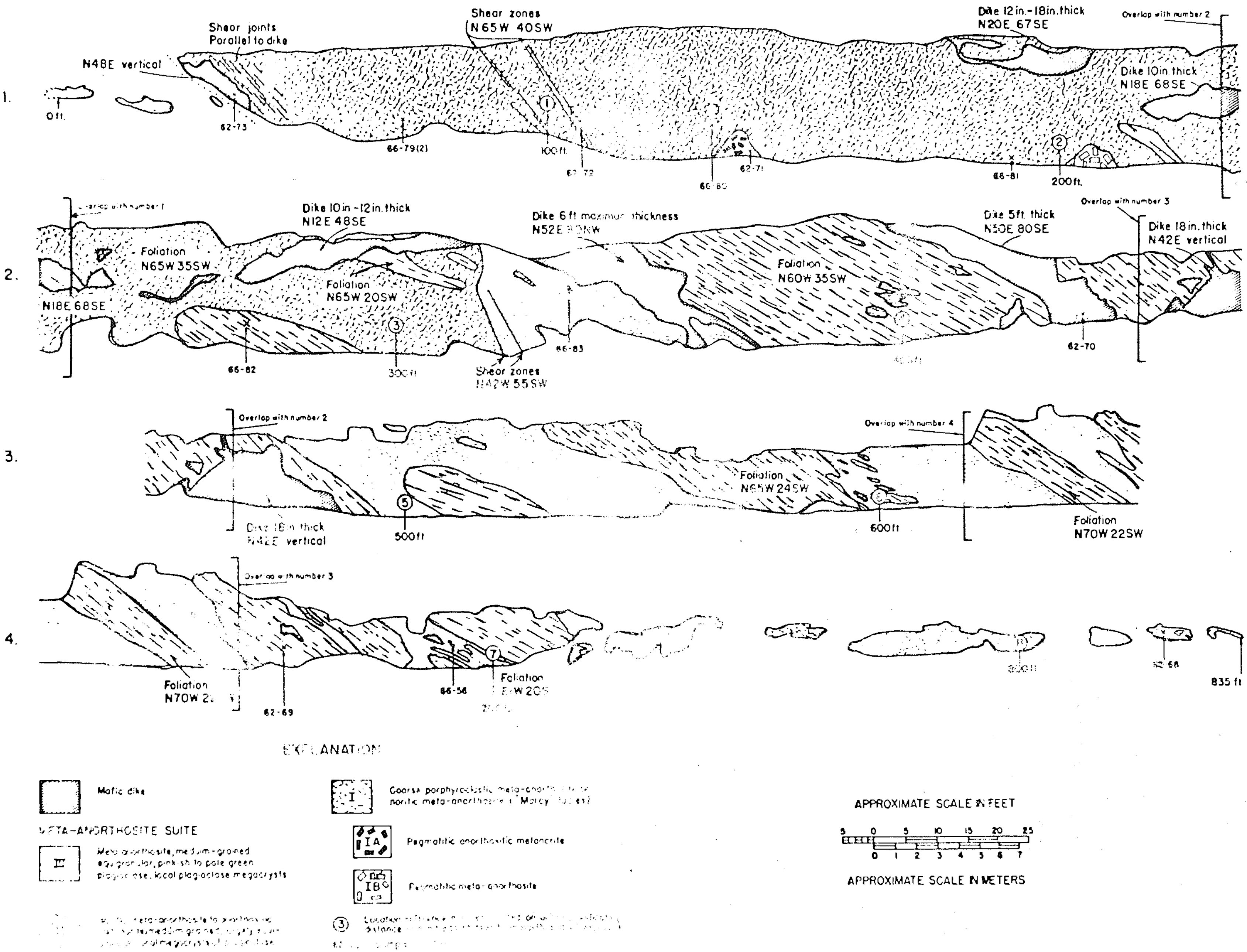
Stop 3. Roadcut South of the Flume, Route 86 Between Wilmington and Lake Placid

In this extensive exposure (for cross-section 835 feet long prepared from a photomosaic refer to Plate 3), the relationships between three distinctive anorthositic varieties are well displayed. Coarse-grained porphyroclastic meta-anorthosite to noritic meta-anorthosite (Facies I) with blue-black plagioclase megacrysts composing from 10-40% of the total rock flanked by a medium-grained, generally equigranular noritic meta-anorthosite to anorthositic meta-norite gneiss (Facies II) and a medium-grained, granoblastic anorthosite with mottled pale green and pink to lavender plagioclase (Facies III). For petrographic details, see Table 3. Despite the considerable compositional & textural variation, the anorthosite content of plagioclase remains remarkably constant (ca. An_{55}) with the principle difference being the Fe-Ti oxide inclusions of the dark plagioclase megacrysts and the absence of impurities and characteristic coloration of the (recrystallized?) plagioclase of Facies III.

Plate 3

ROADCUT SOUTH of THE FLUME, ROUTE 86, WILMINGTON—LAKE PLACID, NEW YORK

Trend of roadcut–N30E; looking S60E



Facies I meta-anorthosite closely resembles massive core meta-anorthosite of the Marcy-type although here it appears to be isolated from any extensive exposed body of such meta-anorthosite. Facies II is most closely related to border facies (Whiteface-type) meta-anorthosite and Facies III which forms most of the gorge (Flume) along the Ausable River just to the north is found interlayered with noritic meta-anorthosite at numerous localities in the Whiteface sheet to the west.

The meta-anorthosite facies are numbered in the order of their presumed relative ages as shown at this exposure. Block structure with inclusions of Facies II noritic meta-anorthosite gneiss in the much more leucocratic Facies III is especially well developed 600 feet south of the northern end of the cut. The position of Facies I meta-anorthosite in the sequence is much less certain, and it is placed first largely because of the inclusion within Facies II near the 400 feet marker. Large masses of Facies II, however, are surrounded by Facies I between the 200 and 300 feet markers. There is thus some evidence of reciprocal intrusion if geometric factors are ignored. Another example is patches of Facies III meta-anorthosite surrounded by Facies II at 400 feet. Some discussion of field criteria for age relationships will undoubtedly be warranted. In general elsewhere in the eastern Adirondacks as described in the literature, it is more common to find gabbroic meta-anorthosite intruding and enveloping blocks of a more leucocratic meta-anorthosite. At the next stop we shall examine further evidence bearing upon the anorthosite sequence.

There are small inclusions of diopsidic or garnet-biotite rich fieldspathic gneisses or granofelses in Facies III meta-anorthosite at 690 feet (specimen 66-56). More extensive layers of diopsidic meta-sediments in Facies II gabbroic meta-anorthosite are to be found 100 yards west of the bridge over the Flume just to the north.

The outcrop shows a number of fine-grained diabase dikes from 10 inches to 6 feet thick nearly parallel to the general trend of the cut (estimated mode, samples 62-70, Table 3).

Many shear surfaces of indeterminate displacement are present, the most prominent set perhaps being about N30E, parallel to the cut face and on strike with the pronounced linear through Wilmington Notch visible to the south, a locus of probably major faulting. Augen gneiss zones in the meta-anorthosite with considerable microclinization may be seen at 100 feet and at 320 feet (estimated mode, sample 62-72, Table 3). Garnet in the meta-anorthosite appears to be localized in these gneiss zones, a phenomenon observed at many other exposures. Many secondary minerals occur along the late shear surfaces, including calcite, quartz, epidote, and chlorite. Natrolite has also been identified.

TABLE 3, MODES VICINITY OF THE FLUME, AUSABLE R., W. BRANCH

	FACIES I				FACIES II		FACIES III			Micro clinized gneiss zone	Diabase dike
Mineral	66-79	66-80	66-81	62-71	62-69	62-79[3]	62-68	62-74	62-81[4]	62-72*	62-70*
Plagioclase[1]	Plagioclase determination only	Plagioclase determination only	Plagioclase determination only	Orthopyroxene determination only	77.6	85.9	92.4	96.6	93.4	30	54
Hypersthene					4.9	3.2					
Clinopyroxene					11.8	2.7		0.3	3.0	4	35
Hornblende					5.6	6.5		1.8	0.3		4
Chlorite						1.6	4.4	0.7	2.4	2	1
Garnet										<1	
Quartz										2(?)	
Microperthite										60	
Biotite											tr.
Calcite											1
Scapolite							3.1		0.5	tr.	
Sphene								0.1	0.1	<1	
Apatite						tr.		0.1		tr.	
Magnetite								0.4	0.4	<1	5
Ilmenite					0.1		tr.				
Pyrite[2]						tr.	tr.				
Color Index					22.4	14.1	4.5	3.2	6.0		
An plag. (megacrysts	56	56	53								
An plag. (matrix)	53	53	53		54	55	53	55	48	57	60
En hypersthene				65							

FOOTNOTES:

[1] includes Kaolinite alt'n

[2] includes hematite alt'n

[3] 300 ft. upstream from bridge along Ausable River

[4] Lower end of the Flume 0.3 mi. NE of Rte. 86 bridge

*estimated mode

Stop 4. Stream-worn slabs under lower ski lift, Whiteface Mt., elevation 1800 - 2000 feet between powerhouse and mid-lift station.

Drive into Whiteface Ski Center from Route 86 between Wilmington and Lake Placid. The lift will probably not be operating, so climb ski trail 600 feet vertically right (north) of stream along lift line to bare stream slabs above powerhouse.

Three distinct facies of the meta-anorthosite series are represented at this exposure, two of them related to those seen at the Flume. The earliest member of the series (Facies I) is not, and is preserved as several rounded inclusions mostly under running water in the stream bed as it veers north of the lift line towards the upper end of the exposure. It is a fine-to-medium-grained equigranular mafic anorthositic meta-gabbro enclosed by both Facies II and Facies III rocks. For thin-section mode see specimen 65-175 in Table 5. Notable is the calcic content of the plagioclase (An_{70}) compared to that of Facies II (An_{52-55}).

Facies II comprises most of the outcrop. For thin-section modes, see Table 5; for larger-area point counts with the screen employed at Stop 1, see Table 4 -- the numbers are painted on the outcrop. The average rock is a noritic-meta-anorthosite (color index 17.85) with mean per cent plagioclase megacrysts 24.25 and plagioclase matrix 57.80. The proportion of megacrysts varies from a minimum of 7.6% to a maximum of 42%. There is also considerable textural variation with a medium-grained rock showing subtle compositional banding and a suggestion of sub-ophitic texture in the matrix the preponderant type (modes, no. 1-10). Mineralogically similar, but coarser-grained and showing better developed ophitic texture is mode no. 11, whereas modes no. 13 and 14 are somewhat more leucocratic than the average but otherwise related texturally.

Facies III is an inequigranular medium-to-coarse-grained leucocratic meta-anorthosite apparently cutting Facies II noritic meta-anorthosite in irregular dikes with apophyses. It is interpreted as definitely younger than Facies II, and bears out the sequence deduced at the Flume. Similar dike-like bodies of Facies III in Facies II meta-anorthosite are present in slabs along the Boreen ski trail 100 feet higher to the northwest, and may be visited if time permits.

It is worthwhile inspecting some of the coarser-grained ophitic Facies II noritic meta-anorthosite in the lower narrow portion of the stream slabs for textural evidence of protoclasis or several stages of granulation followed by crystallization. Representative of the textures seen are large, partially granulated, plagioclase megacrysts

TABLE 4
MODES, LOWER WHITEFACE MTN. (SKI LIFT)

	FACIES II													Mean Facies II,	Facies III
Mineral	1	2	3	4	5	6	7	8	9	10	11	13	14	N=13	12
Plagioclase (matrix)	48.2	53.6	58.0	54.5	56.2	63.8	57.4	64.4	78.9	67.4	43.9	56.4	48.7	57.80	80.5
Plagioclase (megacrysts)	29.3	25.5	21.8	25.2	22.4	19.0	25.3	17.3	7.6	10.7	36.4	33.1	41.6	24.25	17.0
Hypersthene	20.8	19.2	19.0	18.8	18.0	15.6	16.4	16.7	11.9	17.5	16.4	9.8	8.2	16.02	1.5
Pyribole	1.7	1.7	1.2	1.5	3.4	1.6	0.9	1.6	1.6	4.4	3.3				1.0*
Garnet												0.7	1.5	1.93	
Magnetite															
Total plag.	77.5	79.1	79.8	79.7	78.6	82.8	82.7	81.7	86.5	78.1	80.3	89.5	90.3	82.05	97.5
Color Index	22.5	20.9	20.2	20.3	21.4	17.2	17.3	18.3	13.5	21.9	19.7	10.5	9.7	17.95	2.5

* includes magnetite

TABLE 5
THIN SECTION MODES
LOWER WHITEFACE MTN. (SKI LIFT)

Mineral	FACIES I	FACIES II	
	65-175	63-62	65-177
Plagioclase	66.5	79.7	88.1
Hypersthene	7.8	3.2	
Clinopyroxene		13.0	6.0
Hornblende	20.8	3.6	4.0
Biotite	4.4		0.1
Chlorite			1.4
Apatite		0.2	0.2
Magnetite		0.1	0.2
Ilmenite		0.1	
Pyrite	0.5	0.1	
Color Index	33.5	20.1	11.7
An Plag. (matrix)	70	52	55

with inserted ungranulated hypersthene crystals and shattered plagioclase augen veined by noritic meta-anorthosite. Relationships may be explained by varying paths of crystallization in Di-Ab-An ternary coupled with one or more stages of cataclasis. Locally there appear to be eutectic intergrowths of plagioclase and hypersthene between plagioclase megacrysts.

Observations bearing upon the metamorphic history of the meta-anorthosite at this locality are the following:

1. Garnet is generally absent except along shears. At the slabs in the Boreen ski trail a little higher, leucocratic meta-anorthosite "dikes" in gabbroic meta-anorthosite have garnet and clinopyroxene + hornblende rims to hypersthene grains whereas hypersthene does not have such reaction rims in the gabbroic meta-anorthosite.
2. Hypersthene generally is rimmed by clinopyroxene or hornblende or an intergrowth of the two in the noritic meta-anorthosite under the lift. Locally, a hypersthene core is rimmed by clinopyroxene and this in turn by hornblende. It is possible that the clinopyroxene rim represents exsolution from a primary orthopyroxene or inverted pigeonite host. No exsolution lamellae have, however, yet been detected in the hypersthene. If the clinopyroxene is a result of unmixing, then the only metamorphic mineral here is hornblende.

<u>Stop 5 (6, 7...)</u> Whiteface Memorial Highway and summit of Whiteface Mountain.

If time permits, we will ride up the Whiteface Memorial Highway, making one or more stops, and take one of the trails to the summit, preferably the northeast ridge trail from the "Wilmington turn" at the large cut below the main parking lot.

The meta-anorthosite rocks exposed in the Whiteface sheet extending from the upper slopes of Whiteface Mt. on the south to Catamount Mt. on the north and the Franklin Falls area on the west show many mineralogical, textural, and structural contrasts with the border facies of the meta-anorthosite we have thus far examined.

In general, they are much more recrystallized and relict igneous textures as observed under the ski lift at Stop 4 are rare. Foliation, and often lineation as well, is strongly developed and plagioclase megacrysts, mostly small and augen-shaped, seldom constitute more than a few per cent of the total rock. Banding is also common, and gabbroic meta-anorthosite alternates with leucocratic meta-anorthosite layers over short intervals. Garnet becomes a major phase and hypersthene a correspondingly less important constituent. There are layers of varying thickness from less than an inch to many tens of feet of mangeritic rocks, of Keene gneiss and of metasediments including coarse-grained gray quartzite and garnet-diopside granofels. Graphite is present locally near marble or calc-silicate contacts. I believe many of the physical and mineralogical characteristics of the Whiteface meta-anorthosite sheet can be explained by its tectonic position at the leading edge and base of the nappe described in the introduction to these notes.

Table 6 presents 20 modes of anorthosite rocks on Whiteface Mt. along the Memorial Highway and summit ridges in order of increasing elevation to emphasize any depth-controlled trends that may be present in the sheet. As we climb the northern slope of the Whiteface massif we are slowly passing upward through a nearly dipslope compositional layering parallel to a regional foliation.

At the Lake Placid turn (First switchback) there is a spectacular view of Lake Placid to the south. The contact between gabbroic meta-anorthosite, here somewhat more mafic than average, and mangeritic rocks is exposed just to the east of the turn. At the contact the mangerites are greenish but further away they become progressively pinker and quartz content increases. Boudins of anorthosite are enclosed in the mangerite-charnockite sequence -- is this an intrusive or tectonic relationship?

At the Wilmington turn, gabbroic meta-anorthosite structurally overlies green mangerite at the eastern end of the large cut. Meta-anorthosite blocks in the retaining wall excavated from the cut provide a good sample of the average rock in the cut. Garnet coronas are fairly common. On the upper, slightly weathered surfaces of the cut strong gently northeast-plunging lineation shown by aligned mafic minerals is shown to advantage. There are also thin quartzitic beds parallel to the foliation in the meta-anorthosite. One meta-anorthosite block not quite in place shows sharp folding of a quartzite layer.

Continuing up the trail along the northeast ridge of Whiteface Mt. to the summit, the open slabs will show the strongly gneissic, lineated, and banded character of the gabbroic meta-anorthosite. Thin plate-like quartzite layers parallel to foliation are common.

TABLE 6

MODES OF ANORTHOSITIC ROCKS ALONG WHITEFACE MEMORAL HIGHWAY TO SUMMIT RIDGES OF WHITEFACE MT. IN ORDER OF INCREASING ELEVATION

Mineral	65-88	65-89	65-90	65-91	65-92	65-93	65-100	65-101	65-103	65-204
Plagioclase	97.9	52.7	76.0	90.2	58.5	74.2	86.1	86.2	79.1	16.9
Clinopyroxene		9.6	16.5	3.6	11.9	6.2	8.2	3.7	12.0	11.1
Hornblende		26.7	6.8	5.8	21.6		5.3	8.7	5.3	4.6
Hypersthene		5.8			7.9			0.8		
Garnet	0.1	2.9				7.6			0.3	56.0
Biotite	0.1	0.4	0.2						1.5	0.3
Chlorite	0.8							0.5	1.7	2.0
Scapolite										
Sphene	0.2	1.8	0.1			2.8	tr.	tr.	tr.	0.1
Apatite	0.1		0.2	tr.	0.1	1.1	0.4			
Epidote										2.4
Calcite	0.5									
Magnetite		0.1	0.2			8.1		tr.	tr.	6.6
Ilmenite	0.2			0.3				tr.		
Pyrite	0.1			tr.						
Color Index	1.3									
An plag.	68	70	60	70	68	56	52	43	54	66
ELEV.	2710'	2710'	2850'	2877'	2930'	2960'	3980'	3980'	4080'	4150'

TABLE 6 (continued)

MODES OF ANORTHOSITIC ROCKS ALONG WHITEFACE MEMORAL HIGHWAY TO SUMMIT RIDGES OF WHITEFACE MT. IN ORDER OF INCREASING ELEVATION

Mineral	65-109	65-111	65-113	65-118	65-119	65-121	65-126	65-122	WS-30a	65-125
Plagioclase	83.9	41.3	84.1	57.2	79.9	60.1	89.0	29.6	18.1	88.0
Clinopyroxene	8.0	8.8	5.1	4.1	6.9	24.1	4.9	40.6	27.2	6.6
Hornblende	7.0	26.4	10.1	1.2	11.0	4.5	5.5	29.1	10.6	4.9
Hypersthene				1.7		6.4				
Garnet		17.2		34.3					37.1	
Biotite	0.3		0.3				0.3			
Chlorite		0.4			1.6					
Scapolite					tr.					
Sphene	0.4	0.3			0.2	0.3		0.4	0.1	
Apatite	0.1	0.9	0.1	0.3	tr.	0.3	0.2	0.2	1.0	0.1
Epidote										
Calcite										
Magnetite	0.3	4.7	0.1	1.2		4.3	0.1	0.1	5.2	0.3
Ilmenite										
Pyrite			0.2						0.7	0.1
Color Index										
An plag.	45	50	52	52	60	35	49	63	65	58
	4230'	4310'	4440'	4510'	4590'	4630'	4640'	4680'	4755'	Summit 4860'

From the summit, if you descend the south face 100 vertical feet you will cross the meta-anorthosite-mangerite contact once more. There is no intermediate andesine augen mesoperthite gneiss (Keene gneiss) at the boundary. Quartz content varies widely from 30-40 per cent to less than 5% in adjacent layers.

If the day is fine, it will be possible to point out regional relationships between anorthosite and related rocks in the High Peaks to the south and in the Jay-Whiteface sheet to the southeast and northwest.