NEW YORK STATE GEOLOGICAL ASSOCIATION

36th ANNUAL MEETING

MAY 8-10, 1964

GUIDEBOOK

DEPARTMENT OF GEOLOGY, SYRACUSE UNIVERSITY

NEW YORK STATE GEOLOGICAL ASSOCIATION

36th Annual Meeting — May 8-10, 1964

GUIDEBOOK

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TABLE OF CONTENTS

PREFACE

This GUIDEBOOK is intended to be a permanent record of the 36th annual meeting of the New York State Geological Association. The short papers accompanying the road logs of the various field trips are presented to enhance the merit of the field excursions. For the most part they summarize previous information and ideas which are pertinent to the trips; in lesser part they provide information and concepts which have not been published elsewhere but which reflect the continuing research on problems of New York State geology in the Syracuse area and in the south-central Adirondacks.

The editor's contribution in assembling this volume has been nominal. Individual authors have been responsible for the contributions which they offer here, and for the most part they have done their own proof-reading and editing of copy. The effort which has gone into the planning of the field trips and the road logs can be fully appreciated only by those who have made similar contributions to the Association in past years.

Special acknowledgment is made of the generous contributions by authors outside the Department of Geology at Syracuse University. Gratitude is expressed also to those Syracuse University students who have contributed their time, energy and enthusiasm toward making the 36th annual meeting of the Association a success.

John James Prucha
Editor and President 1964

NOTES ON THE GEOLOGY OF THE SOUTH-CENTRAL ADIRONDACK HIGHLANDS

by Dirk de Waard

GEOLOGIC RELATIONS

Present investigations in the central Adirondacks (and in the eastern Adirondacks by Matt Walton) emphasize stratigraphy, catazonal tectonics, metamorphism, and anatexis as the essential facets. A new interpretation of the geologic relations in the Precambrian of the Adirondack highlands recently proposed by Walton and de Waard (1963a, b) is summarized as follows:

1. Contrary to the impression given in Buddington's (1939) famous memoir: "Adirondack Igneous Rocks and Their Metamorphism", almost all Precambrian rocks in the Adirondacks are metamorphic rocks with metamorphic assemblages and textures. The Adirondack anorthosite is a meta-anorthosite with a granulite facies mineral assemblage in which large relic andesine plagioclase makes up a large part of the rock. Metagabbro and metadolerite commonly display a relic ophitic texture and contain cores of relic pyroxene, olivine, and plagioclase. Meta-anorthosite and associated rocks, and metagabbro and metadolerite are the only rocks which show evidence of their pre-metamorphic origin. All other metamorphic rocks are completely recrystallized and without relic textures. On the basis of their composition some of them, such as marble and quartzite, can indisputably be called metasediments. The origin of the great majority of rocks, including diverse potassic and sodic gneisses, charnockites, and metabasites, is not certain; they may have been plutonic, volcanic, or sedimentary.

2. Detailed mapping has revealed a consistent and persistent stratigraphy of alternating layers of diverse gneisses, charnockite, marble, amphibolite, and quartzite. The layered sequence, which is over 1750 meters thick, appears to envelope and overlie massifs of generally more homogeneous metamorphic rocks which include masses of anorthosite and associated rocks, charnockites, granulites, leptites, and gneisses of granitic composition. Because of this consistent relationship between the stratigraphic sequence and the underlying massifs the present, most simple interpretation is that the massifs represent a basement complex which was formed, metamorphosed, folded, and intruded during an earlier orogenic cycle, and denudated before deposition of supracrustal rocks began. The previous and alternative interpretation is that anorthositic, noritic, syenitic, and granitic masses intruded a supracrustal sequence at approximately the same stratigraphic level.

3. The structural pattern of the mapped area does not substantiate the presence of intrusive masses of batholithic dimensions and a sequence of intrusive events. The pattern is consistent with intense, deep-seated folding of basement and supracrustal sequence during the Grenville period of deformation and metamorphism. If primary flow structures were present in rocks they were obliterated and replaced by metamorphic foliation. Foliation in the stratigraphic sequence is a bedding-plane foliation, paralleling sedimentary bedding and compositional layering. In the basement complex foliation parallels the layering of the overlying supracrustal sequence. Mineral lineations and minor fold axes are parallel to fold axes of major folds. One exception to this rule is found in dome-shaped structures where radially oriented lineations occurring at a certain level indicate final-stage updoming movements. The map pattern, with sinuous belts of supracrustal rocks wrapped around basement masses, resembles in many

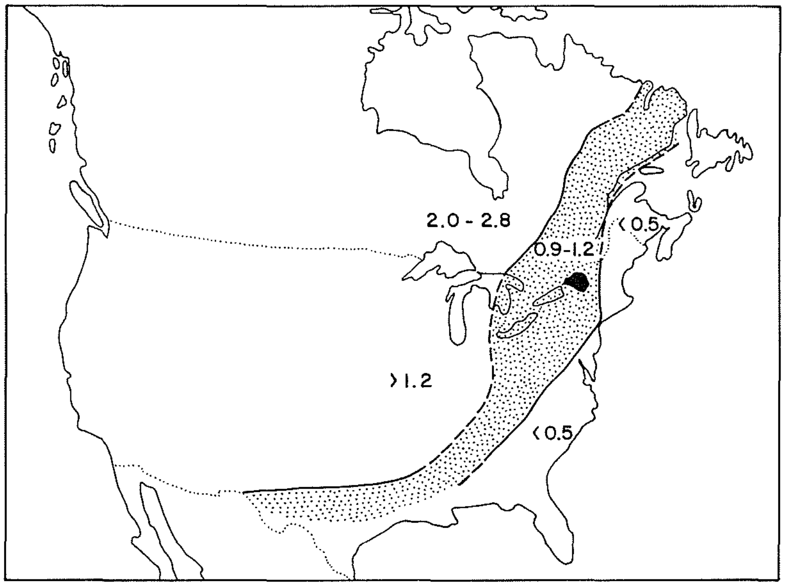


Fig. 1. Location of the Adirondack Mountains (black) in the Grenville orogenic belt. Province boundaries and ages after Tilton, et al (1962) and Stockwell (1962).

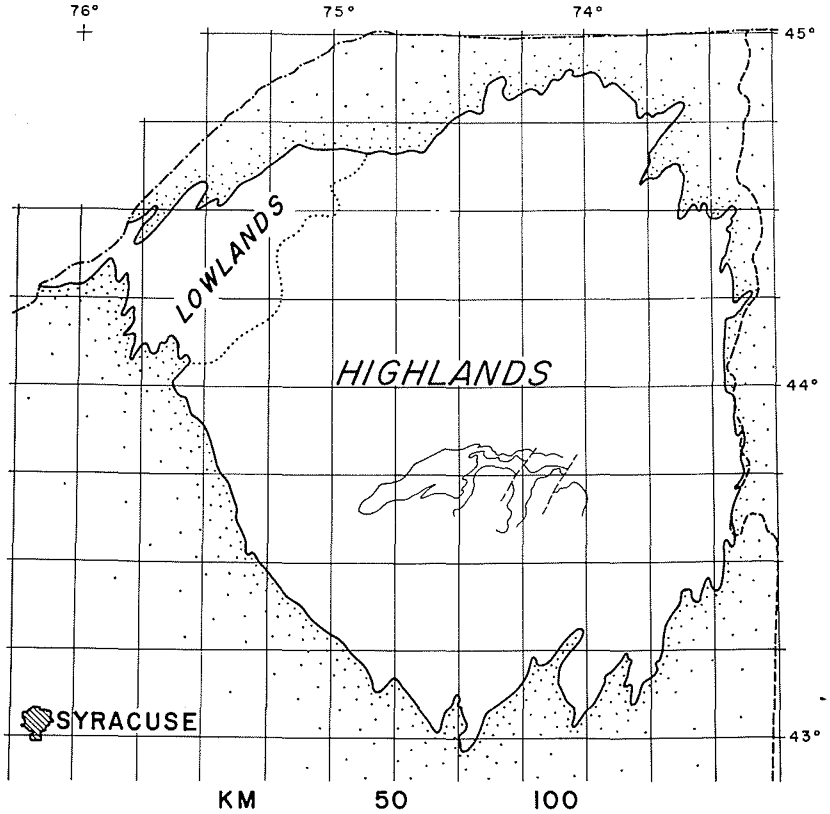


Fig. 2. Location of the investigated region in the south-central Adirondack highlands.

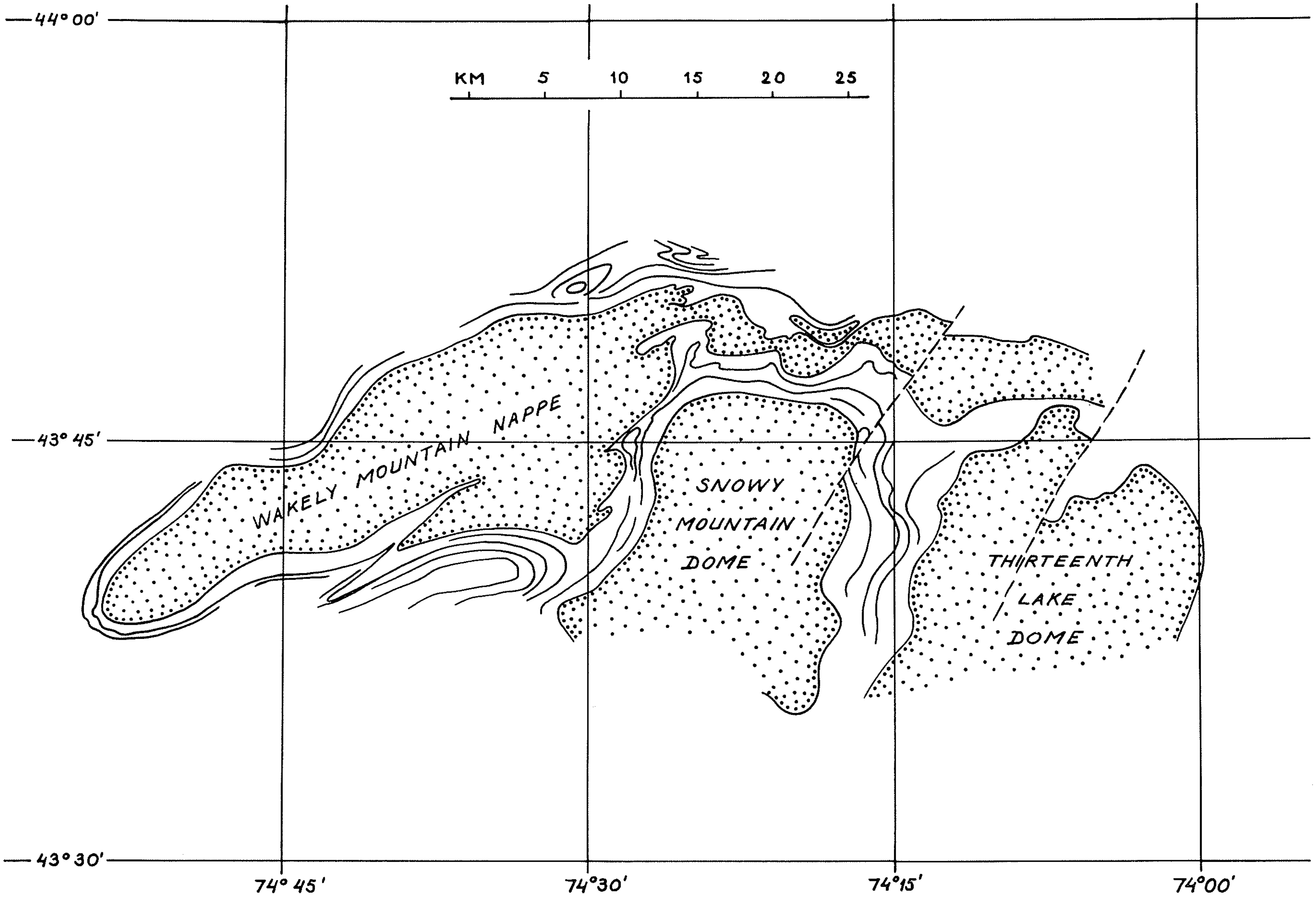


Fig. 3. Basement-supracrustal relationship in the south-central Adirondack highlands. Anticlinal cores (stippled) of basement rocks are enveloped in mantles of supracrustal rocks which join in synclinal keels.

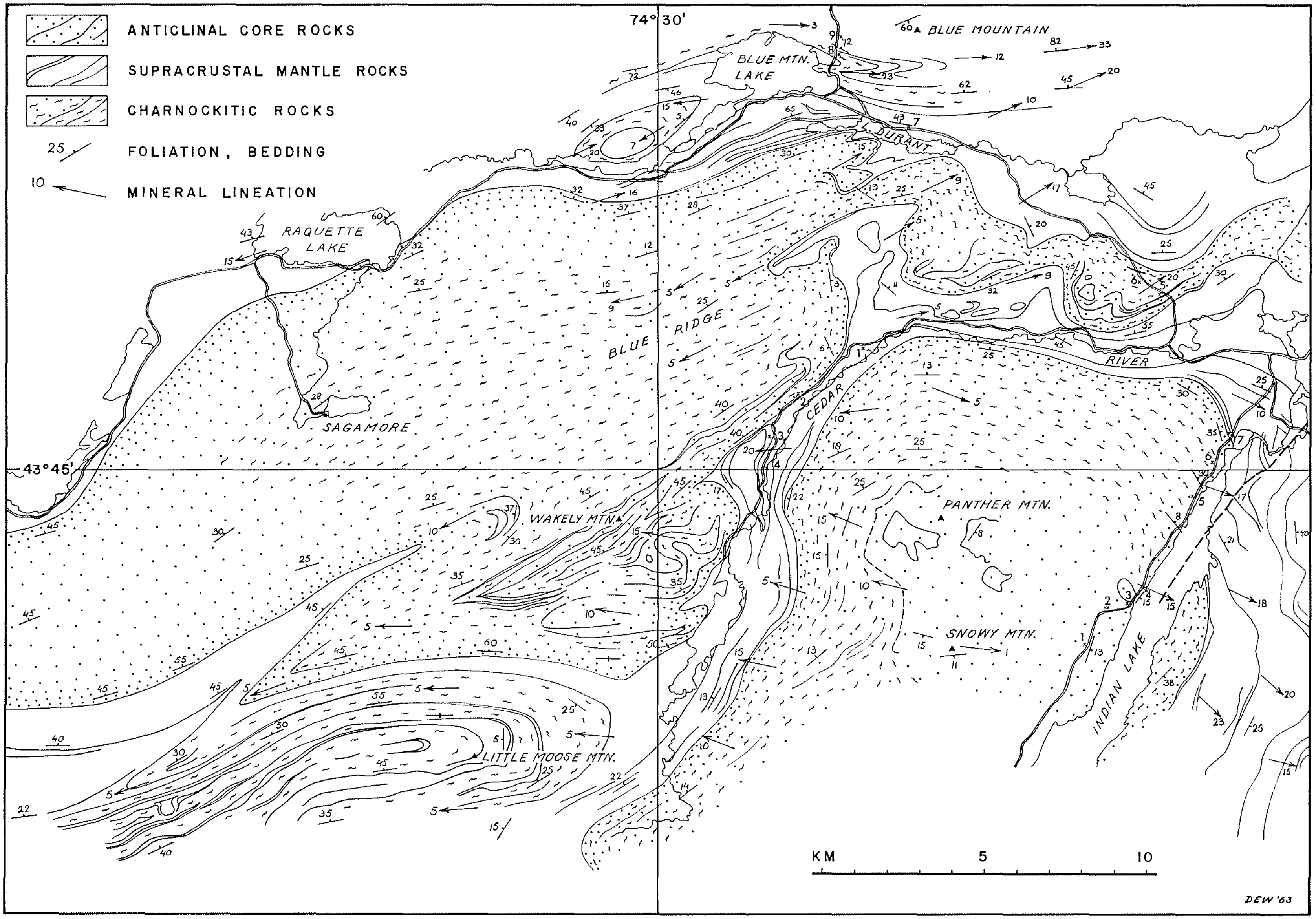


Fig. 4. Tentative geologic map of the Raquette Lake - Blue Mountain Lake - West Canada Lakes - Indian Lake region in the south-central Adirondack highlands. The map shows the major occurrences of charnockites in the basement complex and in the supracrustal sequence.

details the structural pattern of the Pennine nappes in the Swiss Alps. Basement rocks form the cores of anticlinal structures which vary in shape from domes and doubly-plunging anticlines to recumbent anticlines and nappes. The anticlinal cores are enveloped in mantles of supracrustal rocks which join in deeply-wedged synclinal keels. Catazonal environment of tectonics is demonstrated by the plastic behavior of most rock types, in particular of marble, and gneisses of granitic composition. It is further expressed in the folded shape of axial planes of folds and in the strong spatial variation of fold-axis orientations represented by the regional b-lineation pattern.

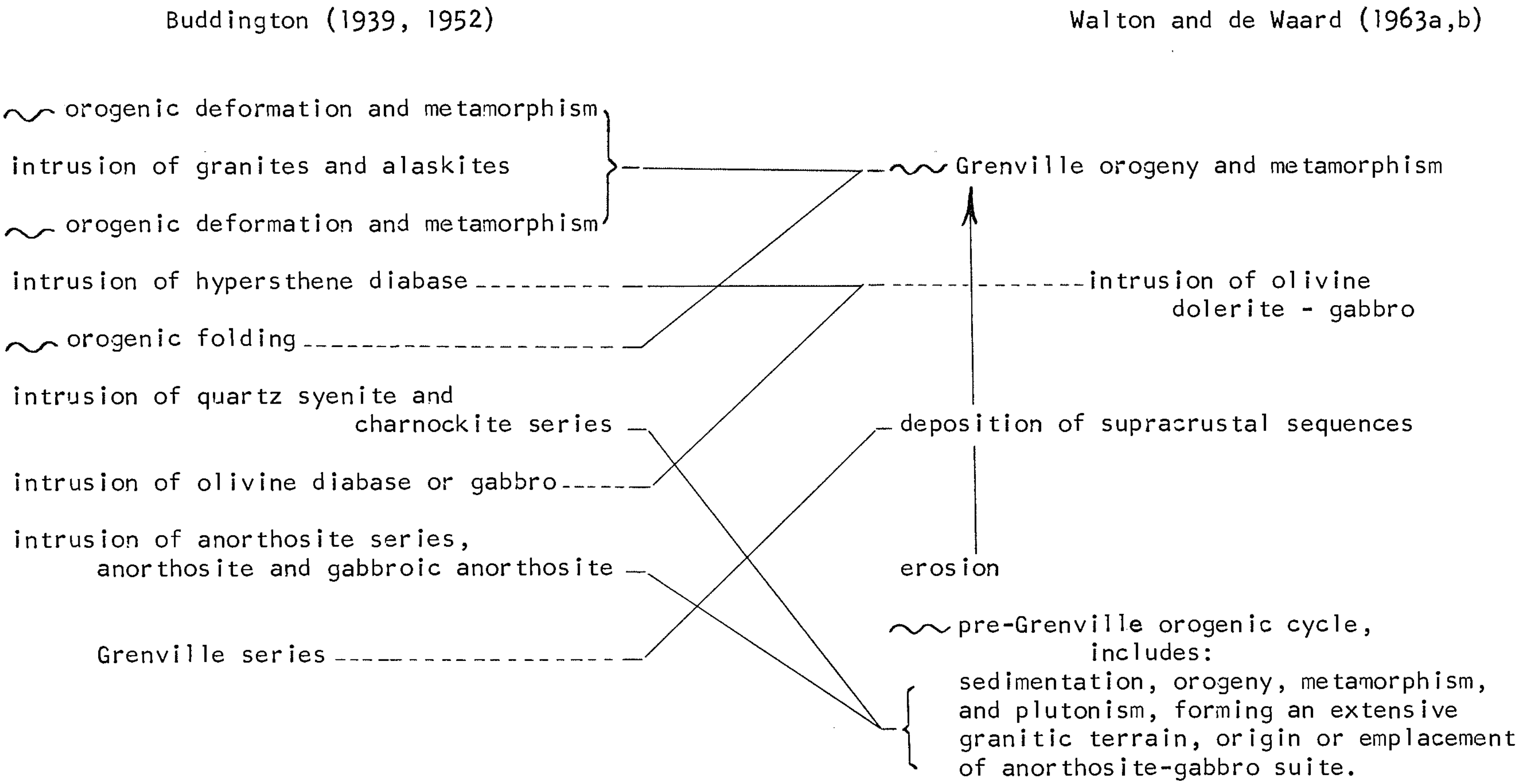
4. In rocks with granitic components migmatites occur as vaguely bordered patches and streaks of commonly unoriented, hypidiomorphic-granular granite surrounded by foliated metamorphic rock. Crocydite and stromatite are the most common migmatites in the Adirondack highlands, followed by dictyonite and nebulite. The granite of the metatect is interpreted to have developed in place or in its immediate vicinity by anatexis. During high-grade metamorphism, granite melt will form in quartz, K-feldspar, and plagioclase-bearing rocks if water is present. Small amounts of melt may have been generated throughout the rock as an intergranular film which increased the structural mobility of the rock unit during deformation. Migmatites developed by partial melting of rock of granitic composition and by migration of melt to structurally controlled sites. Dilatant sites were formed during deformation in rock units which reacted more rigidly than surrounding rocks. Anatectic melt was derived from the neighboring rock and moved into fissures of the rigid rock unit, there to form apophyses which have given rise to misinterpretation of age relations between the two rocks. The amount of metatect present in metamorphic rocks of granitic composition indicates that sufficient water was present to melt up to about 5 per cent of the rock. Granitic magmatism during the Grenville orogeny was thus limited to these venitic migmatites and to apophyses, pegmatite dikes, and some small, locally mobilized, granitic bodies. Predominantly dry conditions, apparently, prevented large-scale anatexis in the Adirondack highlands.

GEOLOGIC EVOLUTION

During the Grenville orogenic cycle, approximately 1.1 b.y. ago, supracrustal and basement rocks were metamorphosed and deformed to a complex structure of mantled domes, folds, and nappes. The basement was formed during an earlier, pre-Grenville orogenic cycle, and presumably consisted of metamorphic and plutonic rocks, the nature and origin of which are now largely obscure. Supracrustal rocks were deposited on the denudated surface of this older terrane. Basement and supracrustal rocks were intruded by olivine-basaltic magma which consolidated as gabbro and ophitic dolerite in sills and lenticular bodies. All rocks were affected by high-grade metamorphism during the Grenville period.

Evidence is lacking for the origin of gneisses and charnockites which occur interlayered with metasediments in the supracrustal sequence. Conglomerates, arkoses, and acidic volcanics may all conceivably be metamorphosed to foliated rocks of granitic composition. Conditions during metamorphism varied to the extent that most of the granitic rocks of the basement and part of those in the supracrustal sequence were metamorphosed to charnockites while others became hornblende or biotite gneisses. Metamorphic conditions also controlled the extent of magmatism during the Grenville orogeny. The occurrence of anatectic granite is limited to some small, nebulite-bordered granite bodies, and to the presence of venitic migmatites in metamorphosed rocks of granitic composition.

The present sequence of geologic events as compared with the concept of previous investigators is shown in table 1.



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 (1963a,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.

CHARNOCKITES AND CHARNOCKITIZATION IN THE CENTRAL ADIRONDACKS

Charnockites are widespread in the Adirondack highlands. They were formed during high-grade metamorphism from pre-existing quartzofeldspathic rocks of diverse origin. In part they developed from rocks of a supracrustal sequence, and in part from rocks belonging to an underlying basement complex which originated during a cycle of diastrophism, metamorphism, and plutonism, previous to the Grenville orogenic cycle.

Charnockites are confined to portions of the basement complex and to certain layers in the supracrustal sequence. Their occurrence is explained as having been formed from initially dry, pre-existing rocks of granitic composition, i.e., from crystalline rocks with sparse amounts of hydrous minerals. Charnockites in the basement complex may have developed from metamorphic and plutonic igneous rocks, and those in the supracrustal sequence from acidic volcanics.

Charnockitization is a metamorphic process. P_{load}-T conditions were above the alkali feldspar solvus maximum, above the curve for the reaction: garnet + sillimanite + quartz $\leftrightarrow$ cordierite, and below the kyanite $\leftrightarrow$ sillimanite inversion curve. P_{water} varied from place to place to form orthopyroxene in charnockitic rock units but not in biotitic and hornblendic gneiss units.

Mineral assemblages in the investigated area are predominantly those of the hornblende-granulite subfacies. In certain rock units and in layers within rock units assemblages occur which are characteristic for the sillimanite-almandine-orthoclase subfacies or for the pyroxene-granulite subfacies. Hornblende and biotite, which are common additional phases in the Adirondack charnockites, are regarded to be stable in the hornblende-granulite subfacies. Equilibrium between coexisting hydrous and anhydrous ferromagnesian phases is considered to be controlled by Mg/Fe ratios, and to be dependent upon the bulk composition of the rock, water pressure, and temperature. The difference in metamorphic facies between charnockitic and gneissic rock units is explained as the result of a difference in water pressure which reflects a difference in initial water content between these rock units.

ANORTHOSITE-CHARNOCKITE RELATIONSHIPS

Relationships between anorthosites and charnockites can be observed in the anticlinal core rocks of Snowy Mountain dome. Coarse, bluish-gray, crystalloclastic, andesine anorthosite at the center of the dome resembles the Marcy anorthosite of the eastern Adirondacks. Near the borders of the anorthosite the size of large crystals diminished locally until the rock becomes a granulated mass of plagioclase similar to the Whiteface anorthosite. In the contact zone between the anorthosite and the overlying metanorite the two rock types intermingle in an irregular, patchy fashion, with each commonly retaining its own lithologic characteristics. Less commonly an intermediate rock type with the texture of the anorthosite and the composition of the norite is found.

The metanorite is distinguished from the underlying anorthosite by its smaller grain size and higher mafic content. Metanorite with well-preserved palimpsest texture grades outward into well-foliated andesine augen gneiss and ultimately into homogeneous, streaky gneiss (fig. 5).

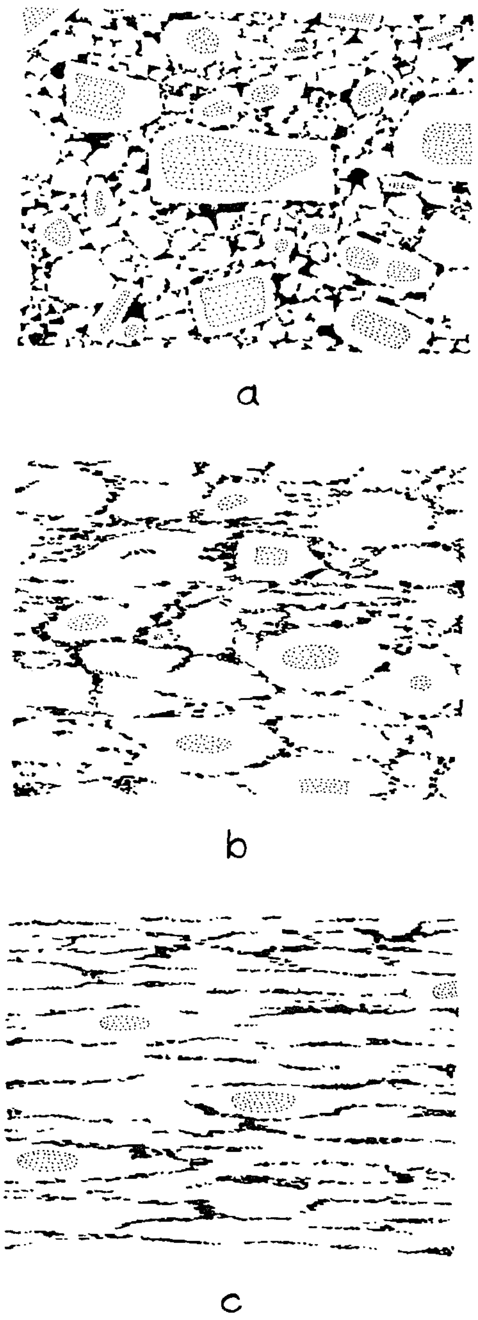


Fig. 5. Three stages in the gradual transition from (a) palimpsest texture of metanorite, to (b) weakly foliated metanorite, and to (c) well-foliated andesine augen gneiss or Keene gneiss. Andesine cores and augen are shown in stippled pattern. Approximately natural size. (From de Waard & Romey, 1963)

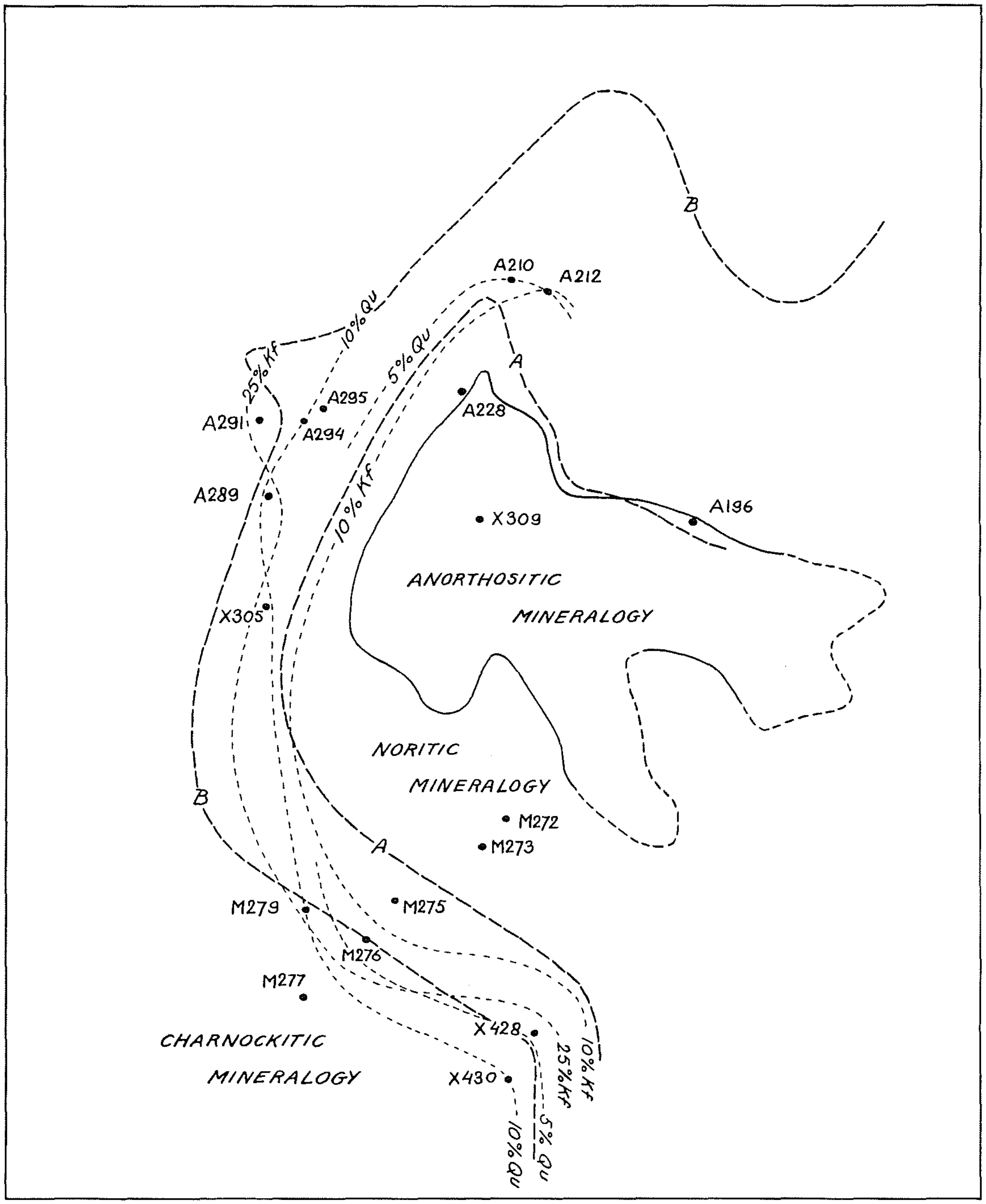


Fig. 6. Textural and compositional boundaries and gradations in the central part of Snowy Mountain dome. Arbitrary textural lines from center outward: (A) indicates the approximate location of the transition from deformed blastonoritic texture to augen-gneiss texture; (B) indicates the approximate zone in which the number of andesine augen decreases to less than one per square meter. Compositional boundaries and isopleths: solid line indicates the boundary zone between anorthosite and metanorite; dashed lines are the isopleths of 10 and 25 per cent modal K feldspar, and 5 and 10 per cent modal quartz. The intersection of structural line A with the anorthosite-metanorite boundary zone reflects the occurrence of the finer-grained and foliated Whiteface-type anorthosite developed along this part of the boundary. (From de Waard & Romey, 1963).

Concomitant with the textural transition from norite to augen gneiss and streaky gneiss, which appears to be entirely due to a gradual increase in intensity of deformation during the metamorphism of the norite, subtle changes in mineralogy also occur. While the foliation increases and the andesine augen decrease in size and number, K feldspar and quartz become noticeably present, and the gray-green, streaky gneiss which appears to be the final product in this process is in effect a quartz and orthopyroxene-bearing microperthite gneiss or charnockite.

Recrystallization, granulation, and foliation of the anorthosite and norite occurred during the Grenville period of metamorphism and deformation. The degree of metamorphism was in the granulite facies. Recrystallization was incomplete as shown by the presence of large andesine crystals and relic pyroxenes in both the anorthosite and the norite. The anorthosite behaved as a relatively rigid body during deformation with shearing and granulation occurring along fairly widely spaced planes. Granulation and recrystallization were more intense near the borders of the massif where the grain size of crystalloclasts diminishes. The metanorite next to the anorthosite had a relatively sheltered position and was consequently little deformed.

Textural gradation from metanorite to andesine augen gneiss and ultimately to charnockite is entirely due to the gradually increasing effect of deformation from the center of the dome outward.

There are two possible explanations for the concomitant mineralogical gradation from metanorite to charnockite: (a) The transition may be primary, caused during the pre-Grenville orogeny, and associated with the development of the anorthosite-norite body. The gradual increase in quartz and K feldspar may have been a factor which made the rock more susceptible to the development of foliation. (b) The transition may be secondary, caused by metasomatism during the development of foliation in the Grenville period of deformation and metamorphism. Replacement increased with the intensity of deformation. Charnockite developed by metasomatism, metamorphism, and deformation from norite. (condensed from de Waard and Romey, 1963).

MINERAL ASSEMBLAGES OF CHARNOCKITES IN THE GRANULITE FACIES

Rocks of the central Adirondack highlands have been metamorphosed predominantly in conditions of the hornblende-granulite subfacies. In the Adirondacks, as well as in other charnockite regions, there are two distinctive features which characterize hornblende-granulite-subfacies terranes, viz., (1) mineral assemblages of the hornblende-granulite subfacies consist of coexisting anhydrous phases of the granulite facies and hydrous phases of the almandine-amphibolite facies in apparent equilibrium with each other, and (2) rock units or rock layers with assemblages of the hornblende-granulite subfacies commonly occur intimately intermingled with those apparently of higher and of lower subfacies. These two related characteristics can be explained as follows.

The hornblende-granulite subfacies represents univariant equilibrium for boundary reactions between the almandine-amphibolite and granulite facies, provided that variable cation ratios in mafic phases remain constant (or divariant equilibrium if systematic changes occur). Mineral assemblages in which reactants and products of those reactions coexist are, therefore, typomorphic for the hornblende-granulite subfacies. Equilibrium between phases on both sides of the boundary reactions may have been maintained over a relatively wide P-T interval because of reciprocity between liberated water and water pressure in rocks of low permeability. Varying cation ratios influence the stability of mafic minerals and affect the P-T conditions of the reactions. Local differences in bulk composition of the rock and in water pressure and temperature may result in departures from the univariant equilibrium to either side of the boundary reactions, and intermingled development may be expected with almandine-amphibolite-facies and with pyroxene-granulite-subfacies assemblages.

The following reactions characterize the transition from the almandine-amphibolite facies to the granulite facies:

(1) hornblende + 4 quartz $\longleftrightarrow$ 3 orthopyroxene + clinopyroxene + albite + anorthite + H_2O

(2) 2 biotite + 12 quartz $\longleftrightarrow$ 8 orthopyroxene + garnet + 4 orthoclase + 4 H_2O

(3) 6 biotite + 8 sillimanite + 28 quartz $\longleftrightarrow$ 11 garnet + 12 orthoclase + 12 H_2O

(4) hornblende + 2 biotite + 17 quartz $\longleftrightarrow$ 15 orthopyroxene + 4 orthoclase + albite + 2 anorthite + 5 H_2O

(5) hornblende + garnet + 5 quartz $\longleftrightarrow$ 7 orthopyroxene + albite + 2 anorthite + H_2O

All but reaction (3) produce orthopyroxene which is the index mineral for the granulite facies. Orthopyroxene forms in a wide range of rock compositions, viz.; in all rocks except for the calcareous and aluminous rocks. The first (prograde) appearance in the field which delineates the orthopyroxene isograd is, therefore, the best possible boundary between almandine-amphibolite and granulite-facies terranes.

The hornblende-granulite subfacies, established by Fyfe, Turner, and Verhoogen (1958) is unique among the metamorphic facies and subfacies in being the only one to have the same reactions define its lower as well as its upper boundary. The left-hand sides of equations (1) to (5) represent stable assemblages in the upper almandine-amphibolite facies (sillimanite-biotite-orthoclase subfacies), and the right-hand sides represent typical anhydrous assemblages of the pyroxene-granulite subfacies. The hornblende-granulite subfacies is thus defined as the range of conditions in which equilibrium exists between the mineral phases on both sides of the reactions.

The tentative ACFK diagram for the hornblende-granulite subfacies, shown in fig. 7, represents a combination of sillimanite-biotite-orthoclase and pyroxene-granulite-subfacies diagrams. The hydrous phases hornblende and biotite, shown with dashed lines in sillimanite-biotite-orthoclase subfacies configuration, are in equilibrium with the anhydrous phases of the pyroxene-granulite subfacies which is represented by full lines.

The following charnockite compositions are typical for the hornblende-granuline subfacies and most of these are widespread in charnockite terranes. The mineral assemblages can also be predicted by applying reactions (1), (2), and (4) to assemblages of rocks similar in bulk composition belonging to the sillimanite-

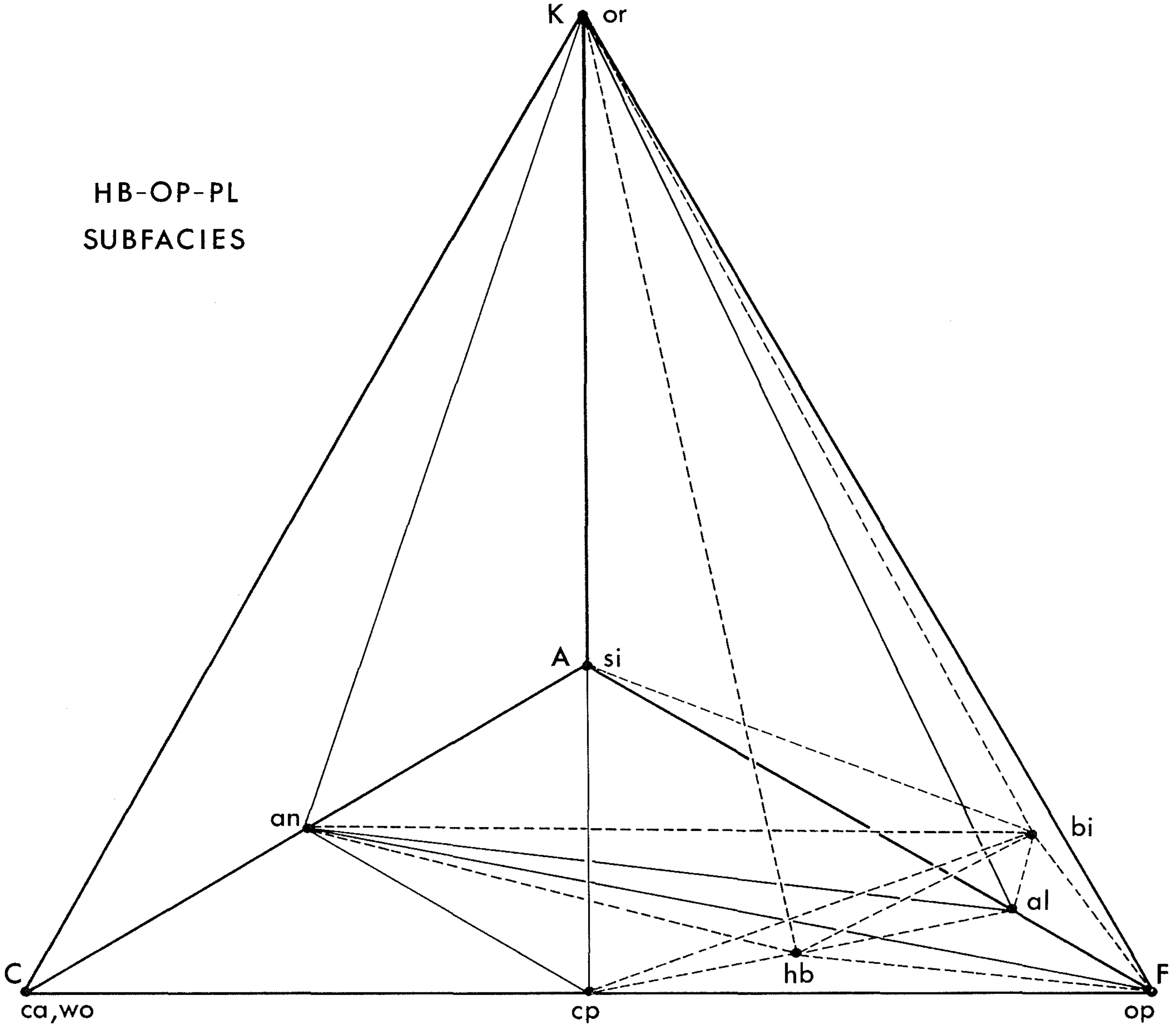


Fig. 7. Tentative ACFK tetrahedron diagram for the hornblende-granulite subfacies (hornblende-orthopyroxene-plagioclase subfacies).

biotite-orthoclase subfacies or the pyroxene-granulite subfacies which are given in the table for comparison.

si-bi-or subfacies	hb-granulite subfacies	py-granulite subfacies
K-feldspar gneisses	charnockites	charnockites or acidic granulites

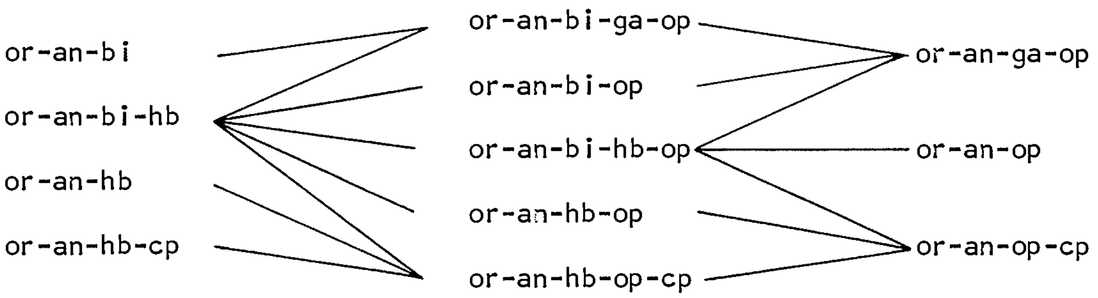


Table 2. Correlation of mineral assemblages of charnockites and chemically similar gneisses and granulites, expressed in phases of ACFK diagrams. The feldspars are commonly combined in perthite, and quartz is always present. The assemblages are listed in order of decreasing alumina and increasing lime content.

With increasing load pressure the following reaction between anhydrous phases of the granulite facies is expected to proceed to the right:

(6) 6 orthopyroxene + 2 anorthite ⟷ clinopyroxene + 2 almandine + 2 quartz

The local occurrence in the central Adirondack highlands of charnockites and metabasites in which the pair orthopyroxene - plagioclase is partly or entirely replaced by the pair clinopyroxene - (calcic) almandine suggests a possible subdivision of the hornblende-granulite subfacies into a hornblende-orthopyroxene-plagioclase subfacies and a hornblende-clinopyroxene-almandine subfacies, and a subdivision of the pyroxene-granulite subfacies into an orthopyroxene-plagioclase subfacies and a clinopyroxene-almandine subfacies. In the following table a correlation is given of mineral assemblages of charnockites in the two hornblende-granulite subfacies.

op-pl subfacies	hb-op-pl subfacies	hb-cp-al subfacies	cp-al subfacies
charnockites or acidic granulites	charnockites	charnockites	charnockites or acidic granulites

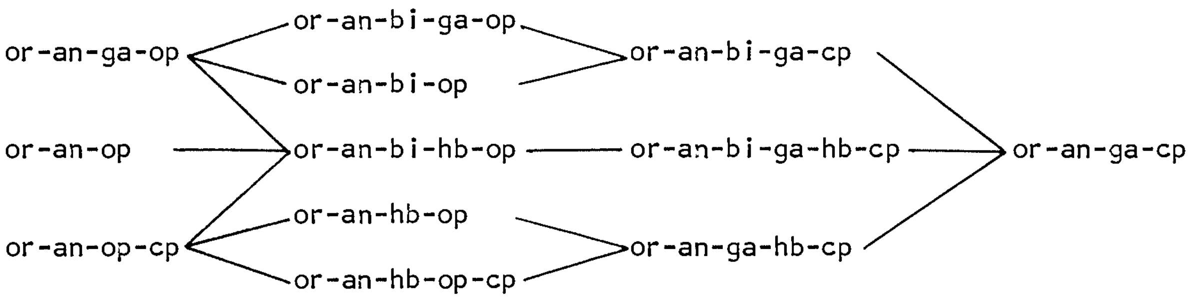


Table 3. Complete list of possible mineral assemblages of charnockites expressed in phases of ACFK diagrams (quartz always present and perthitic feldspar common) in order of decreasing alumina and increasing lime content.

BIBLIOGRAPHY

Buddington, A. F.: Adirondack igneous rocks and their metamorphism. Geol. Soc. America Mem., 7, 1939, 354 p.

______________: Chemical petrology of some metamorphosed Adirondack gabbroic, syenitic and quartz syenitic rocks. Am. Jour. Sci., Bowen volume 1, 1952, 37-84.

______________: Isograds and the role of H_2O in metamorphic facies of orthogneisses of the northwest Adirondack area, New York. Geol. Soc. America Bull., 74, 1963, 1155-1182.

de Waard, D.: Tectonics of a metagabbro laccolith in the Adirondack Mts., and its significance in determining top and bottom of a metamorphic series. Proc. Kon. Ned. Akad. Wetensch., Amsterdam, B, 64, 1961, 335-342.

______________: Structure and composition of the Little Moose Mountain syncline in the southwestern Adirondack Mountains, New York (Abstract). Geol. Soc. America Spec. Paper, 68, 1962(a), p. 162.

______________: Structural analysis of a Precambrian fold: The Little Moose Mountain syncline in the southwestern Adirondacks. Proc. Kon. Ned. Akad. Wetensch., Amsterdam, B, 65, 1962(b), 404-417.

______________: Precambrian recumbent folding and geologic development in the southwestern Adirondack Mountains (Abstract). Geol. Soc. America Spec. Paper, 73, 1963, p. 138.

______________: Metamorphic grade of the Adirondack highlands: The sillimanite-mangerite subfacies (Abstract). Geol. Soc. America Spec. Paper, 1964.

______________: Garnet development and garnet isograds in the granulite facies terrane of the Adirondack highlands (Abstract). Am. Geophys. Union Trans., 45, 1964.

de Waard, D. & Romey, W. D.: Boundary relationships of the Snowy Mountain Anorthosite in the Adirondack Mountains. Proc. Kon. Ned. Akad. Wetensch., Amsterdam, B, 66, 1963, 251-264.

Fyfe, W. S., Turner, F. J., & Verhoogen, J.: Metamorphic reactions and metamorphic facies. Geol. Soc. America Mem., 73, 1958, 259 p.

Geologic Map of New York, New York State Mus. & Sci. Serv., Geol. Surv. Map & Chart Ser., 5, 1962 (Adirondack Precambrian compiled by Y. W. Isachsen).

Krieger, M. H.: Geology of the Indian Lake quadrangle, New York. U. S. Geol. Survey, unpub. rep., 1951.

Miller, W. J.: Geology of the Blue Mountain, New York, quadrangle. New York State Mus. Bull., 192, 1917, 68 p.

Rogers, C. L.: Geology of the Raquette Lake quadrangle, New York. Unpub. rep., 1941.

Romey, W. D. & de Waard, D.: Evolution of anorthosite and associated rock suite in the Snowy Mountain dome, Adirondack highlands (Abstract). Geol. Soc. America Spec. Paper, 1964.

Stockwell, C. H.: A tectonic map of the Canadian shield. In: The tectonics of the Canadian shield, Stevenson, J. S., editor, Royal Soc. Canada Spec. Publ., 4, 1962, 6-15.

Tilton, G. R., Davis, G. L., Hart, S. R., & Aldrich, L. T.: The ages of rocks and minerals. Carnegie Inst. Washington Year Book 61, 1962, 173-179.

Walton, M. & de Waard, D.: Orogenic and stratigraphic development of the Precambrian in the Adirondack highlands (Abstract). Geol. Soc. America Spec. Paper, 73, p. 258, 1963(a).

_______________: Orogenic evolution of the Precambrian in the Adirondack highlands, a new synthesis. Proc. Kon. Ned. Akad. Wetensch., Amsterdam, B, 66, 98-106, 1963(b).

TRIP A: Cedar River - Blue Mountain section

On route 28-30, 9.3 miles east of Blue Mountain Lake and 2.1 miles west of Indian Lake village, take Cedar River Road which branches off west of the cemetary to the south.

Mileage

0 Intersection Cedar River Road with route 28-30.

6.7 Stop 1. View towards the southwest from hill opposite Cedar Bend Lodge (ask permission). In the Cedar River valley marble and other supracrustal rocks are exposed which are folded in a synclinal keel wedged in between the Snowy Mountain dome towards the south (left) and the Wakely Mountain nappe towards the west (right). Dip of foliation and bedding in the structure is to the northwest (right), and the fold axis plunges west. Dip slopes of the Snowy Mountain dome are visible towards the south. Gneisses of the Wakely Mountain nappe are exposed in Wakely Mountain, Round Top, and Blue Ridge to the west. Sugarloaf Mountain in the center is the gneissic core of the syncline.

8.5 Stop 2. Ledges in bushes on right are charnockitic gneisses which form the uppermost overturned portion of the core of Wakely Mountain nappe. Stratigraphically overlying amphibolite and marble are exposed in several places along the road.

9.6 Stop 3. Short walk up hill to the right to the first ledges of Sugarloaf Mountain. Traverse across supracrustal strata of diverse composition (marble, amphibolite, layered gneisses, diopsidic quartzite and gneiss, diopsidite) towards the core of the syncline which consists of biotite-(hornblende)-microcline-oligoclase-(pp. mesoperthite)-quartz gneiss.

10.3 Stop 4. Small trail to the left down to the Cedar River. Gorge and falls in marble. Walls demonstrate intense plastic deformation and flow folding in the marble, distortion and rotation of amphibolite pieces. Exposures of amphibolite, quartzite, and sillimanitic garnet-biotite gneiss.

0 Return to the insersection with route 28-30, and turn left towards Blue Mountain Lake.

1.1 Stop 5. On the left, about 30 meters in the bushes, is a small outcrop of amphibolitized metadolerite (sill in charnockitic gneiss of Stop 6). The amphibolite consists of andesine, hornblende, and orthopyroxene. The exposure shows some large garnet porphyroblasts (15 cm diameter) similar to those of the famous Gore Mountain occurrence. PLEASE DON'T SAMPLE THE GARNET HERE. Others may like to see this outcrop after you.

1.5 Stop 6. Road cut on the left shows typical grey-green, hornblende-bearing, perthitic charnockite of the basement core of the Wakely Mountain nappe.

7.6 Stop 7. Large road cut on the north shore of Lake Durant. The section of diverse, layered metamorphic rocks includes pink and greenish leucocratic gneisses with thin metabasic layers, marble, and calc-silicate rocks. The section forms part of the supracrustal sequence which overlies the leptites of the Wakely nappe exposed in the hills visible towards the south across the lake, and which underlies the Blue Mountain charnockite sequence towards the north. Lineations on foliation planes indicate a 30° NE plunging fold axis. The intrusive nature of marble into boudinaged layered gneiss is shown on the west end of the north side of the road cut.

9.3 Intersection of route 28-30 and 28N-30 in Blue Mountain Lake. Turn right towards Long Lake.

10.2 Stop 8. Road cut on the right just downhill from diner, in charnockite of the supracrustal sequence. The grey-green charnockite, interlayered with metabasic rocks and tremolite schist (in the brook), is part of a series of charnockitic rocks which presumably forms an isoclinally folded, complex syncline (Blue Mountain). The charnockite layers, which overlie the marble exposed in the lake and the rocks of stop 7 north of Lake Durant, form part of the supracrustal envelope of the Wakely-Mountain nappe. The Blue Mountain charnockite sequence is considered to be equivalent to the Little Moose Mountain sequence of charnockites. They are stratigraphically the youngest supracrustal rocks known in this area. The composition of the charnockite at this stop is predominantly: quartz-microperthite-oligoclase-hornblende-orthopyroxene-clinopyroxene.

10.5 Stop 9. Large exposure in the brook on the right shows pattern of typical migmatite (crocydite) in quartzofeldspathic metamorphic rocks of the Adirondack highlands. The metatect is anatectically generated granite in hornblende-biotite-quartz microcline microperthite oligoclase gneiss. The gneiss grades into charnockite and belongs to the Blue Mountain charnockite sequence.

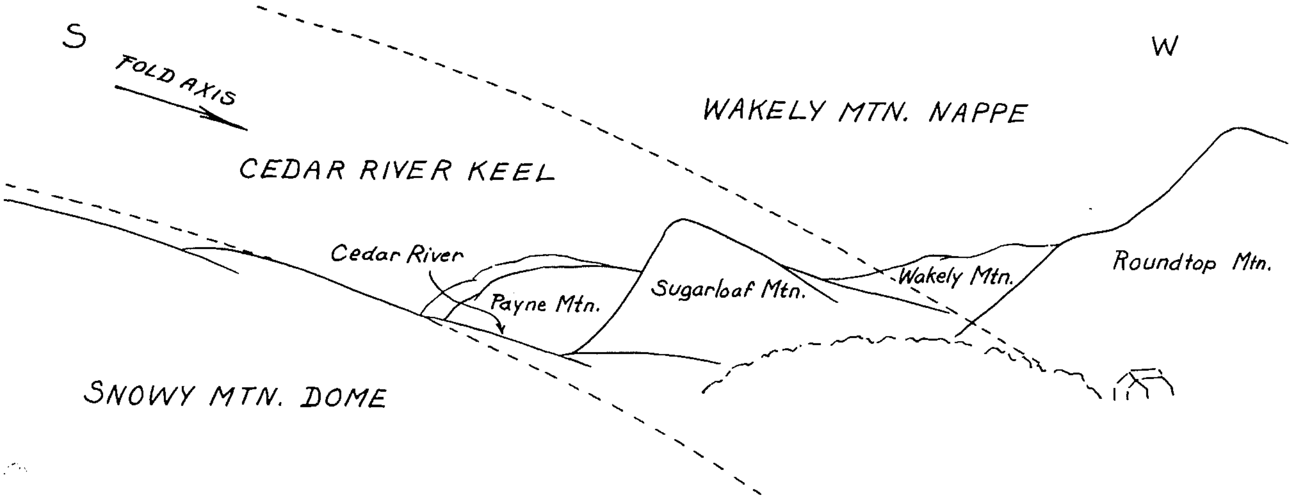


Fig. 8. View from hill at Stop 1 (Cedar River road) towards the southwest. Dashed lines demonstrate the structural relationships. Cores of anticlinal structures are separated by isoclinally folded supracrustal layers of the Cedar River synclinal keel. Note dip slopes of Snowy Mountain dome and Sugarloaf Mountain. Marble layers in the supracrustal sequence caused the Cedar River valley.

TRIP A: Snowy Mountain section (by William D. Romey)

Mileages are measured from the intersection of New York highways 28 and 30 in the center of the town of Indian Lake. Take highway 30 south towards Speculator.

Mileage

0 Intersection of highways 28 and 30 in Indian Lake village.

7.4 Stop 1. Roadcuts 0.1 miles west southwest of trail leading to the top of Snowy Mountain. K feldspar-plagioclase-quartz-andesine-pyroxene-hornblende augen gneiss (charnockitic "Keene"-type gneiss) of the type which is widespread in Snowy Mountain dome. Foliation about horizontal.

6.5 Stop 2. From the highway walk west a few yards along a narrow dirt road to flat outcrops. Andesine-pyroxene-hornblende gneiss with relict ophitic to hypidiomorphic granular texture preserved. Note relict cores of dark gray plagioclase (An_{42}) surrounded by recrystallized plagioclase (approximately An_{34}). Square masses of plagioclase are outlined by partially recrystallized mafic minerals. This rock is similar to some of Buddington's gabbroic anorthosites, but we have preferred to call it a (leuco) metanorite. Foliation dips west southwest at a low angle.

5.9 Stop 3. Large roadcut on the hill 0.4 miles southwest of the intersection of highway 30 with the lake shore road through Sabael. Anorthosite at the lower end of the outcrop is overlain by metanorite (unfoliated andesine-pyroxene-hornblende gneiss) which is in turn overlain by streaky andesine-pyroxene-hornblende augen gneiss. Both "Marcy-" and "Whiteface-" type anorthosites are present. The grain size of metanorites ranges from coarse to fine, and the original texture of the rock is preserved to various degrees in different parts of the exposure. Several small amphibolite (metadolerite) lenses may be observed in the streaky gneiss. Foliation is nearly horizontal. Walk up the steep hillside above the road to see massive ledges of anorthosite, metanorite, and a rock which is texturally and compositionally intermediate between these two types.

5.5 Stop 4. From the intersection of highway 30 with the lake shore road through Sabael walk east about 100 yards on a private road (get permission) leading to a house on a small peninsula. Outcrops are on the lake shore east of the house. Well-foliated K feldspar- plagioclase-quartz-orthopyroxene-clinopyroxene-hornblende gneiss (charnockite). Domal structure of the complex on the east side of Indian Lake can be observed from the point east of the intersection.

3.5 Stop 5. Roadcuts on the main road 0.1 miles northeast of Squaw Brook. Charnockitic augen gneiss similar to the rock seen at stop number 1 (K feldspar-quartz-plagioclase-hornblende-pyroxene-(biotite)-augen gneiss).

2.8 No stop. From the bus observe banded gneisses in roadcut. K feldspar-quartz-plagioclase-amphibole gneiss is interlayered with plagioclase-hornblende-biotite amphibolite.

2.6 Stop 6. Roadcuts consisting of well-foliated, homogeneous, leucocratic charnockite (K feldspar-quartz-plagioclase-pyroxene-hornblende-garnet gneiss). A few amphibolite layers are present. This is the granitic end-member of the "syenite" series of Buddington. This is the last stop in what we have called "anticlinal core rocks".

2.0 Stop 7. Roadcuts consisting of banded microcline-quartz-plagioclase-hornblende-pyroxene gneisses. These are the first clearly supracrustal mantle rocks overlying the anticlinal core rocks. Note intense folding of the gneisses.

Possible extra stops

1.2 Roadcuts of feldspathic gneisses containing large diopside clots. About 0.2 miles west of the road are spectacular exposures of the same gneiss in a newly reopened quarry (get permission to visit).

0 Cross-road in Indian Lake village

0.5 East of Indian Lake village on highway 28 there are flat outcrops of amphibolite and very coarse-grained white marble at the outlet to Adirondack Lake. At times of high water these cannot be easily seen.

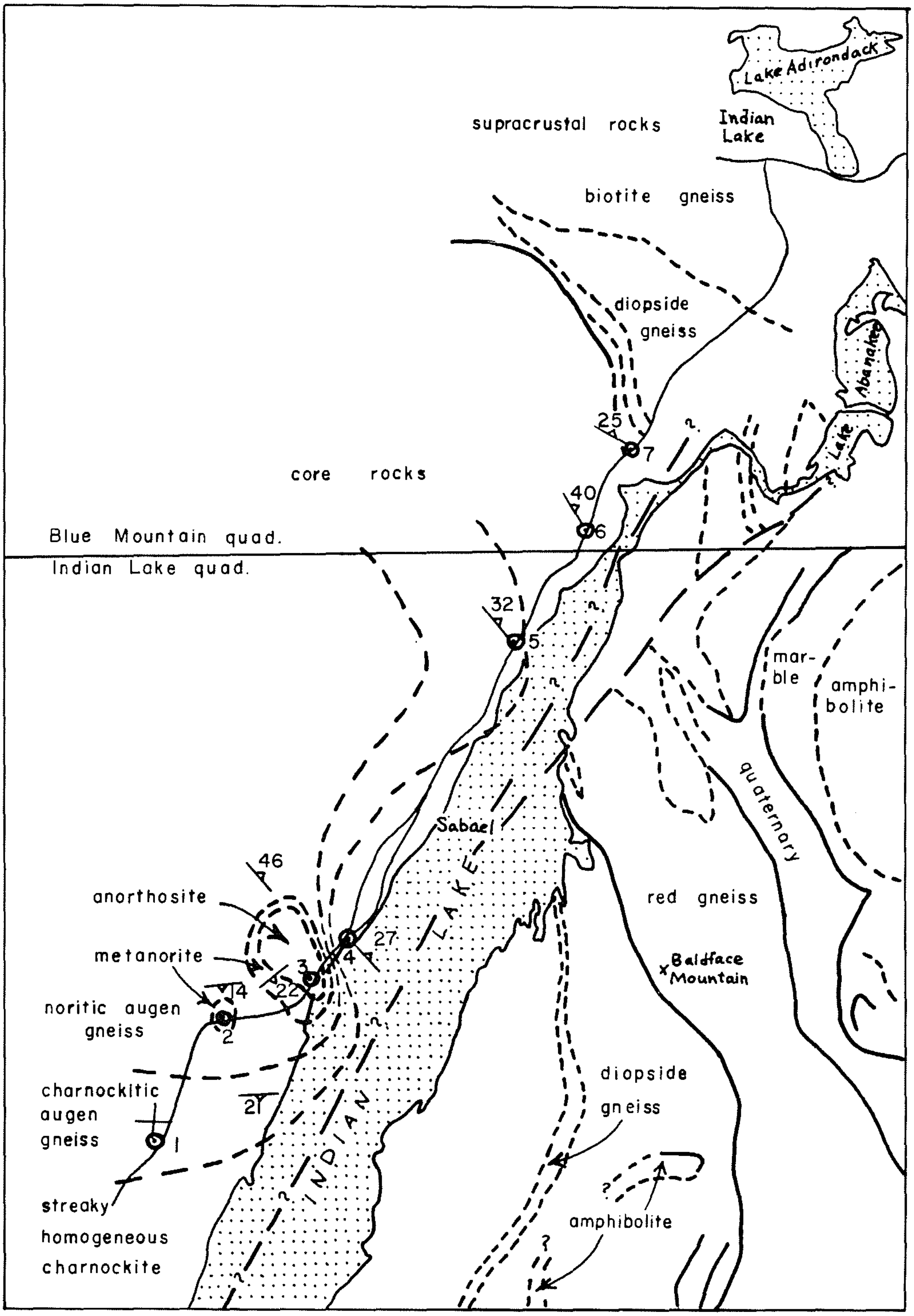


Fig. 9. Geologic sketch map of the northeastern corner of the Indian Lake quadrangle and southeastern corner of the Blue Mountain quadrangle. Data are taken from geologic maps by William D. Romey, Dirk de Waard, and Cole Letteney.

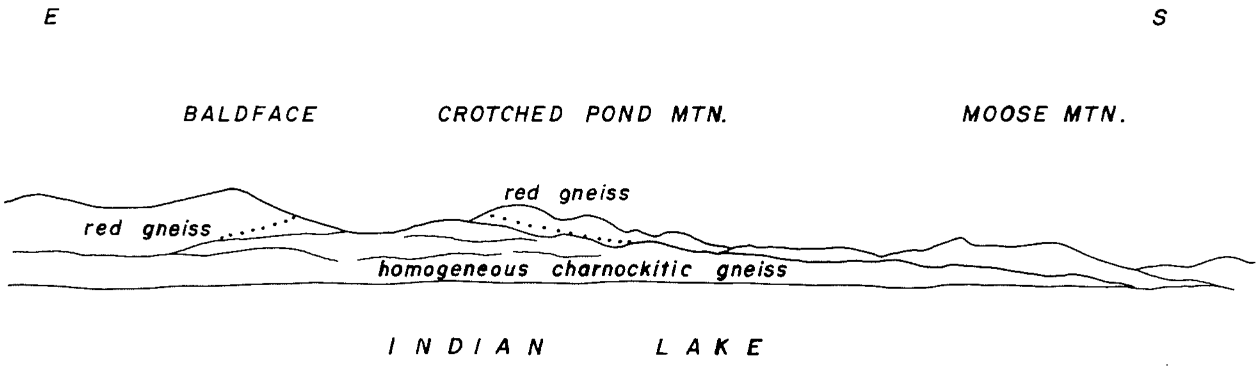
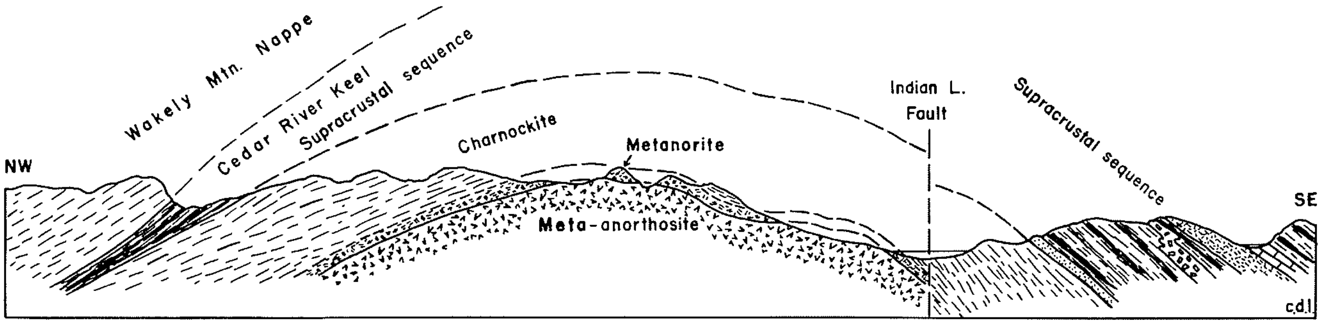


Fig. 10. View east from stop number 4 (Snowy Mountain section) across Indian Lake.



Schematic Section across Snowy Mtn. Mantled Gneiss Dome

Table 4

Approximate Mineral Content of Rocks along the Snowy Mountain Section

Legend: o - less than 5%; x - 5 to 20%; * - more than 20% ;
a - antiperthitic K feldspar in plagioclase

Rock No.	name	pf	kf	qu	hb	cp	op	ga	bi	ore
W117 (stop 2)	metanoritic gneiss	*	a		x	x	x	o		o
W118A	metanorite	*	a				*			o
W118B	metanoritic granulite	*	x		x	x	x			o
W118C	plagioclase granulite	*				o	*		o	o
W119A (stop 3)	meta-anorthosite	*	a		o					o
W119B (stop 3)	metanoritic granulite	*	o	o	x	x		o	o	o
W119C (stop 3)	noritic augen gneiss	*	x	o	x	x	x			o
W120 (stop 4)	charnockite	*	*	o	x	x	x			o
W121	charnockite	*	*	x	o	x	x			
W122	charnockite	*	*	x	x	x	x			o
W123	charnockitic augen gneiss	*	x	x	x	x	x			o
W124 (stop 5)	charnockitic augen gneiss	*	*	x	x		x		o	o
W125	charnockite	*	*	*	x	x	o			o
W126A	K spar gneiss	x	*	*	x					o
W126B	biotite amphibolite	*		o	*	o	o		o	
W127 (stop 6)	leucocratic charnockite	*	*	*	o	o	o	o		o
W128	K spar gneiss	*	*	x	x					o
W129	biotite amphibolite	*			*	o	o		x	
W130 (stop 7)	K spar gneiss	*	*	*	x	o				o