ASYMMETRIC DIFFERENTIATION IN A BATHYLITH OF
ADIRONDACK SYENITE*

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INTRODUCTION

Of late years much evidence has accumulated to the effect that, under deep-seated conditions of igneous intrusion, not only is contact action widespread and on a large scale, but also that rock injection and rock assimilation are equally, or even more, pronounced. During the field work of the special committee on the correlation of the pre-Cambrian rocks of the Adirondack mountains, the original Laurentian area and of eastern Ontario, it was noteworthy that in both areas visited such phenomena were prominently to the fore. This paper deals with one of the specific instances examined by the committee, an asymmetric bathylith of syenite occurring in the mid-Adirondack region, whose

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asymmetry is thought to be owing to incorporation and assimilation of material from the bordering rocks.

GENERAL DESCRIPTION

The syenite rock in question is a common one in the Precambrian area of northern New York, occurring in both large and small masses, in bathyliths and stocks, in dikes and sills. It is a member of the series of great intrusive bodies which invaded the region in pre-Cambrian time, and which solidified far below the surface, and is younger than the Grenville sediments and the Laurentian granite-gneisses of the district. Of the post-Laurentian intrusives it was the second in order of appearance, being younger than the anorthosite. As the above form the bulk of the Precambrian, it follows that the usual contacts of the syenite are those in intrusion. The rock is usually gneissoid, the smaller masses especially being thoroughly so, and so stretched and interleaved with other gneisses that the relations are much disguised. The especial mass under consideration is one of the most extensive, is adjoined by and shows contacts against two of the three great groups of older rocks, and the metamorphism is not sufficiently pronounced to obscure its relations to them. It therefore furnishes a very satisfactory sample for the study of these relations. Its main disadvantage is that it lies in a forested region, in which outcrops are not as abundant nor as satisfactory as could be wished and in which getting about is slow and laborious work.

This bathylith is situated near the central part of the woods, in the district centering about Big Tupper lake, and its main portion lies within the limits of the Long Lake topographic sheet, though running well into the Tupper Lake quadrangle, next west. It is of rudely elliptical shape, with a minor axis of about 8 and a major axis of from 12 to 15 miles; hence with an area of some 75 square miles as cut by the present erosion surface. On the north and east it is adjoined by anorthosite and on the south and west by Laurentian granite-gneiss containing much included amphibolite. Against both these it shows irruptive contacts, it incloses numerous fragments of them, and it sends out abundant dikes into them.

THE NORMAL SYENITE

When fresh this is a green to grayish green rock, which experiences rapid color change upon exposure to the air, becoming first a deeper green, then more slowly passing to a yellow brown, and finally to a deeper rusty brown.* The color change does not at all affect the freshness of the rock as seen in thin-section.

* R. A. Daly: Bull. no. 209, U. S. Geological Survey, pp. 51-53.

The rock is a feldspathic one, averaging 75 per cent of this mineral, which is chiefly microperthite, although a small amount of oligoclase is always present in addition. Pyroxenes are next in importance, both augite and bronzite (or hypersthene) being present and exhibiting characteristic intergrowths. Quartz and magnetite are always present, hornblende often, and zircon, apatite, biotite, titanite, garnet, pyrite, and allanite are more or less frequent accessories. The rock is essentially a feldspar-pyroxene combination, with accessory quartz and magnetite, the feldspar being orthoclase in part and plagioclase (albite to oligoclase) in part, in perthitic intergrowth.

It is mostly a quite even grained rock, having been rather thoroughly granulated during a time of general metamorphism in the region during the Precambrian. Occasional small feldspar augen remain nearly everywhere and in some areas become much coarser and more numerous. Though crushed, the normal rock is not especially foliated, owing to its mineralogy. In its general aspect it seems much more metamorphosed than does the older anorthosite, and this is thought to be due to an original finer grain and lack of the huge porphyritic crystals which characterize the anorthosite.

THE BASIC SYENITE

When followed from place to place the syenite proves to be a quite variable rock, becoming both more basic and more acidic than the normal. Both are peripheral changes in the main, though both occur locally within the general mass. The greater basicity is produced simply by increase in the amount of ferro-magnesian minerals, with corresponding decrease in the feldspar and quartz, the extreme phase being a dark colored, heavy, gabbroic looking rock in which the dark minerals substantially equal the feldspar in amount, though it still remains a microperthite-pyroxene rock. The plagioclase constituent of the microperthite is slightly more basic than in the normal rock, but only slightly. Some hornblende is usually present and garnet often appears, occurring as a corrosion rim between magnetite and feldspar, quite as it does in the gabbros, though less abundantly. Quartz practically disappears in the most basic phases, feldspar augen are seldom seen, and the rock is much more distinctly foliated than is the normal variety.

While there are occasional masses of more basic rock within the normal syenite area, the bulk of it is a border development along the contact with the anorthosite, and to a lesser extent when in contact with the calcareous sediments of the Grenville. Where the border rock is the Laurentian granite gneiss, the syenite becomes more acid rather than

more basic. In this respect it contrasts sharply with the neighboring anorthosite, this latter rock showing everywhere a broad, more basic border, with a slow gradation from anorthosite into anorthosite-gabbro, which in its turn passes into a heavy, basic gabbro at the extreme border, apparently a normal and uniform differentiation border, largely independent of the character of the adjoining rock.

THE GRANITIC SYENITE

Since the normal syenite is a fairly acid rock, its acid phases do not depart as widely from the type as do the more basic ones. It becomes more acid by increase in quartz and by the plagioclase becoming more albitic. At the same time hornblende tends to replace pyroxene, the feldspar becomes red instead of green, and the quartz tends to take on the lens or spindle form. All intermediate gradations are found between the normal green syenite and the red hornblende granite, both in composition and in color. The granite is normally of coarser grain than the syenite.

This acid variety is also a border phase of the syenite and occurs at the south and west sides of the bathylith, where the adjoining rocks are granitic gneisses involved with amphibolites, of supposed Laurentian age. The apparent great breadth of this acid border as seen on the map is more apparent than real. There is a great amount of a later granite which cuts the syenite here which can be separately mapped only in part, and there is also a considerable amount of a red syenite which differs somewhat from the other and may be a separate intrusion. This also could not be separately mapped. Could these two be excluded, the area of the certain acid syenite would be greatly diminished.

BORDER RELATIONS BETWEEN THE SYENITE AND THE GRANITE-GNEISS

These are by no means as clear as could be wished. Both sets of rocks are cut by dikes and larger masses of a later granite which is exceedingly like some phases of the granite-gneiss and also not unlike the granitic syenite. The discrimination of the three rocks is difficult at best and frequently is an impossible matter. No certain inclusions of the granite-gneiss have been found in the syenite, and none of the granite dikes found cutting the granite-gneiss have been definitely shown to be dikes of the granitic syenite. They may all be dikes of the later granite. There are some larger masses of the syenite which cut the granite-gneiss, and they are all of rather acid type and become more acid at their borders; yet they are of the green syenite type rather than the red

granitic syenite type. This may well be because the one type is easy of recognition and the other not easy to distinguish from the other granite types, except where it can plainly be traced into the syenite by imperceptible gradations. The areal mapping, however, brings out clearly the asymmetric differentiation of the syenite and the limitation of the granitic syenite to the granite-gneiss border. The granite-gneiss is confidently believed to be the older rock, from evidence seen elsewhere in the region and because this older granite-gneiss is characterized by its associated amphibolite inclusions, which are also abundant here. So the utmost confidence is felt in the associations here urged, even though it is appreciated that they fall short of demonstration.

BORDER RELATIONS BETWEEN THE SYENITE AND ANORTHOSITE

Inspection of the geologic map shows that in two localities along the border between these two rocks the syenite has so cut its way into the anorthosite as to cause the disappearance of the entire gabbro border of the latter. The most notable instance is that of the great tongue of syenite which extends eastward from Follensby pond to the Raquette river. North and south of this tongue the gabbro border has a breadth of a mile or more, while east of the tongue there is little sign of it. The tongue is full of inclusions of gabbro and anorthosite gabbro, many of large size, and in the near vicinity of these the syenite becomes much more basic, in precisely the same fashion as it does along the entire border, and in considering the origin of the basic phase these basic fringes around the inclusions are held to have much significance. The syenite here has either cut away or wedged apart the gabbro, and again the inclusions are thought to be helpful in determining which of the two has been done.

The second area of the sort is along the northern border of the map. Here the evidence is not so conclusive as to the cutting away of the gabbro border, since the main contact line is obscured by drift; but no gabbro appears anywhere, the exposures nearest the syenite all being of anorthosite gabbro, and this is all shot full of dikes from the syenite, sometimes of large size and of the basic variety of the syenite, while the exposed border of the main syenite mass tends also to the basic type, as it does in fact everywhere along this border. The drift-covered area which conceals the main contact line is most unfortunate, but the rock of the larger dikes is so identical in all respects with that of the adjoining syenite mass, and with that of the great tongue of syenite which cuts into the anorthosite on the north edge of the map, that the age relations

seem well demonstrated, especially when it is considered that we are dealing with the contact between two bathyliths of contrasted eruptive rocks, and that one of them, near the contact, is full of dikes of a rock similar to the other and with dikes of no other kind, while the reverse is not the case, but instead occasional inclusions of anorthosite are found in the syenite.

SOAKED ANORTHOSITE

In the area along the north border of the map, and also farther north on the next map sheet (Saint Regis quadrangle), are a few exposures of a type of a rock which seems most expressively described as anorthosite soaked by syenite. This is the area just noted as lacking the ordinary, non-porphyrific gabbro border, the rock adjacent to the syenite being anorthosite gabbro, in which labradorite augen always occur, often plentifully. In the soaked rock these augen are present, and in so far the rock is distinctly anorthosite; but the matrix is distinctly of the syenite type, having the characteristic green color of that rock and with micropertthite as the prevailing feldspar; yet the proportion of plagioclase is larger than in the usual syenite. Chemically also the rock is of an intermediate type. It is an impossible matter to tell how much of the granular portion of the rock is of syenite derivation and how much came from the anorthosite, since in both rocks much of the granulated feldspar is unmarked, showing neither twinning nor intergrowths.

The ferro-magnesian minerals also are very like in both rocks. It is probably for this reason that the existence of soaked rocks along the contact of the syenite and the gabbro border has not been demonstrated. Both are fine grained and lack augen and resemble one another so much that soaked rocks would defy recognition.

It is, however, suggestive that, whereas usually there is little difficulty in discriminating between the gabbro and the basic syenite in the field, in frequent cases rocks are found which defy classification and which may well be soaked rocks. The matter is much simplified so soon as labradorite augen are present, and in the rock under consideration there seems no question but that the augen are of anorthosite derivation, and that a respectable amount of the granular portion is syenite.

The only outcrop of soaked rock seen from which material fresh enough to repay careful study could be obtained is in a rock cut by the railway nearly 5 miles north of Tupper Lake Junction, and hence beyond the map limits. The rock has numerous dark blue feldspar augen, easily proved to be labradorite by the specific gravity and by the extinction angles shown on cleavage pieces. The remainder of the rock

resembles syenite more than anorthosite, and in thin-section the half of the feldspar that shows structures is about equally divided between microperthite and plagioclase (oligoclase to andesine). Chemically also the rock is an intermediate one, as will shortly be shown. The rock is regarded as an anorthosite gabbro which has been penetrated and broken up by syenite which has forced its way between all the granules of the original rock, in precisely the same way that the Laurentian granite-gneisses of the region have invaded and soaked the older amphibolites, separating every grain from its neighbor and inclosing it with a film of granite. Such granite-soaked amphibolites pass over by imperceptible stages into gray gneisses, intermediate rocks which seem to have resulted from the complete assimilation of the one rock by the other. In like manner this soaked anorthosite gabbro is regarded as representing the preliminary stage in the process which, when carried to completion, has produced the basic border of the syenite by its complete digestion of material from the gabbro.

THE ANORTHOSITE OUTLIER IN LITCHFIELD PARK

Inspection of the map will show this outlier a half mile northeast of Jenkins pond, near the western edge of the map. It is entirely inclosed by syenite. The ordinary syenite of the vicinity is of the granitic type, but as the anorthosite is approached this grades into the basic type, which forms a zone around the anorthosite and sends dikes into it, the numerous exposures on the hill summit showing the relations clearly. We have here, then, a large inclosure of anorthosite in granitic syenite, which latter rock passes into basic syenite as the anorthosite is neared. It is not the most basic type of the rock, but distinctly more so than the normal.

RELATIONS OF THE SYENITE TO THE GRENVILLE

There is no doubt that the syenite is a much younger rock than the Grenville sediments, but there is much doubt as to the structural relations which obtain between it and the Grenville belt which runs south from Follensby pond and which cleaves the syenite instead of bordering it. No inclusions of undoubted Grenville rocks have been seen in the syenite, nor does the syenite vary in character as the Grenville is neared, except that the acid syenite changes back to the normal variety. Within the Grenville area are occasional small knobs of syenite, which likely represent little offshoots from the main mass which cut the sediments, though lack of contacts prevents any certainty in the matter. There is much in

the field relations to suggest that the Grenville here lies in a downfaulted trough in the syenite, is underlaid by syenite in depth, with the small syenite knobs representing dikes running upward from this underlying mass, and that the contacts with the syenite are therefore fault contacts. If this be true, they have no significance bearing on the general purpose of this paper.

SUMMARY OF FIELD RELATIONS

The Tupper syenite batholith is in contact with a gabbro on two sides and with granite-gneiss on the other two. The gabbro is a basic differentiation border of anorthosite. The gabbro is a much more basic, the granite a somewhat more acid rock than the syenite. The syenite grades into a much more basic phase as the anorthosite is neared, but becomes somewhat more acid near the granite. Its contacts with both rocks are those of a later intrusive.

Along its contact with the gabbro it seems locally to have cut away the entire gabbro border from the anorthosite. It holds frequent large inclusions of anorthosite gabbro, around which it becomes more basic. Anorthosite gabbro soaked by syenite is found. Rocks are also found which are so distinctly intermediate between the gabbro and the basic syenite that they defy classification as either the one or the other. Around a large inclusion of anorthosite gabbro in the granitic syenite a fringe of basic syenite has developed.

These relations are readily explained on the assumption that there has been actual incorporation and digestion of material from the surrounding rocks by the syenite, and that the digestion has mainly been a border phenomenon. Nothing that was observed is antagonistic to such an explanation. No other solution that will at all account for the observed relations suggests itself. It is therefore an instance which needs to be taken into account when the general question of the possibility of such assimilation taking place is under consideration.

CHEMICAL EVIDENCE

It has been frequently and cogently urged that, in case one rock had been assimilated by another, the resultant rock should have a distinctly intermediate composition. It is no part of the purpose of this paper to consider the validity of this point. For purposes of argument it is granted, and it remains to be seen whether it has any antagonistic bearing in this specific instance.

LEGEND

- Morainic Deposits concealing underlying formations
- Sands deposited from glacial streams
- Igneous rocks
- Diabase dikes
- Gabbro (hyperite) usually with amphibolite border
- Red Morris granite
- Red to green quartzose syenite, forming a granitic phase—Simons syenite
- Green to gray syenite, usually augite syenite; mostly very feldspathic; Tupper syenite
- Basic border phase of syenite, and grading into it
- Anorthosite, with some patches of anorthosite-gabbro
- Gabbro border of anorthosite, which grades into it
- Doubtful rocks
- Red, gray and black gneisses, mostly igneous and of granitic, syenitic or gabbroic composition, and of uncertain age
- Sedimentary rocks
- Grenville series
- Crystalline limestones, quartz gneisses, graphitic and garnetiferous gneisses, mingled with igneous gneisses
- Strike and dip of foliation
- Glacial striae
- Actual limestone outcrops seen

PLEISTOCENE ROCKS

LATE SERIES

EARLY SERIES

PRECAMBRIAN ROCKS

Contour interval 20 feet.
Datum is mean sea level.

GEOLOGY OF LONG LAKE QUADRANGLE, NEW YORK
Reproduced by the courtesy of the New York State Museum

Geology by H. P. Cushing
1902-1904

The rocks concerned are all igneous and the syenite and anorthosite seem surely derivatives from the same parent magma and of no great difference in age; hence they present no striking differences in composition. The granite-gneisses are in all probability of much greater age and from a different magma, but are nevertheless related igneous rocks and have a composition quite like that of the granites which did arise from the anorthosite-syenite magma. Because of this close chemical relationship the chemical evidence is likely to be much less positive in character than would be the case were the rocks possessed of more prominent differences in composition.

It is also the case that the rock of the syenite and anorthosite batholiths is so variable that it is an impossible matter at the present time to arrive at any exact notion regarding their average composition.

Furthermore, if the syenite has digested material from the anorthosite the field relations make it clear that the rock mostly concerned is the gabbro border along with a wholly uncertain amount of anorthosite gabbro, and the precise proportions and composition of this mixture is again an uncertain matter.

CHEMICAL ANALYSES AND DISCUSSION

	1	2	3	4	5	6	7	8
SiO ₂	44.77	47.42	51.62	54.47	54.62	54.38	54.10	57.00
Al ₂ O ₃	12.46	17.34	24.45	26.45	26.5	20.53	17.45	16.01
Fe ₂ O ₃	4.63	4.91	1.65	1.3	.75	2.78	4.52	} 10.3
FeO.....	12.99	10.22	5.3	.66	.56	5.5	6.47	
MgO.....	5.34	5.21	1.21	.69	.74	1.99	2.33	1.62
CaO.....	10.2	8.09	9.97	10.8	9.88	5.39	6.17	6.20
Na ₂ O.....	2.47	3.48	3.49	4.37	4.5	5.2	3.81	4.35
K ₂ O.....	.95	1.89	1.27	.92	1.23	3.4	3.06	3.53
H ₂ O.....	.6	1.13	.72	.53	.91	.5	.57	.15
CO ₂	.37							
TiO ₂	5.26	3.6				.09	.19	
P ₂ O ₅	.28	.06	.01			.15	.38	
Cl.....		.21				.03		
F.....						.03	.05	
S.....	.26						.14	
MnO.....	.17	.06	.1			.01	.35	
BaO.....	Trace	.04				.16	.10	
Total.....	100.75	100.01	99.79	100.19	99.7	100.03	100.19	99.16

	9	10	11	12	13	14	15	16
SiO ₂	59.7	61.01	63.45	65.65	66.72	68.5	68.18	69.24
Al ₂ O ₃	19.52	15.36	18.38	16.84	16.15	14.69	16.15	14.85
Fe ₂ O ₃	1.89	2.98	1.09	} 4.01	1.23	1.34	1.26	} 2.62
FeO.....	4.92	7.77	2.89		2.19	3.25	1.00	
MgO.....	.78	.78	.35	.13	.73	.26	.64	.97
CaO.....	3.36	4.05	3.06	2.47	2.3	2.2	2.48	2.1
Na ₂ O.....	5.31	3.68	5.06	5.27	4.36	3.5	4.22	4.3
K ₂ O.....	4.14	3.9	5.15	5.04	5.66	5.9	5.59	4.33
H ₂ O.....	.52	.49	.3	.3	.77	.4		.07
TiO ₂			.07					
P ₂ O ₅						.03	0.1	
Cl.....							0.02	
F.....								
S.....							0.03	
MnO.....	.09	.08	Trace		.07	.1		.45
BaO.....			.13			.05		
Total.....	100.23	100.1	99.73	99.71	100.18	100.22	100.02	99.56

1. Norite, wall rock of titaniferous magnetite deposit, Lincoln pond, Elizabethtown, Essex county, New York. Description by J. F. Kemp, analysis by W. F. Hillebrand, U. S. Geological Survey. 19th Ann. Rept., 1899, part 3, p. 407.

2. Gabbro (hyperite), dike near Nicholville, Hopkinton, Saint Lawrence county, New York. Brief mention by H. P. Cushing. 16th Ann. Rept. New York State Geologist, 1896, p. 22. E. W. Morley, analyst.

3. Anorthosite gabbro, Carnes's quarry, Altona, Clinton county, New York. Description by H. P. Cushing, analysis by E. W. Morley. 19th Ann. Rept. New York State Geologist, p. r58.

4. Anorthosite, summit of Mount Marcy, Keene, Essex county, New York. A. R. Leeds, analyst. 30th Ann. Rept. New York State Museum, p. 92.
 5. Anorthosite, Keene township, Essex county, New York (precise locality not given). A. R. Leeds, analyst. 30th Ann. Rept. New York State Museum.
 6. Anorthosite showing transition to augite syenite, cut by New York Central and Hudson River railroad nearly 5 miles north of Tupper Lake Junction, Altamont, Franklin county, New York. E. W. Morley, analyst. 20th Ann. Rept. New York State Geologist, p. r68.
 7. Basic syenite (andose) from near Raquette Falls, New York. Analysis by E. W. Morley. Bulletin no. 115, New York State Museum, p. 514.
 8. Basic syenite from Natural Bridge, Diana, Lewis county, New York. C. H. Smyth, Jr. Bulletin of the Geological Society of America, vol. 6, p. 274.
 9. Augite syenite (laurvikose), road from Tupper lake to Wawbeek. Bulletin no. 115, New York State Museum, p. 514.
 10. Augite syenite (harzose), by New York Central and Hudson River railroad, $3\frac{1}{2}$ miles north of Tupper Lake Junction. Op. cit., p. 514.
 11. Augite syenite (pulaskose), Loon lake, Franklin county, New York. Bulletin of the Geological Society of America, vol. 10, pp. 177-192.
 12. Augite syenite, near Harrisville, Diana, Lewis county, New York. C. H. Smyth, Jr. Bulletin of the Geological Society of America, vol. 6, pp. 271-274.
 13. Augite syenite (toscanose), Little Falls, Herkimer county, New York. Op. cit., p. 514.
 14. Quartz syenite (toscanose), New York and Ottawa railroad, $2\frac{1}{2}$ miles south of Willis pond, Altamont, Franklin county, New York. Op. cit., p. 514.
 15. Quartz syenite, near south end of Big Tupper lake. Microscopic analysis.
 16. Granitic gneiss, Trembling mountain, Quebec. F. D. Adams. American Journal of Science, July, 1895, p. 67. W. C. Adams, analyst.
- Analyses 9, 10, 11, 13 and 14 by E. W. Morley.

It is to be noted that these analyses are from widely scattered localities, though all of rocks believed to be the equivalents of those under discussion. Only numbers 7, 9, 10, and 15 are from the immediate district. It is thought that the syenite analyses give a good representation of the variation in composition of the Tupper bathylith; but it is feared that the anorthosite gabbro and gabbro analyses may not serve as well as representatives of the similar rocks under consideration here. None of the analyses were made with the purposes of this discussion in mind, and an element of uncertainty necessarily enters into their use.

The basic syenites (analyses 7-10) are thought to be owing to assimilation of gabbro and anorthosite gabbro from the syenite border. From the field situation of the most basic of these (number 7) it is judged that gabbro, rather than anorthosite gabbro, has been the rock digested. Study of the slides of this gabbro leads to the belief that its composition is more nearly represented by the rock of analysis 2 than of analysis 1, though considerable uncertainty prevails as to whether either is a close representative of its composition. Therefore a calculation of the com-

position of a mixture of this rock with a normal syenite (analysis 11) in proper proportion to give a silica percentage equal to that of the basic syenite of analysis 7 is presented for comparison with the rock itself. This mixture would consist of 58.3 per cent gabbro and 41.7 per cent syenite. These relative percentages of the gabbro and syenite form columns 1 and 2, their sums give the composition of the mixture in column 3, and in column 4 is the analysis of the basic syenite for comparison. The two iron oxides are put together and only the principal oxides included in the table.

	1	2	3	4	5
SiO ₂	27.65	26.45	54.1	54.1	
Al ₂ O ₃	10.11	7.66	17.77	17.45	+ .32
Fe ₂ O ₃	8.82	1.66	10.48	10.99	— .51
MgO.....	3.04	.15	3.19	2.33	+ .86
CaO.....	4.72	1.27	5.99	6.17	— .18
Na ₂ O.....	2.03	2.11	4.14	3.81	+ .33
K ₂ O.....	1.1	2.15	3.25	3.06	+ .19
	57.47	41.45	98.92	97.91	

In view of the many uncertainties connected with the calculations, it has not been deemed necessary to recalculate the footings to 100 per cent. It is thought that they show just as clearly the size and importance of the discrepancies as they stand as if so recalculated. Though there is a considerable difference in the magnesia percentage of the two, it is not thought to be of a higher order than the differences in magnesia content shown by the rocks of both classes of similar silica content when followed from place to place. The other differences are certainly of no higher order. The calculation is therefore thought to indicate that in this instance the chemical evidence is not opposed to the suggested hypothesis. Neither the gabbro nor the syenite used in the calculation are from the immediate region, though it is thought that each could be closely duplicated there. Each rock also varies considerably from place to place, and it is an open question whether the syenite and the gabbro from the Tupper Lake region would or would not have furnished a closer agreement had analyses been available.

This very basic syenite is not the average variety of the basic rock, but the most extreme type met with which furnished material sufficiently fresh for chemical analysis. The only available analysis of syenite of more average basicity is that from the syenite intrusion inlying in the anorthosite nearly midway on the northern border of the map. The

adjacent rock along this portion of the border is anorthosite gabbro. If there has been incorporation of material from the anorthosite by this syenite, it is but fair to assume that the assimilated rock was not mere gabbro, but anorthosite gabbro. No analysis of the typical anorthosite gabbro of the region is available, the rock from Rand hill, Clinton county, a distant locality where the rock occurs as an outlier instead of as a portion of the great anorthosite batholith, being the only one so far analyzed. Like the rock of most of the outliers, this is of a somewhat abnormal type, being certainly higher in alumina and lime and lower in iron and magnesia than the usual anorthosite gabbro. Study of the slides of the Tupper Lake rock, however, suggests that its composition would be quite similar to a half and half combination of this Rand Hill rock, whose analysis appears as number 3 of the table, with that of the gabbro of number 2, and the calculation is then made of a combination of this with the normal syenite of number 11 in the proper proportions to obtain a rock of the silica percentage of the medium basic syenite of number 9. In the following table columns 1 and 2 are the respective analyses of the gabbro and anorthosite gabbro, column 3 a combination of 50 per cent of each, column 4 the syenite, column 5 the result of combining 3 and 4 on the basis of 26.8 per cent of the former and 73.2 per cent of the latter, while column 6 gives the analysis of the basic syenite for comparison with the calculated composition of the mixture, and column 7 the discrepancies between the two.

	1	2	3	4	5	6	7
SiO ₂	47.42	51.62	49.52	63.45	59.7	59.7	
Al ₂ O ₃	17.34	24.45	20.89	18.38	19.05	19.52	— .47
Fe ₂ O ₃	15.13	6.95	11.04	3.98	5.87	6.81	— .96
MgO.....	5.21	1.21	3.21	.35	1.11	.78	+ .33
CaO.....	8.09	9.97	9.03	3.06	4.66	3.36	+1.3
Na ₂ O.....	3.48	3.49	3.48	5.06	4.63	5.31	— .68
K ₂ O.....	1.89	1.27	1.58	5.15	4.19	4.14	+ .05
	98.56	98.96	98.75	99.43	99.21	99.62	

Here is a large discrepancy in lime and considerable ones in other constituents. These are thought to be due in part at least to unsoundness in the original assumption that the rock of column 3 is closely akin to the anorthosite gabbro of the district, the trouble arising from the abnormal character of the rock of column 2. But inspection of analyses 8-10 of the original table, all of which are basic syenites of not widely differing silica percentages, shows much variation in all the constituents which show the main discrepancies here, so that if either number 8 or

number 10 had been used in the calculation instead of number 9 the discrepancies would have varied largely, or, in other words, that the differences between numbers 5 and 6 of this table are of the same order as those between 8 and 9 or 9 and 10 of the original table. It is not thought, therefore, that the calculation can be regarded as furnishing an argument against the general hypothesis, though it is not maintained that it is of any especial value, owing to the assumptions which enter into it.

In attempting a calculation of the soaked rock (analysis 6 of the original table) the same difficulty is met as in the previous case, namely, lack of an analysis of the anorthosite gabbro near by. From study of the thin-section this is estimated to have a composition similar to that of a mixture of the analyzed gabbro and anorthosite gabbro in the proportion of 35 per cent of the former and 65 per cent of the latter. Labradorite augen are more abundant and conspicuous than in the previous case, where a half and half mixture was assumed. Obviously there is the same uncertainty here as appeared in the previous calculation, the somewhat abnormal character of the anorthosite gabbro of the analysis. Since the calculation is precisely similar to the last, the analyses of the gabbro and anorthosite gabbro are not repeated and column 1 of the following table is the combination of 35 per cent and 65 per cent of the two respectively. The adjacent syenite which is supposed to have soaked the other rock is of about the basicity and character of that of analysis 9 of the original table, appearing here in column 2. These two are combined in the proportion of 56 per cent of the former and 44 per cent of the latter, the result appearing in column 3, with the analysis of the soaked rock in column 4 and the discrepancies in column 5.

	1	2	3	4	5
SiO ₂	50.15	59.7	54.36	54.38	
Al ₂ O ₃	21.96	19.52	20.87	20.53	+ .34
Fe ₂ O ₃	9.82	6.81	8.5	8.28	+ .22
MgO.....	2.61	.78	1.8	1.99	— .19
CaO.....	9.31	3.36	6.69	5.39	+1.3
Na ₂ O.....	3.49	5.31	4.3	5.2	— .9
K ₂ O.....	1.49	4.14	2.65	3.4	— .75
	98.83	99.62	99.17	99.17	

There is more lime and less alkalis in the calculated mixture than in the actual rock, just as was true in the previous calculation. This might suggest either an error common to both, due to the assumed mixture of

gabbro and anorthosite gabbro not adequately representing the character of the anorthosite gabbro here, or else might be regarded as a difference which threw doubt on the suggested origin of the two rocks concerned. To the writer the former seems vastly the more probable, since the anorthosite gabbro used is known to be a somewhat abnormal rock, and the similarities between the calculation and the analysis seem to him also much more significant than the differences. It is not being argued that they afford evidence of the truth of the advanced hypothesis, but only that they do not furnish ground for an argument against it.

So far as the writer is aware, no analyses of the granitic gneisses of the Adirondacks have been made, so that recourse must be had to Canadian analyses in order to get any data for comparison with the acid syenites. The only one of these known to the writer is that quoted as number 16 of the table of analyses and repeated as column 1 of the following table. With it are two analyses of granitic phases of the syenite, numbers 14 and 15 of the original table.

	1	2	3
SiO ₂	69.24	68.5	68.18
Al ₂ O ₃	14.85	14.69	16.15
Fe ₂ O ₃	2.62	4.59	2.26
MgO.....	.97	.26	.64
CaO.....	2.1	2.2	2.48
Na ₂ O.....	4.3	3.5	4.22
K ₂ O.....	4.33	5.9	5.59

These are such trifling differences in composition that there is little to be gained by making calculations. The two syenites differ from one another as much as either differs from the granite. It is, however, to be noted that the syenites are nearly as siliceous as the granite-gneiss, so that if they have been produced from the normal syenite of about 63 per cent of silica by digestion of granite no more acid than this, the amount of granite digested must enormously exceed the syenite in the mixture, which seems most improbable. Experience with other syenite batholiths of the region has led the writer to the view that they have a normal tendency to produce a more acid differentiation border. But the detailed field work necessary to establish that view is as yet undone. If it be true, it follows that the acidity of these syenites is due in whole or part to this normal differentiation, and only in part or not at all to incorporation of material from the granite-gneiss. Such incorporation would, however, evidently yield a rock quite like the acid syenite, so that

there is no chemical difficulty in the way. If the syenites of the region do tend to differentiate a more acid border, the basic border adjacent to the anorthosite is all the more remarkable, and it is there that the major part of the field evidence suggesting incorporation is found. The instance of the acid syenite in Litchfield park passing into basic syenite around the large anorthosite inclusion there will be recalled in this connection.

In conclusion it may be said that while the chemical evidence is by no means of satisfactory nature, owing mainly to the lack of selected analyses made with this problem in view, yet that it does not seem to afford any valid argument in opposition to the field evidence, which does distinctly suggest the incorporation and digestion of material from the surrounding rocks, especially from the anorthosite, as the cause of the peculiar differentiation of the syenite.