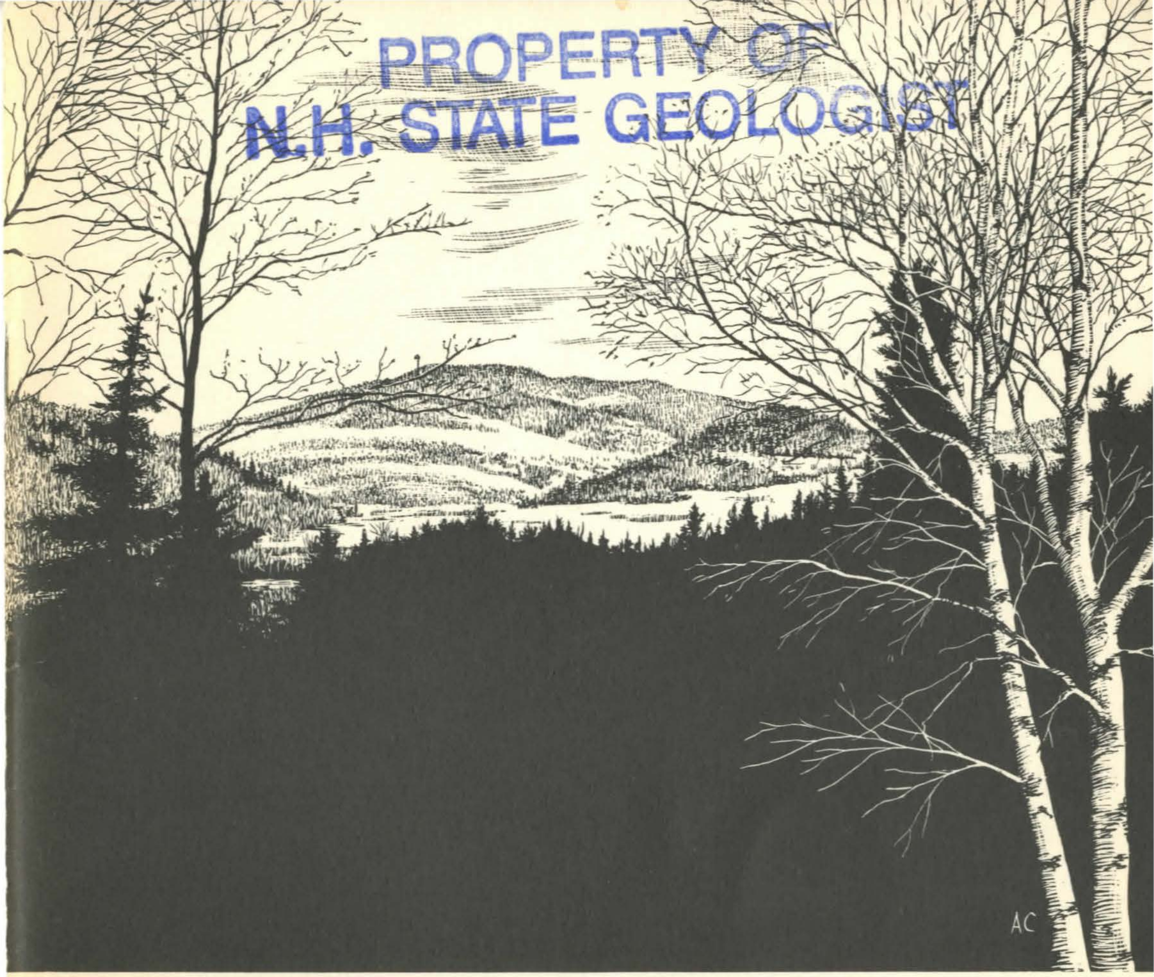

Geology of the AVERILL QUADRANGLE ...Southeast Portion NEW HAMPSHIRE

by Charles Moore Swift Jr.

PUBLISHED BY THE STATE OF NEW HAMPSHIRE
DEPARTMENT OF RESOURCES AND ECONOMIC DEVELOPMENT

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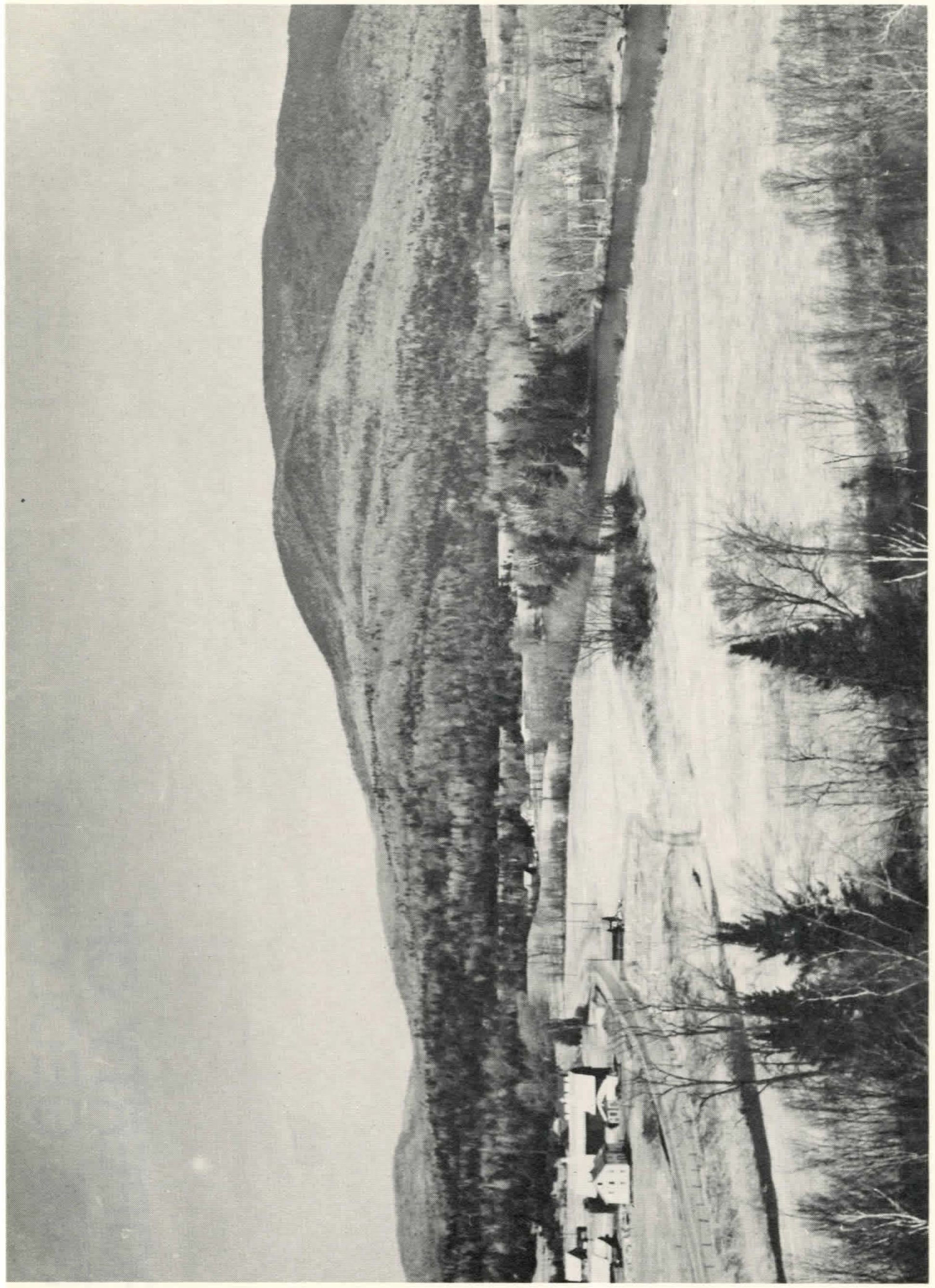

Lightning Mountain, Stratford, from the Connecticut River Valley.

(Photo by John P. Wilson)

GEOLOGY OF THE SOUTHEAST PORTION OF THE AVERILL QUADRANGLE, NEW HAMPSHIRE

By Charles Moore Swift, Jr.

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ABSTRACT

That portion of the Averill quadrangle, New Hampshire, lying east of the Connecticut River and south of the village of Colebrook has been mapped and studied.

Phyllites, mica schists, schistose quartzites and amphibolites of the Lower Devonian (?) Gile Mountain formation trend northeasterly across the area. These rocks have been intruded by diorite, syenite, quartz syenite and Conway granite of the 180-million year old White Mountain plutonic-volcanic series. The southernmost tip of the Monadnock stock and the western portion of the Stratford stock are exposed within the mapped area.

Petrographic study suggests that the diorite, syenite, and quartz syenite of the Stratford stock originated by differentiation from a single parent magma. Gravitative settling of early-formed crystals was the predominant mechanism, but gaseous transfer of alkalis to the upper part of the magma chamber was also important. The Conway granite, on the other hand, is unique. Although derived from the same parent magma as the other rocks, it was partly formed and extensively modified by abyssal assimilation. Water expelled from the Conway granite during its crystallization has extensively altered the older diorite, and has carried potassium into that rock.

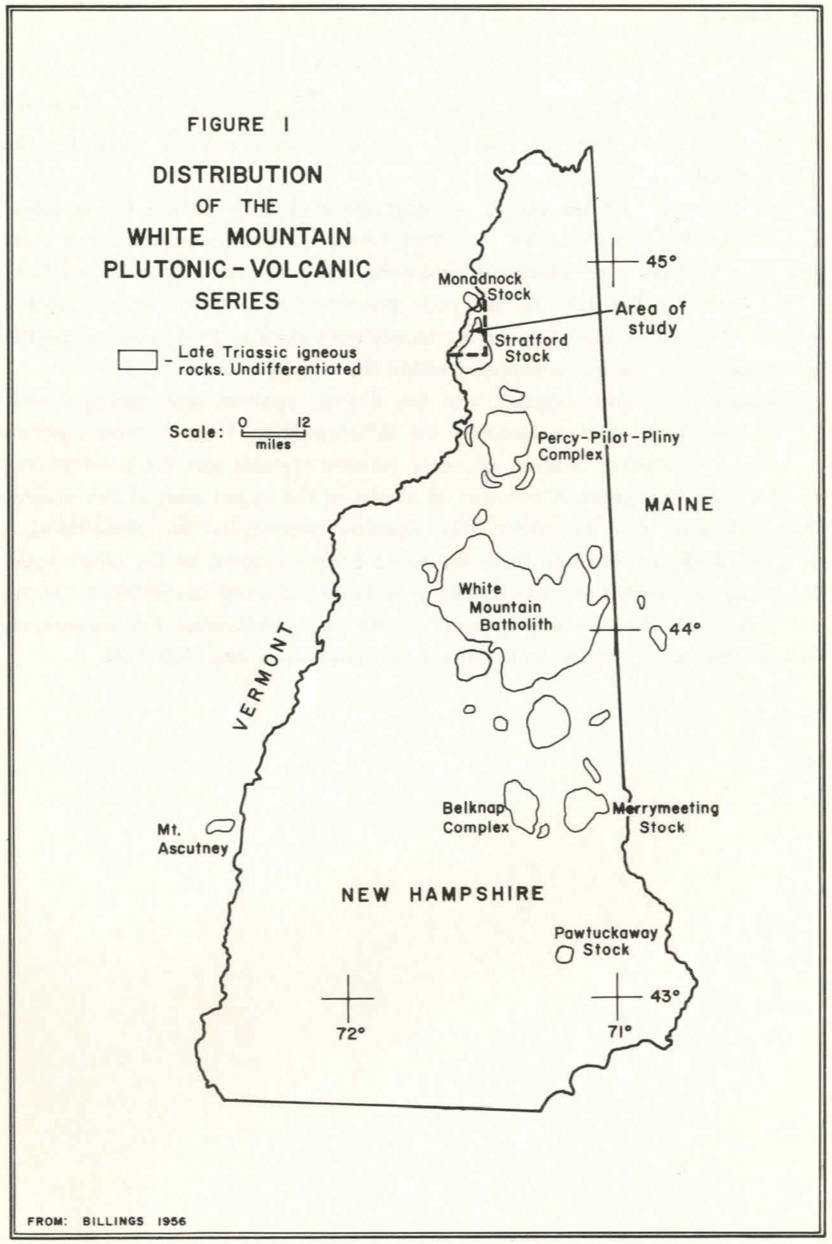


FIGURE I

DISTRIBUTION OF THE WHITE MOUNTAIN PLUTONIC-VOLCANIC SERIES

Geology of the Southeast Portion of the Averill Quadrangle, New Hampshire

By Charles Moore Swift, Jr.

INTRODUCTION

Location

The Averill quadrangle of northern Vermont and New Hampshire lies along the international boundary with Canada, and in the drainage basin of the Connecticut River, which flows southerly through the eastern part of the quadrangle. This report describes the geology of the southeasternmost portion of that quadrangle, embracing an area of 36 square miles in Coos County, New Hampshire. The village of Colebrook lies in the northeast corner of the mapped area, and the village of North Stratford in the southwestern corner. The geology of the remainder of the quadrangle has been described by Myers (1960).

Physiography

The area has a maturely dissected mountain terrain, with a maximum relief of 2461 feet. The highest peak (el. 3351 feet) is an unnamed summit one mile east of Mount Pleasant.

Effects of continental glaciation are evidenced by deposits of till, varved clays, and fluvio-glacial sands, as well as by glacial striae trending S. 30°E.

Regional Geologic Setting

The mapped area is a small portion of the northern Appalachian eugeosyncline, lying approximately 40 miles east of the Green Mountain anticlinorial axis . Here Lower Devonian (?) sediments and volcanics of the Gile Mountain formation have been highly deformed and metamorphosed to mica schists, quartzites, phyllites, and amphibolites. These rocks are intruded by stocks belonging to the Late Triassic White Mountain plutonic-volcanic series.

Methods of Study

The area was mapped during the summer of 1961 by making a series of traverses along brooks and ridges, and by plotting the observed data on the U. S. Geological Survey topographic map (revised, 1953, edition) of the Averill quadrangle. This work was done in fulfillment of the A.B. degree for the Department of Geology at Princeton University. Emphasis in this study was placed on the petrology of the Stratford stock (cf. figure 1), portions of which have previously been described by Chapman (1948) and Hatch (1963). Sixty thin sections of the rocks of the area were studied, and modes were determined using a Swift automatic point-counter. Supplementary mineral determinations were made by taking diffractograms with a Philips X-ray instrument at Princeton.

Previous Geological Work

Generalized large-scale geologic maps of the area covered by this report have previously been published by Hitchcock (1877) and by Billings (1956), but the map of Plate 1 is the first detailed presentation of the bedrock geology. A map of the Vermont portion of the Averill quadrangle has recently been completed by Myers (1964). The Dixville quadrangle, lying immediately east of the Averill quadrangle, has recently been mapped (Hatch, 1963). Wolff (1929) and Chapman (1954) have both written about the geology of Monadnock Mountain, just west of Colebrook.

Acknowledgments

The writer acknowledges with gratitude the hospitality of Dean and Mrs. Ashley Campbell of Randolph, N. H., with whom the writer stayed during the field work. Majorie Cross, Ashley Campbell, and John Stevens rendered assistance in the field. Dr. Norman Hatch, Prof. M. P. Billings, Prof. W. I. Johansson, Richard Chase, William MacDonald and Prof. R. B. Hargraves all contributed helpful discussions. Prof. J. B. Lyons, Dartmouth College, and Prof. G. W. Stewart, State Geologist, critically reviewed the manuscript for publication. The study was made possible through a grant from the Conway Fund at Princeton University.

LITHOLOGY

General Features

Aside from glacial deposits and alluvium, the bedrock consists chiefly of metamorphosed sedimentary rocks intruded by igneous rocks, in the south-

eastern portion of the Averill quadrangle. The lower topographic areas, extending for a mile or two east of the Connecticut River are underlain by the Lower Devonian (?) Gile Mountain formation. Intrusive igneous rocks of the White Mountain series (Late Triassic) underlie the mountainous region bounding the eastern limits of the mapped area.

Lower Devonian (?)

GILE MOUNTAIN FORMATION

Distribution. As indicated by Plate 1, the Gile Mountain formation trends approximately N. 20°E. along the westerly portion of the mapped area.

Petrography. In order of decreasing abundance, the rock types represented within the Gile Mountain formation are mica schists, phyllites, and schistose quartzites. A thin band of amphibolite has been separately mapped east of the village of North Stratford.

Most of the Gile Mountain formation is composed of varying amounts of quartz, plagioclase, biotite, muscovite, chlorite, epidote, magnetite, and apatite. The amphibolite is characterized by blue-green hornblende, plagioclase, epidote, quartz, biotite, and calcite. Numerous ptygmatic quartz veins characterize the phyllite of the Gile Mountain formation.

Thickness. Because of complications caused by folding, and the fact that the entire unit is not exposed within the mapped area, it is not possible to calculate the exact thickness of the Gile Mountain formation. The portion exposed within the area of Plate 1 is estimated to be at least 5000 feet thick.

Age and Correlation. The Gile Mountain formation was first mapped by Doll (1944), and assigned by him to the Devonian. The age of the formation has been in dispute, but most geologists now agree with Cady's (1960) assignation of a Lower Devonian (?) age to it.

Late Triassic

WHITE MOUNTAIN PLUTONIC-VOLCANIC SERIES

Distribution. On both structural and petrographic criteria the igneous rocks of the New Hampshire portion of the Averill quadrangle may be grouped, with confidence, as members of the White Mountain series.

A small stock of syenite near the mouth of Simms Stream is areally continuous with igneous rocks of the Monadnock stock, of which it forms the southernmost extension (cf. Figure 1). Diorite, syenite, quartz syenite and Conway granite stocks which underlie the high terrain in the eastern and southeastern part of the map area are units of the large composite Stratford stock, which also underlies a sizable portion of the Dixville and Percy quadrangles.

Petrography.

Syenite of the Monadnock Stock.

This syenite consists of two phases, both of which weather orange-brown. North of Simms Stream the syenite is medium-to coarse-grained, non-foliated, flesh-colored, and contains about 10% dark minerals. South of Simms Stream the syenite is honey-brown sub-porphyritic, has small inclusions of diorite, and contains about 20% dark minerals. Typical modes of these two rocks are listed in Table 1. It is noteworthy that the coarse-grained syenite contains ferrohastingsite as a dark mineral (cf. also Chapman, 1954, p. 100), whereas altered pyroxene characterizes the sub-porphyritic syenite. Field relations suggest that the coarse-grained syenite is younger than the sub-porphyritic variety.

Diorite of the Stratford Stock.

Diorite, complexly cut and altered by biotite granite, is exposed from the hill north of Cree Notch (Plate 1) southward to Cone Brook. A second small stock of diorite lies north of Cree Notch.

The diorite is massive and varies both in grain size and in concentration of dark minerals. South of Cree Notch much of the diorite is a fine-grained, salt-and-pepper-textured rock corresponding to a similar type mapped by Hatch (1963, Plate 1) to the east. North of Cree Notch the diorite is coarse-grained, profusely cut by granite, and of an orange hue. Modes of two typical diorites (A-27a and A-42a) are given in Table 1.

Mineralogically the diorite is distinguished by the presence of lepidomelane (β= 1.661; 2V = 15^0) as the mica, and by the sporadic development of hastingsite in place of hornblende. Augite shows typical reaction rims of hornblende and biotite.

Near its margins the diorite is commonly shattered and veined by dikes of fine-grained granite. These dikes have little perceptible effect upon the diorite, but elsewhere, where coarse-grained granite injects the diorite, the latter rock is extensively metasomatized by the addition of microcline feldspar. Samples A-31c and A-40b (Table 1) show typical modes of the metasomatized diorite.

Syenite of the Stratford Stock.

The syenite exposed in the southeast corner of the Averill quadrangle is continuous with other portions of a syenite stock described by Chapman (1948) and Hatch (1963). It is normally a massive, light yellow-brown rock that weathers white, but at Ledge Mountain the syenite is blue-gray and sub-porphyritic (cf. A-68 of Table 1).

Because both the syenite and the Conway granite become finer-grained toward their mutual boundary, age relations are uncertain. However, thin-section study indicates that the syenite has been contaminated by the granite, which has introduced quartz and plagioclase into the syenite. Therefore, the Conway granite is considered to be younger than the syenite.

Quartz Syenite of the Stratford Stock.

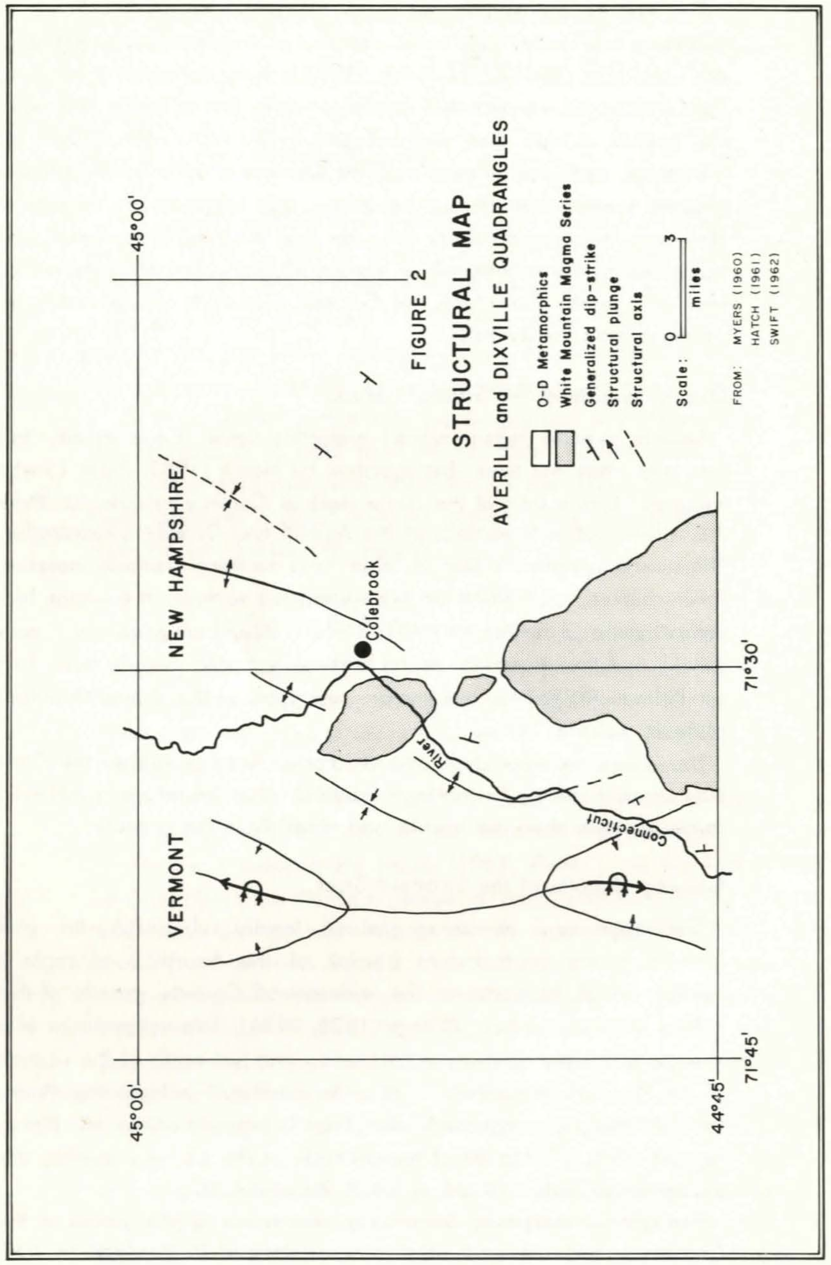
Quartz syenite (nordmarkite) underlies upper Cone Brook. This rock type has not been distinguished by Hatch (1963, Plate 1) who mapped it as a part of the large stock of Conway granite (cf. Plate 1) in the southern portions of the Averill and Dixville quadrangles. The quartz syenite (A-80a of Table 1) is medium-grained, massive, flesh-colored, and white on the weathered surface. It contains ferrohastingsite ($Z \beta c=26^0; \gamma=1.701$; Y = Z = deep blue green; X = pale olive), and thus is similar to the hastingsite quartz syenite described by Billings (1956) as a common rock type of the White Mountain plutonic-volcanic series.

The quartz syenite chills against diorite, but not against the Conway granite along its southern contact. It is therefore considered to be younger than the diorite and older than the granite.

Conway Granite of the Stratford Stock.

The large mass of coarse-grained, locally sub-porphyritic, pink granite in the southeastern portion of the Averill quadrangle is similar in all respects to the widespread Conway granite of the White Mountain series (Billings, 1928, 1956). Two occurrences of a granite porphyry exist as contact zones, one just north of the summit of Mt. Pleasant, the other 1 1/2 miles northeast of Lightning Mountain. A fine-grained granodioritic phase is exposed east of Mt. Pleasant (cf. Plate 1). Modes of typical rocks of the Conway granite are presented in Table 1 (A-46, A-60, A-76, and A-82).

The granite porphyry apparently represents a chill phase of the Conway granite magma, and is characterized in the field by perthitic phenocrysts up to 6 mm. in diameter set in a finer-grained



matrix. The granodiorite is interpreted to be an early-crystallized and more mafic portion of the Conway magma which has been shattered, engulfed, and sericitized by the main mass of granite.

Typical Conway granite is coarse-grained to sub-porphyritic, and contains conspicuous pink perthitic feldspar up to 2 inches in length. A few small miarolitic cavities were observed on joint faces, but these are not as abundant as elsewhere in New Hampshire (Gillson, 1927; Billings, 1928; Quinn and Stewart, 1941). Inclusions of the Gile Mountain formation are restricted to the outer margins of the granite, and these have random orientations, sharp contacts with the granite, and no indications of assimilation *in situ* as was originally suggested by Billings for the granite at its type locality (Billings, 1928).

Contacts between the Conway granite and other members of the Stratford stock are not well exposed, but the granite shows a decreasing grain size toward the quartz syenite, and is presumably younger than it. It is also seemingly younger than the syenite at Ledge Mountain.

Near the outer margins of the granite, east of the summit of Mt. Pleasant and north of Ledge Mountain, hydrothermal activity has introduced pyrite and pyrrhotite into the rock, and has imparted a blue-green color to it.

Dikes.

Late dikes of varying composition transect all the previously described igneous and metamorphic units. Diorite porphyry is exposed near Columbia Bridge, in Simms Creek, in Cree Notch, and near the summit of Mt. Pleasant. A coarse-grained camptonite is exposed parallel to the southwestern contact of the Monadnock syenite. Albitite, which produces a hornfels at its contact with the schists, occurs near Columbia Bridge. Granitic aplite has a sporadic distribution throughout the area, and is younger in age than the diorite porphyry.

STRUCTURAL GEOLOGY

Metamorphic Rocks

Figure 2, compiled from the work of Myers (1960), Hatch (1963) and the writer shows the major antiformal and synformal structures which have been identified in the Averill and Dixville quadrangles. Inasmuch as the writer

Table 1

Modes of the Igneous Rocks, in Volume Per Cent

ROCK NO.	PLAG. COMP.	QUARTZ	PERTHITE	BIOTITE	AMPHIBOLE	PYROXENE	MAGNETITE
A-23	7.9(An_{15})	3.4	77.2	6.4	5.1		tr
A-29	22.9(An_{15-20})		51.8	13.0		8.2	1.0
A-27a	72.0(An_{25-30})	6.0	3.0	12.0	6.0	tr	1.0
A-42a	59.2(An_{25-30})	6.1	0.6	20.2	12.2	tr	1.7
A-31c	20.0(An_{25})	8.0	55.0	7.0	8.0	tr	tr
A-40b	28.9(An_{25})	2.0	53.0	9.9	tr	4.3	2.0
A-46	32.4(An_{15})	32.6	30.8	3.1			tr
A-60	30.7(An_{15})	23.2	38.9	7.3			tr
A-76	39.0(An_{15})	20.0	36.0	5.0			tr
A-82	13.3(An_{15})	35.5	49.2	1.6			tr
A-80a	13.5(An_{15})	5.8	68.5	2.7	9.1	tr	tr
A-68	7(An_{15})	tr	85	tr	8		tr

No.	Description and Location of Specimens
A-23	Syenite, coarse-grained, 1140' on slopes 1/2 mile NE of Simms Str. Mt. Monadnock stock.
A-29	Syenite, sub-porphyritic, on small knoll SW of Simms Stream. Stratford stock.
A-27a	Diorite, 2300' NW end of summit of hill N of Cree Notch. Stratford stock.
A-42a	Diorite, 2000' on slopes N of Cree Notch. Stratford stock.
A-31c	Metasomatized diorite, 2540' in stream one mile S of Cree Notch. Stratford stock.
A-40b	Metasomatized diorite, 2200' on slopes S of Cree Notch. Stratford stock.
A-46	Conway granite, 1300' in lower Lyman Brook at road crossing. Stratford stock.
A-60	Conway granite, 1730' at end of dirt road N of upper Lyman Brook. Stratford stock.
A-76	Conway granite, 2200' on ridge N of Lightning Mtn. Stratford stock.
A-82	Conway granite, 2820' on slope N of Teapot Mtn. Stratford stock.
A-80a	Quartz syenite, 2010' on ridge NW of Mt. Pleasant. Stratford stock.
A-68	Syenite, 2700' at top of cliffs on Ledge Mtn. Stratford stock.

did not emphasize structural studies during his field mapping, the reader is referred to discussions in Hatch (op. cit.) and Myers (op. cit.) for a fuller treatment of the regional and local tectonics.

Igneous Rocks

Because of the absence of flowage structures in the composite Stratford stock, a structural analysis of its mode of emplacement has not been possible. Measurements of the attitudes of the joints which so conspicuously cut the stock also fail to indicate a consistent or meaningful pattern. Some of the dikes in the region have utilized the joints as intrusive accessways.

On the basis of the evidence presented under the discussion of the petrography of the Stratford stock, the sequence of intrusions has been established as: diorite, syenite, quartz syenite, and Conway granite. It is noteworthy that where any two of the rocks of the stock are in contact, strongly chilled borders are not developed. This is excellent evidence that the time span between the successive intrusions must have been relatively brief, and that all of the rocks are co-magmatic.

The fracturing and alternation of diorite by Conway granite suggests magmatic stoping as a mechanism for the emplacement of the granite. Otherwise, however, the abrupt contacts, rarity of inclusions, lack of disruption of the country-rock structure by the Stratford stock, and the very limited amount of contact metamorphism all imply cauldron subsidence as the major mechanism for igneous emplacement.

EVOLUTION OF THE STRATFORD STOCK

The differences in the probable modes of emplacement of the rocks of the Stratford stock — cauldron subsidence for the diorite, syenite, and quartz syenite, but at least some piecemeal stoping for the Conway granite — are paralleled by basic petrographic differences between these two groups of rocks. The three older rock types are characterized by alkalic amphiboles, and appear to belong to a single differentiation sequence. The Conway granite, by contrast, contains biotite as its mafic mineral, and was apparently water-rich, as is evidenced by the fact of its alteration of the rocks it intruded, as well as by the development of miarolitic cavities within it. Similar contrasts are valid for the White Mountain series as a whole (cf. Chapman and Williams, 1935; Billings, 1956).

The sequence from diorite to syenite to quartz syenite can probably best be explained as due to gravitative settling of mafic minerals from a magma which, from time to time, stoped its way toward the surface and congealed. The results of laboratory studies can explain the distinctly alkalic affinities of this suite. It has been pointed out by Kennedy (1955) that the solubility of alkalis in water-rich silicate melts increases with pressure, and correspondingly decreases with a decrease in pressure. If fractures exist at the top of a magma chamber, the abrupt drop in the volatile pressure at that point would establish a diffusion gradient whose net effect would be to pump alkalis to the roof of the magma reservoir. This mechanism is regarded by the writer as the likely explanation for the alkalic nature of the White Mountain series.

In order for the above scheme to be valid, it is necessary that the present distribution of White Mountain series intrusives throughout New Hampshire should be the ancient cupolas of a vast batholith. That this is, in fact, true is strongly suggested by Bean's (1953) gravity data which show that on a regional scale a ridge of low-density rocks (the presumed top of a batholith) extends toward the surface throughout the exposed length of the White Mountain series (cf. Billings, 1956, Plate 1).

The non-alkaline character of the Conway granite, its vast areal extent (50% of the total White Mountain series rocks) and its unique petrographic variability indicate that it must have had a genesis different from that of the other rocks of the Stratford stock. An origin for the granite through the process of gravitative settling of mafic minerals seems highly improbable on the basis of volume relations alone. Chapman and Williams (1935) computed that for the amount of Conway granite then known (considerably less than is presently mapped) at least 6300 cubic miles of parental basaltic magma would be required if the crystal-settling mechanism had been operative. It seems to the writer to be far more plausible to explain the field and petrographic relations of the Conway granite in terms of assimilation. The general rarity of inclusions within the exposed portions of the Conway granite necessitates the assumption of assimilation at depth. If the rock digested by the parent magma of the White Mountain series were a shale rich in illite, and if the digestion were incomplete (as one might anticipate) many of the peculiarities of the Conway granite might find an explanation. These peculiarities include the petrographic variability of the granite, its local excess of quartz (up to 50% in some samples), and its high but variable radioactivity.

Petrographic and experimental work (Bowen and Tuttle, 1958) permit an estimation of the physical environment under which the Conway granite crystallized. The average norm of the granite is that which would correspond to a silicate liquid near the eutectic in the $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2-H_2O system at a temperature of 660°C and a pressure of 3 kilobars (Bowen and Tuttle, 1958, p. 75). The nature of the microperthite in the Conway granite (50-50 orthoclase-albite ratio) demonstrates the original magmatic characteristics of the rock, as well as the subsequent unmixing of the feldspar after the rock had crystallized. The Bowen and Tuttle experimental data (op. cit.) also permit us to estimate that the Conway granite magma may have had an initial water content close to 6% by weight; thus we find a source for hydrothermal alterations and replacement caused by the intrusion and crystallization of this unique and interesting magma type.

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Maps of the following quadrangles may be purchased at 50 cents each. A 20% discount allowed in quantities of 10 or more of the same map: Bellows Falls, Hanover, Dixville, Keene-Brattleboro, Lovewell Mountain, Mascoma, Monadnock, Mt. Chocorua, Mt. Cube, Mt. Pawtuckaway, Mt. Washington, Percy, Plymouth, Sunapee, Winnipesaukee, Wolfeboro. The following quadrangle maps are *out of print*: Cardigan, Franconia, Littleton, Moosilauke, Rumney, and Woodsville.

PROFESSIONAL BULLETINS

BULLETIN NO. I. THE GEOLOGY OF THE DIXVILLE QUADRANGLE. Norman L. Hatch, Jr. 1963. 81 p. illus. Maps. $3.50.

BULLETIN NO. II. GEOLOGY OF THE MANCHESTER QUADRANGLE. Aluru Sririmadas. Edited by Marland P. Billings. 1966. 92 p. illus. Map. *In Press.*

MINERAL RESOURCE REPORTS

NEW HAMPSHIRE MINERALS AND MINES. T. R. Meyers. 1941. 49 p. Map. 50 cents. *Out of Print.* See GEOLOGY OF NEW HAMPSHIRE. PART III.

NEW HAMPSHIRE MINERAL RESOURCES SURVEY:

PART I. GENERAL SUMMARY. H. M. Bannerman. 1940. Reprinted 1960. Free.

PART II. DIATOMACEOUS EARTH. Andrew H. McNair. 1941. 6 p. Map. 10 cents.

PART III. PEAT DEPOSITS IN NEW HAMPSHIRE. George W. White. Analyses by Gordon P. Percival. 1941. Reprinted 1949. 16 p. Map. 25 cents.

PART IV. SILLIMANITE, ANDALUSITE, KYANITE, AND MICA SCHIST DEPOSITS. H. M. Bannerman. 1941. Reprinted 1949. 5 p. 25 cents.

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PART VII. STRUCTURAL AND ECONOMIC FEATURES OF SOME NEW HAMPSHIRE PEGMATITES. H. M. Bannerman. 22 p. Maps. 1943. Reprinted 1950. 30 cents.

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PART IX. MINERAL COMPOSITION OF NEW HAMPSHIRE SANDS. J. W. Goldthwait. 1948. 7 p. Map. 10 cents.

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PART XII. CLAYS OF NEW HAMPSHIRE. Preliminary Report. Donald H. Chapman. Physical test of clays by Willard J. Sutton; chemical tests of clays by M. J. Rice. 1950. 21 p. Map. 30 cents.

PART XIII. FOUNDRY SANDS OF NEW HAMPSHIRE. Preliminary Report. T. R. Meyers. Mechanical analyses by Willis C. Campbell. 1950. 32 p. Map. 30 cents.

PART XIV. FELDSPAR AND ASSOCIATED PEGMATITE MINERALS IN NEW HAMPSHIRE. J. C. Olson. 1950. 50 p. Maps. 65 cents.

PART XV. CLAYS OF SOUTHEASTERN NEW HAMPSHIRE. Preliminary Report. Lawrence Goldthwait. 1953. 15 p. Map. 50 cents.

PART XVI. SANDS OF THE MERRIMACK VALLEY. Preliminary Report. Lawrence Goldthwait. 1957. 19 p. 50 cents.

PART XVII. LIGHTWEIGHT AGGREGATE RAW MATERIALS IN NEW HAMPSHIRE. Preliminary Report. Glenn W. Stewart. 1959. 30p. $1.00.

PART XVIII. SUBURBAN AND RURAL WATER SUPPLIES IN SOUTHEASTERN NEW HAMPSHIRE. T. R. Meyers and Edward Bradley. 1960. 31 p. 75 cents.

PART XIX. CHEMICAL ANALYSES OF ROCKS AND ROCK MINERALS FROM NEW HAMPSHIRE. Marland P. Billings and J. Robert Wilson. 1965. 97 p. $1.00.

MISCELLANEOUS REPORTS AND REFERENCES

GEOLOGIC STORY OF FRANCONIA NOTCH AND THE FLUME. Andrew H. McNair. 1949. 14 p. illus. 20 cents.

GEOLOGY STORY OF KINSMAN NOTCH AND LOST RIVER. Andrew H. McNair. 1949. 14 p. illus. 20 cents.

THE MOUNTAINS OF NEW HAMPSHIRE. A directory locating the mountains and prominent elevations of the State. 1949. 145 p. illus. 50 cents.

NEW HAMPSHIRE WATER. Governmental responsibilities and activities in relation to the water resources of New Hampshire. December 1953. Maps. Charts. $2.00.

ORE HILL ZINC MINE, WARREN, NEW HAMPSHIRE. H. M. Bannerman. 1943. Reprinted 1962. 2 p. Map. 10 cents.

MICA-BEARING PEGMATITES OF NEW HAMPSHIRE. U. S. Geological Survey Bulletin. 931-P. Preliminary Report. J. C. Olson. 1941. 41 p. Maps. Free.

ROCK-WELL SURVEY IN NEW HAMPSHIRE. Progress Report. Glenn W. Stewart. 1964. 10 p. 30 cents.

The following reports should be purchased directly from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402:

PEGMATITE INVESTIGATIONS, 1942-45, NEW ENGLAND. U. S. Geological Survey Professional Paper 255. Eugene N. Cameron and others. 1954.

BERYL RESOURCES OF NEW HAMPSHIRE. U. S. Geological Survey Professional Paper 353. James J. Page and David M. Larrabee. 1962. Price: $4.00.

MINERAL DEPOSITS AND OCCURRENCES IN NEW HAMPSHIRE, EXCLUSIVE OF CLAY, SAND, GRAVEL AND PEAT. Mineral investigations Resource Map MR6. Nancy C. Pearre and James A. Calkins. 1957. 50 cents.

GEOLOGY AND GROUND-WATER RESOURCES OF SOUTHEASTERN NEW HAMPSHIRE. U. S. Geological Survey Water-Supply Paper 1695. Edward Bradley. 1964. 80 p. Maps. $1.00.

NEW HAMPSHIRE BASIC-DATA REPORT NO. 1, GROUND-WATER SERIES, SOUTHEASTERN AREA. Edward Bradley and Richard G. Petersen. Prepared by the U. S. Geological Survey in cooperation with the New Hampshire Water Resources Board. 1962. 53 p. Maps. *(Available from N. H. Water Resources Board, Concord, N. H.) (Limited Supply).*

The following report may be purchased from the Geological Society of America, 231 East Forty-Sixth Street, New York, New York, 10017:

STRATIGRAPHY AND STRUCTURE OF THE BOUNDARY MOUNTAIN ANTICLINORIUM IN THE ERROL QUADRANGLE, NEW HAMPSHIRE-MAINE. Geological Society of America Special Paper 77. Robert C. Greene. 1964. $3.50.

MISCELLANEOUS MAPS

SURFICIAL GEOLOGY OF NEW HAMPSHIRE. Map. 1950. Scale 1 inch equals 4 miles. $1.00.

BEDROCK GEOLOGY OF NEW HAMPSHIRE. Map. 1955. Scale 1 inch equals 4 miles. $2.00.

TOPOGRAPHIC MAP OF NEW HAMPSHIRE. In three colors at scale of 1 inch equals 4 miles. 100 foot contour lines. Water areas, streams and town lines indicated. Outside dimensions 51" x 39". $1.00. *Out of Print.*

U. S. G. S. QUADRANGLE MAPS. Maps may be purchased at Division Office at 35 cents each. Large quantities of one map should be purchased directly from Director, U. S. Geological Survey, Washington, D. C. 20402.

AEROMAGNETIC MAPS

The following aeromagnetic maps are on open file at Division Office, Concord, and Geology Department, University of New Hampshire, Durham. They may be purchased for 50 cents each from Distribution Section, U. S. Geological Survey, Washington, D. C. 20402.

AEROMAGNETIC MAP OF THE ALTON QUADRANGLE. Map GP 136.

AEROMAGNETIC MAP OF THE BERWICK QUADRANGLE. Map GP 137.

AEROMAGNETIC MAP OF UMBAGOG LAKE AND VICINITY. Map GP 138.

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