THE GEOLOGY of NEW HAMPSHIRE

Part III - Minerals and Mines

By
T. R. Meyers
and
Glenn W. Stewart

Published by the
State Planning and Development Commission
Concord, New Hampshire

First Printing 1956
Second Printing 1959
Third Printing 1964
New Hampshire Division of Economic Development

TABLE OF CONTENTS

NEW HAMPSHIRE MINERALS and MINES

INTRODUCTION

Among its natural assets New Hampshire includes a rich mineral heritage. Our mineral array is extensive, including many types of present or past economic importance. At one time iron, gold, silver, copper, and lead, were eagerly sought for and mined. Today our production is largely nonmetallic minerals, such as sand and gravel, feldspar, stone, and clay.

In addition to minerals of commercial value, New Hampshire contains many which hold the interest of students of mineralogy and mineral collectors. Each year our knowledge of the state's mineral store increases, and this report might well be considered a report of progress of mineralogical investigations. A somewhat similar compilation which was published by Hawes (103)* in 1878 listed 95 species. The 1941 edition of this report contained nearly twice that number. This report contains nearly 250 minerals, including varieties.

The purpose of this report is to present a review of New Hampshire minerals as to type, distribution, and use, of both economic and general interest. The information has been drawn largely from published data, data in the files of the New Hampshire State Planning and Development Commission (98, 133), and to a more limited extent from the authors' data. Those desiring more information about minerals in general, or about New Hampshire minerals, than that presented here, may find the references in the bibliography helpful.

To those who have additional mineral information, the writers request that such material be forwarded to the New Hampshire State Planning and Development Commission so that an up-to-date file of data may be available to all.

In the revision the authors have attempted to follow the general outline of the 1941 report which was prepared under the guidance and supervision of Dr. George W. White, formerly of the Geology Department, University of New Hampshire and Dr. Harold M. Bannerman, formerly of the Department of Geology, Dartmouth College.

T. R. Meyers

Glenn W. Stewart

*Numbers in parentheses refer to numbered references in Bibliography.

NEW HAMPSHIRE MINERALS

The mineral species listed below are arranged in alphabetical order to permit rapid reference. Certain closely related minerals have been placed in generally recognized groups. Such minerals have a cross reference to direct the reader to the proper group. Mineral varieties are italicized. Numbers enclosed in parentheses refer to numbered references listed under *Bibliography*.

ACMITE (See under Pyroxene Group)

ACTINOLATED QUARTZ (See under Quartz)

ACTINOLITE (See under Amphibole Group)

ADULARIA (See under Orthoclase, Feldspar Group)

AEGIRITE (See Acmite, Pyroxene Group)

AEGIRINAUGITE (See under Pyroxene Group)

ALBITE (See under Feldspar Group)

ALLANITE (See under Epidote Group)

ALMANDITE (See under Garnet Group)

ALMANDITE-SPESSARTITE (See under Garnet Group)

AMAZONSTONE (See under Feldspar Group, Potash Division)

AMBLYGONITE, $LiAlFPO_4$*

Amblygonite is found in small amounts with albite and microcline in narrow veins cutting triphylite at the Parker Mountain mine, Center Strafford, (196, p. 815-816). It has been identified at the Chickering mine, Walpole, and may be associated with spodumene in Alstead (see spodumene under Pyroxene Group).

Use or Importance: No deposits of commercial size are known in New Hampshire, but if large supplies were developed, they might be a source of lithium whose compounds are used in the ceramic and chemical industries.

AMESITE (See under Chlorite Group)

AMETHYST (See under Quartz)

*Compositions of minerals have been taken largely from Palache, C., Berman, H., and Frondel, C., Dana's *System of Mineralogy, Vols. I and II;* Hurlburt, C. S., Jr., Dana's *Manual of Mineralogy*, and Dana, Edward S., *A Textbook of Mineralogy*, Fourth Edition, revised by William E. Ford.

AMPHIBOLE GROUP

This complex group of silicates is widely and abundantly represented in the state. Many species have been identified. Each is considered in alphabetical order below:

ACTINOLITE, $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$

The middle grade metamorphic zone of the Fitch formation, Littleton-Moosilauke quadrangles, may contain up to 50 per cent or more of this mineral (Billings, 50, p. 485-586). It is also reported in the Keene-Brattleboro, Lovewell Mtn. (Marlow Hill), Monadnock, Mt. Cube, Mt. Pawtuckaway, Mt. Washington, Plymouth, Sunapee, and Wolfeboro quadrangles. Hawes notes its presence in Unity (103, p. 60).

Use or Importance: A rock-forming mineral.

ANTHOPHYLLITE, $(Mg,Fe)_7Si_8O_{22}(OH)_2$

A brown fibrous type of anthophyllite has been identified in the talcose rocks at Richmond (103, p. 60). It has also been identified in the Ammonoosuc volcanics in Alstead and at Ore Hill, Warren.

Use or Importance: The fibrous type is used as a type of asbestos; no commercial deposits are known in New Hampshire.

BARKEVIKITE, $Na_3Fe_4Al(OH)_2Si_8O_{22}$

Barkevikite is identified as phenocrysts and groundmass material in the camptonite of the Littleton-Moosilauke quadrangles by Billings (50, p. 514).

Use or Importance: It is of interest as an uncommon mineral.

CROCIDOLITE, $Na_2Fe''Fe_2'''Si_8O_{22}(OH)$

Crocidolite is a blue asbestiform variety of riebeckite. Millard Chandler (personal communication) found specimens near the top of Hurricane Mountain, Conway. The crocidolite is associated with actinolite, hornblende and adularia.

Use or Importance: When found in large quantities it is mined for uses similar to the chrysolite asbestos of Quebec.

HASTINGSITE, $Ca_2NaMg_4Al_3Si_6O_{22}(OH,F)_2$

This is not a common mineral. However, it is a characteristic one in the White Mountain plutonic series, occasionally making up 10 per cent or more of the rock. It has been identified by Billings in the North Conway quadrangle (47, p. 86-125) and

by Billings and Williams in the Franconia quadrangle (49, p. 12) (206, p. 1020-1034). It is present in the Percy area in a hastingsite-riebeckite granite and to a limited extent in syenite (72, p. 427). Chapman and Williams give an analysis of some of the North Conway material (71, p. 512) and indicate 12 per cent present in the Albany quartz syenite of the Belknap area (71, table 1). Quinn has shown that it is quite abundant in the outer coarse syenite and nepheline-sodalite syenite of Red Hill, while large bladed hastingsite, 2x6 centimeters, is present in the amphibole pegmatite of the area. Needle-like grains are a striking feature of the Garland Peak syenite (167, p. 383-389).

Use or Importance: It is of interest as an unusual rock-forming mineral.

HORNBLENDE, $Ca_2Na\,(Mg,Fe'')_4\,(Al,Fe''',Ti)_3Si_6O_{22}\,(O,OH)_2$

This common mineral is of rather widespread distribution in the state. It is present, often in considerable abundance, in many of our igneous rocks, and in metamorphic rocks of the middle and high grade types. Hawes describes the finding of fine to superb crystals in the towns of Lisbon, Warren, Exeter, Hanover, and Moultonborough (103, p. 60). The amphibolite at Long Point, Red Hill district, contains up to 74 per cent of hornblende crystals, some of which are up to 2 inches in length (167, p. 378-379). It is also abundant in the amphibolites of the Littleton-Moosilauke quadrangles (50) and in Lyme (101, p. 25). A chemical analysis of hornblende from syenite of the Percy quadrangle is given by Chapman and Williams (71, p. 512, No. 5). This mineral is also abundant in the Cherry Mountain stock (73, p. 180).

Use or Importance: Important as a common rock-forming mineral.

RIEBECKITE, $Na_3Fe''_3Fe'''_2Si_8O_{23}\,(OH)$

This is another amphibole that is generally considered to be rare. However, it is one of the minerals characteristic of the White Mountain plutonic series and has been noted in several localities such as the riebeckite granite of the North Conway and Percy quadrangles (71, p. 505; *Chemical Analysis,* p. 512, No. 7). It has been found in the Franconia quadrangle by Williams and Billings (206, p. 1025ff.).

Use or Importance: Important only as a rather uncommon rock-forming mineral.

TREMOLITE, $Ca_2Mg_5Si_8O_{22}\,(OH)_2$

This species of amphibole has been described as abundant in Bedford, Gilmanton and Warren. The asbestos variety has been found in thin sheets at Franconia and Mount Monadnock. A dark fibrous variety was noted at Lebanon (103, p. 61).

Use or Importance: The fibrous variety comprises one type of asbestos. No deposit of commercial importance has been opened in New Hampshire.

ANALCIME, $NaAlSi_2O_6H_2O$

This species of zeolite has been observed as microscopic crystals in small cavities of the augite porphyry at Campton Falls (103, p. 112).

Use or Importance: A common zeolite which is of no commercial importance.

ANATASE (Octahedrite), TiO_2

This tetragonal form of titanium dioxide has been found by Gillson in druses of the North Conway granite. It is present as minute crystals, probably always pseudomorphic after ilmenite (99, p. 312).

Use or Importance: It is of no commercial value.

ANDALUSITE, Al_2SiO_5

This mineral is frequently found in highly aluminous layers in some of the schists of the state. It was noted also in the Chatham granite of the North Conway area, presumably derived from an andalusite-bearing schist during the intrusion of the granite (47, p. 85). In a number of areas slender crystals up to 8 inches in length are common. Seldom are they more than one-half inch across. Some of the towns in which it has been noted are Charlestown, Troy, Rochester, Farmington, and Andover (103, p. 105). Andalusite is conspicuous in places in the towns of Pittsfield, Strafford, Barnstead and Epsom. The variety *chiastolite* with its characteristic "cross" is present at Mount Washington, Walpole, Albany, Alstead, Langdon, Rye (103, p. 105), and Rochester (125, p. 173).

Use or Importance: It is occasionally used as a gem stone. Its most important use, however, is in the ceramic industry to produce spark plug cores and high-grade laboratory porcelain.

ANDESINE (See under Feldspar Group)

ANDRADITE (See under Garnet Group)

ANKERITE, $CaCO_3$ $(Mg,Fe,Mn)CO_3$

Hawes describes the mineral as characteristic of the auriferous quartz veins in Littleton, Lisbon, and Lyman. Here it occurs as honey-yellow rhombohedral crystals (103, p. 130). In this same general locality Billings noted pink to light brown ankerite as an abundant constituent of the metamorphosed dikes and sills (50, p. 512).

ANORTHITE (See under Feldspar Group)

ANORTHOCLASE (See under Microline, Feldspar Group)

ANTHOPHYLLITE (See under Amphibole Group)

APATITE GROUP

Minerals of this group occur in minute amounts in all of our rocks, usually as microscopic crystals or grains. In pegmatites, irregular masses or crystals up to an inch or more in length are common. The color is generally a moderately dark, mottled green. Hawes notes apatite as abundant in the Westmoreland molybdenite deposits, blue and green crystals at Grafton, and fine crystals in the white limestone at Piermont (103, p. 122).

Microscopic grains of apatite occur commonly as an accessory mineral in granites and some of the metamorphic rocks.

FLUORAPATITE, $Ca_5(PO_4)_3F$

Fluorapatite is undoubtedly the predominating variety in New Hampshire. Stewart describes an interesting occurrence of this type at Center Strafford. These small, short prismatic, pale blue to colorless crystals from Center Strafford fluoresce to a strong light orange under ultraviolet light from a mercury vapor lamp (193). It is common in the druses of the North Conway granite. Some rare crystals were of gem quality (99, p. 312). Bluish green fluorapatite is reported by Bannerman (38, p. 3) at the Ruggles mine, where it often occurs as well-formed doubly terminated crystals.

FRANCOLITE

Francolite is a carbonate apatite that contains considerable amounts of carbon dioxide. According to Seaman (183, p. 137-140) it has been identified at the Smith mine, Newport.

MANGANAPATITE, $(Ca,Mn)_5(PO_4)F$

This variety is identified by Switzer (196, p. 815) at the Parker Mountain mica mine near Center Strafford. It occurs as dark

green, transparent, anhedral masses; less common are opaque brown crystals.

VOELCKERITE, $3Ca_3(PO_4)_2CaO$

This rare member of the apatite group is reported by Bannerman (38, p. 3) as present at the Ruggles mine, Grafton, where it occurs intimately intergrown with fluorapatite and is light gray in color.

Use or Importance: The members of this group are the source of natural phosphate in our soils. Occasionally deposits of high concentration are used in the manufacture of fertilizer. No such concentrated deposit has been noted in New Hampshire.

ARGENTITE, Ag_2S

This is reported as found in Cornish (103, p. 27). As all of our galena is more or less argentiferous, it is undoubtedly present as minute inclusions in the galena.

Use or Importance: It is an ore of silver, but it has not been found profitable to mine in New Hampshire. It probably was the silver mineral of our old silver mines.

ARSENIC, As

Arsenic has been noted in Haverhill and at the tin mine in Jackson. At both localities it was present in thin layers in a dark-blue mica schist, associated with pyrite and arsenopyrite (103, p. 25).

Use or Importance: It is a source of arsenic when present in large amounts.

ARSENOPYRITE, FeAsS

This mineral is common in the quartzites and schists along the Connecticut Valley, usually as granular or compact material, occasionally as well-shaped crystals. Towns in which it has been observed in appreciable amounts are Jackson, Francestown, Haverhill, Lebanon, Weare, Groton, Lisbon, Lyman, Middleton, and Alton. It occurs in pegmatites at Newport, Groton, Alexandria and Raymond. In arsenopyrite from a number of areas traces of gold, silver, or nickel are present. *Danaite,* the cobalt-bearing variety, was first recognized from well-crystallized material gathered in Franconia (110, Vol. III, pt. V, p. 68).

Use or Importance: It is an ore of arsenic.

ASBESTOS (See Anthophyllite, Crocidolite and Tremolite of the Amphibole Group, and Serpentine).

ASTROPHYLLITE, $(Na,Ca)_3 (Fe'',Al,Ti)_{15} (Si_2O_7)_6 (F,OH)_8$

Billings describes this mineral as being persistently present in small amounts, about 1 per cent, in the riebeckite granite of the North Conway quadrangle (47, p. 117). R. Chapman notes it in the granites of the Percy area (72, p. 4).

Use or Importance: It is a rare rock-forming mineral.

AUGELITE, $Al_2(PO_4)(OH)_3$

Augelite, a basic phosphate of aluminum, has been found in waste rock at the G. F. Smith mine at Newport and material collected at the Palermo mine at North Groton. At the Smith mine Seaman (181, p. 728) describes "transparent, pale aquamarine-blue crystals associated with lazulite, albite, and quartz . . . The crystals are embedded and poorly formed. Tiny blue inclusions can be seen under low magnification and the color of the mineral apparently is due to disseminated particles of lazulite." At the Palermo mine "the mineral occurs both as anhedral colorless masses up to 1 centimeter in size embedded in a granular matrix of quartz, siderite, and feldspar, and as small crystals associated with whitlockite, brazilianite, goyazite, quartz, siderite, and apatite in drusy cavities." (Seaman, 181, p. 729). Due to a pseudo-rhombohedral habit, augelite is distinguished from whitlockite only with difficulty.

Use or Importance: None is known.

AUGITE (See under Pyroxene Group)

AUGITE-DIOPSIDE (See under Pyroxene Group)

AUTUNITE, $Ca(UO_2)_2 (PO_4)_2.10\text{-}12H_2O$

This pale yellowish, uranium-bearing mineral is present in some feldspar and mica mines as small, thin scales or flakes on feldspar and muscovite. Individual plates are seldom over 2 millimeters across, but collectively they often cover extensive fracture surfaces. When exposed to strong ultra-violet radiation the mineral glows a brilliant light green. New Hampshire specimens were first found in the mica quarries of Acworth (103, p. 126). Since then it has been identified by Switzer (196, p. 817) at the Parker Mountain Mica mine near Center Strafford, and by Megathlin (144, p. 578) in the French mine, Alstead. It is relatively abundant in places at the Ruggles mine, Grafton. Autunite has been identified also in the towns of Alexandria, Groton and Raymond.

Use or Importance: It is of no commercial value in New Hampshire but is of interest to mineral collectors.

AZURITE, $Cu_3 (CO_3)_2 (OH)_2$

Hawes describes this deep blue mineral with its common associate, malachite, at Franconia (103, p. 131). Hitchcock observed it in the old copper mines of Littleton, Monroe, Lyman, and Bath (110, Vol. III, pt. V, p. 37-56).

Use or Importance: In some areas azurite is an ore of copper. The New Hampshire material has not been found in commercial quantities.

BARITE, $BaSO_4$

Barite is found in bunches in the specular hematite on Cross Hill, Piermont (103, p. 126) and noted in the fluorite deposits of Westmoreland by Bannerman and Stoiber (36, p. 6).

Use or Importance: Used mainly as a filler in rubber, paper, etc.; it has not been found in commercial quantities in New Hampshire.

BARKEVIKITE (See under Amphibole Group)

BERAUNITE, $Fe''Fe_4''' (PO_4)_3 (OH)_5.3H_2O$

Beraunite occurs at the Palermo mine at North Groton as an alteration product of triphylite. It is most commonly found as radiated foliated globules and crusts or as radial-fibrous aggregates; also as discoidal concretions with coarse fibrous structure. It has a vitreous luster and is usually reddish brown to dark hyacinth red or blood red. The fibrous beraunite at the Palermo mine is green. (Palache, 27, Vol. II, p. 959-960).

Use or Importance: None is known.

BERTRANDITE, $H_2Be_4Si_2O_9$

Bertrandite, a hydrated silicate of beryllium, has been identified at the Smith mine, Raymond, and at Beryl Mountain near West Andover. It occurs in small tabular or prismatic crystals and is colorless to pale yellow. Bertrandite is commonly associated with beryl and occurs in cavities formerly occupied by beryl crystals. At Beryl Mountain, Andover, bertrandite occurs as pseudomorphs after beryl and as individual crystals (Seaman, 180, p. 608-609).

Use or Importance: None is known.

BERYL, $Be_3Al_2Si_6O_{18}$

Beryl is common in the feldspar and mica-producing areas of the state. Crystals up to a foot across are not unusual. The large ones are generally fractured and may contain numerous inclusions of

other minerals. The color is usually bluish or yellowish green, but golden and white beryl have been found.

Holden (113, p. 199-200) and Flint (83, p. 21-22) describe large specimens which have been quarried at Beryl Mountain, Acworth. The diameter of the largest is 36 inches. A Mr. Edwards had a five-ton crystal uncovered at this locality, but did not take it from the quarry. It has been removed by mineral collectors. All of the beryl exposed in the pit at Beryl Mountain, Acworth, was mined during the latter part of World War II. In 1952, four large crystals were exposed and estimated to contain about 10 tons of beryl at the Osborne mine, Alstead. One of the crystals was 5 by 1.5 by 1.5 feet, another 3.5 by 2.5 by 2.5 feet, a third, 3.3 by 4.5 by 3.4 feet, the largest was approximately 6 feet long and about 2 feet in diameter. Some light green beryl crystals have been collected in Ossipee.

Aquamarine and golden beryl varieties have been reported by Megathlin in the Gilsum area (144 p. 175) and by Larrabee in Grafton (133, p. 38, 55). Gem quality material of both varieties has been found in these localities. A limited amount of gem quality aquamarine has been obtained near Center Strafford and Alexandria. Other towns in which beryl has been noted by Hawes (103, p. 66) are Acworth, Canaan, Wilmot, Springfield, Danbury, Rumney, Chatham, Campton, New Ipswich, Sullivan, Plymouth, New London, Millsfield, Groton and Warren.

Morganite is the name for pink beryl. It has been reported only at the Chandler mine, Raymond. *White beryl* has been found at the Eight Ball mine, Rumney.

Use or Importance: Gem quality beryl has long been sought in the New Hampshire pegmatites. At present beryl is an important ore of beryllium which is used chiefly as an alloy with copper. Beryllium oxide is used in ceramic, refractory and abrasive products. Pure beryllium metal is used in the plutonium atomic energy plants. Since 1942 New Hampshire has produced more than 250 tons of beryl, but known reserves are limited.

BERYLLONITE, $NaBe(PO_4)$

Beryllonite is a phosphate of sodium and beryllium which occurs at the Smith mine, Newport. Beryllonite has a vitreous to brilliant luster and is colorless to snow-white or pale yellow. Crystals (monoclinic) are tabular to short prismatic and have a marked orthorhombic pseudosymmetry. The pegmatite at the Smith mine contains secondary hydrothermal minerals "which occur as drusy crystals in

small solution cavities — beryllonite, albite, brazilianite, in composite growths as well as single crystals, twinned amblygonite crystals, tiny colorless and purple hexagonal prisms of apatite and siderite." (Mrose, 153, p. 932).

Use or Importance: None is known.

BIOTITE (See under Mica Group)

BISMUTH, Bi

Native bismuth is reported from Sunapee Mountain, near Newbury (110, Vol. III, pt. V, p. 68).

Use or Importance: It is used largely in medical preparations and low melting-point alloys. There is no production in New Hampshire.

BISMUTHINITE, Bi_2S_3

Bismuthinite is a rare mineral which occurs in scheelite-bearing quartz veins at Holts Ledge, Lyme. It resembles stibnite (Sb_2S_3) and is commonly massive with a foliated or fibrous texture. Crystals are usually acicular and striated. The mineral was reported originally by Flint (field notes for the N. H. State Planning & Development Commission), and is associated with scheelite, molybdenite and powellite.

Use or Importance: An ore of bismuth.

BOG IRON (See under Limonite)

BOG MANGANESE (See under Psilomelane)

BORNITE, Cu_5FeS_4

This ore of copper is found in limited amounts in a number of the metal-bearing deposits of the state. Hawes states that large specimens have been found in the copper deposits of Dalton, and noted its association with chalcopyrite in Littleton and with chalcopyrite and cassiterite in Jackson (103, p. 29). Larrabee (133, p. 83-84) reports its presence in the Mascot lead mine, Gorham, and in the Shelburne lead mine. Emmons (81) states that bornite is present in varying amounts at the Milan mine. Small amounts of bornite were noted at the Westmoreland fluorite deposits by Bannerman (40, p. 4).

Use or Importance: It is an ore of copper, but no deposits of commercial value are known in New Hampshire.

BRAZILIANITE, $NaAl_3(PO_4)_2(OH)_4$

The second known occurrence of brazilianite, a basic phosphate of aluminum and sodium, was discovered at the Palermo mine, North Groton. Brazilianite occurs also at the Smith mine, Newport. Some

of the crystals at the Palermo mine are as much as one inch long but averaged one-quarter inch. The color is pale yellow to chartreuse yellow. Brazilianite is associated with whitlockite, apatite, and quartz, and occurs in drusy cavities as an alteration product of triphylite. (Frondel and Lindberg, 93, p. 135-141).
Use or Importance: None is known.

BROOKITE, TiO_2

This orthorhombic form of titanium dioxide has been found by Gillson (99, p. 312) in druses of the North Conway granite. It is present as minute crystals, probably always pseudomorphic after ilmenite, as in the case of anatase.
Use or Importance: It is of no commercial importance.

BUHRSTONE (See under Quartz)

BYTOWNITE (See under Feldspar Group)

CACOXENITE, $Fe_4(PO_4)_3(OH)_3 \cdot 12H_2O$

Holden believes that the finely fibrous yellow mineral he found in a pegmatite at Deering associated with dufrenite, is cacoxenite, despite the fact that the indices are somewhat higher than in published figures for this mineral (115, p. 206-207).
Use or Importance: It is of no commercial value.

CALCITE, $CaCO_3$

This mineral predominates in limestone and marble. High grade limestone deposits are unknown in New Hampshire. Some old limestone quarries are noted by Hadley and Chapman in Orford (101, p. 23). Other towns where calcite has been found are Haverhill, Littleton, and Meredith. Hawes states that good crystals have been found in Amherst, Surry, and Warren. The variety *argentine,* with silver luster, was found at the old iron mine at Lisbon (103, p. 127). Clear amber and translucent white cleavable masses have been collected in the calcite veins in Rand's Quarry, Portsmouth. Small amounts of secondary calcite are present in many of our igneous rocks. An interesting occurrence is the presence of snow-white calcite amygdules in some of the basic dikes of Portsmouth, Newcastle and Rye. Bannerman (40, p. 4) noted the occurrence of calcite at the Westmoreland fluorite mines.
Use or Importance: Calcite is used in large amounts in the manufacturing of lime and Portland Cement. It is the predominating material in limestones and marbles which are used for building and ornamental purposes.

In recent years increasing amounts of rock wool are being used in insulating New Hampshire buildings. Some of the impure limestones of the western part of the state, high in silica and alumina, could probably be used in the manufacture of this material.

CASSITERITE, SnO_2

The first tin deposits found in the United States were discovered in the town of Jackson about 1840. Four veins, bearing the mineral cassiterite, are described by C. T. Jackson. The widest portion of any of the veins was 8 inches and the usual width was under 1 inch (121, p. 139-140). Small amounts have been found in Lyme (103, p. 44) and Strafford (196, p. 817). According to Weeks and Leggett (personal communication) small cassiterite crystals have been found on the southwest flanks of Grant's Peak, Ossipee.
Use or Importance: Cassiterite is the most important source of tin. Although the New Hampshire deposits seem too lean to be of commercial value, the possibility of finding a deposit of this important mineral should not be overlooked.

CHALCOCITE, Cu_2S

Small amounts have been identified in the copper-bearing mineral deposits of Orford. The chalcocite is associated with chalcopyrite and malachite (103, p. 30). Emmons (81) has found a little chalcocite at the Milan mine.
Use or Importance: Chalcocite is an ore of copper. It has not been found in commercial quantities in New Hampshire.

CHALCOPYRITE, $CuFeS_2$

This important ore of copper was diligently sought in New Hampshire during the 19th century. Numerous mines and prospects were opened, but none is operating today.

Chalcopyrite has been identified in Bath, Berlin, Franconia, Haverhill, Jackson, Lyman, Lyme, Madison, Milan, Monroe, Shelburne, Unity, Warren, Westmoreland, Littleton, Pittsburg, Croydon, Plainfield, and Orford (103, p. 32; 110, Vol. III, pt. V, p. 37-56).
Use or Importance: Chalcopyrite is the most important ore mineral of copper. Unfortunately, though some has been produced in the past, it has not been found in deposits of sufficient size or concentration in New Hampshire to compete with the present large-scale production of other areas.

CHIASTOLITE (See under Andalusite)

CHLORITE GROUP

A number of chlorite species have been recognized in New Hampshire. Our knowledge of the group is not complete, and many writers have used the group name only. Members of the group are widely distributed, often in considerable abundance, in many low-grade metamorphic rocks and altered igneous rocks. A general formula for chlorite is $(Mg,Fe)_5 (Al,Fe''')_2Si_3O_{10} (OH)_8$.

AMESITE, $Mg_4Al_2 (OH)_8Si_2Al_2O_{10}$

This chlorite species has been identified by C. Chapman in the kyanite schists of Plainfield (61, p. 171-172).

DIABANITE, $H_{18} (Fe,Mg)_{12}Al_4Si_9O_{45}$

Billings found this rather rare chlorite to be abundant in the metamorphosed basic dikes and sills of the Littleton-Moosilauke quadrangle (50, p. 512).

PENNINITE, $H_8 (Mg,Fe)_5Al_2Si_3O_{18}$

This type is present in the Post Pond member of the Orfordville formation, Mascoma quadrangle, particularly north of Gleason Cemetery (61, p. 171-172). It is abundant also near Sawyers Station, Dover.

PROCHLORITE; $H_4Mg_3Si_2O_9H_4Mg_2Al_2SiO_9$

A fairly common type of chlorite, probably present in the Littleton and Orfordville schists (61, p. 172). It is abundant in the contact zone flanking the diabase dikes along the Carriage Road, Mt. Washington (103, p. 119). Worm-like books of this mineral have been found by Gillson in the druses of the North Conway granite (99 p. 313).

STRIGOVITE, $H_4Fe_2 (Al,Fe)_2Si_2O_{11}$

This chlorite, a quite rare type, has been found in druses and clefts of the North Conway granite by Gillson (99, p. 313).
Use or Importance: The chlorites are important as rock-forming minerals.

CHLOROPAL, $H_4Fe_2Si_2O_9$

Nontronite, a variety of chloropal occurs as a light yellow powder in druses of the North Conway granite (99, p. 312).
Use or Importance: It is of no commercial value.

CHLOROPHYLLITE, (See under Cordierite)

CHROMITE, $FeCr_2O_4$

A small amount has been found in the soil in Dublin (103, p. 44).
Use or Importance: It is an ore of chromium, but not known in commercial quantities in New Hampshire.

CHRYSOBERYL, $BeAl_2O_4$

Chrysoberyl has been found in a narrow vein which cuts through the granite at Orange Summit (103, p. 44).

Pale yellowish-green, transparent plates, found in a pegmatite in the garnet mine of the Wasau Abrasives Company, Wilmot, have been identified as ordinary chrysoberyl. Bannerman (38, p. 10) reports dull moss green tabular crystals as one of the rare minerals at the Ruggles mine, Grafton. Yellow to apple-green chrysoberyl has been identified at the Weeks feldspar quarry, Wakefield, by Chayes (75, p. 320-322). It was found coating or cutting beryl, or embedded in feldspar directly in contact with beryl crystals.
Use or Importance: The ordinary variety of chrysoberyl described above has no commercial value. Some varieties are used as gem stones.

CHRYSOLITE (See under Olivine Group)

CLARKEITE (See under Gummite)

CLEAVELANDITE (See under Feldspar Group)

CLINOZOISITE (See under Epidote Group)

COLUMBITE, $(Fe,Mn) (Cb,Ta)_2O_6$

This rather rare mineral, ordinarily containing appreciable amounts of tantalum, has been identified in several pegmatite deposits. Hawes notes columbite in Acworth and Plymouth (103, p. 121). Modell has obtained columbite from the Allen mine in Alstead (148, p. 18). At Center Strafford, Switzer has found small, widely-scattered, tabular crystals which are usually in second generation quartz (196, p. 816). Bannerman (38, p. 10) reports stubby brownish to black crystals at the Ruggles mine, Grafton.

In addition, columbite occurs in the following mica or feldspar mines: Pattuck and E. E. Smith, Alexandria; Weeks, Wakefield; Colony, Alstead; Beryl Mountain, Andover; Smith and Chandler, Raymond; and in the towns of Nottingham and Ossipee.
Use or Importance: Columbite commonly contains varying amounts

of tantalum which is used chiefly as a metal. Columbium is used as a ferro-alloy in the manufacture of stainless and heat and corrosion resisting steels. Tantalum metal, due to its good heat conductivity, high melting point and resistance to many chemical reagents, is used as a coating or lining material. Metallic tantalum is used in making of spinarets used in the production of rayon and in making surgical instruments. Both tantalum and columbium have the capacity to absorb large volumes of gases in radio and electronic tubes.

COPPER, Native-Cu

Metallic copper is a rare mineral in this state. Hitchcock observed small amounts at the tin mine in Jackson (110, Vol. III, pt. V, p. 67). Hawes notes that dendritic copper is reported from Lyman and Orford (103, p. 23).

Use or Importance: It is an ore of copper.

CORDIERITE, $Mg_2Al_4Si_5O_{18}$

This mineral was known to Hawes as iolite. It was found in Richmond when a soapstone quarry was being opened. He describes it as follows: "Very fine specimens of this beautiful mineral are found at Richmond. It occurs in the quartz rock and mica schist. Its color is blue, but its dichroism is very marked — one species being blue when the light passes in the direction of the vertical axis, and brownish-violet when it passes at right angles thereto, the two colors obtained parallel to the two lateral axes being not markedly different." He notes its presence also in Unity and Croydon (103, p. 77).

About 5 per cent of cordierite is reported by Williams and Billings in the cordierite schist and sillimanite-cordierite schist of the Franconia quadrangle (206, p. 1018).

Conant describes small, somewhat smoky, and slightly bluish grains in Stoddard. It is present in the local granite and is quite unusual in that it is optically positive (76, p. 310-311). A hydrous alteration product of cordierite, *chlorophyllite,* has been identified in Richmond and Unity (103, p. 77).

Heald (104, p. 15) states that cordierite "Occurs in many outcrops along Route 123 south of Island Pond in Washington."

Use or Importance: Cordierite is sometimes used as a gem stone.

CORUNDUM, Al_2O_3

This mineral is present in a number of the plutonic rocks of the Belknap Mountains area in amounts up to 4.28 per cent (149, p. 1897).

Use or Importance: Used in the abrasive industry; New Hampshire corundum has not been found in commercial quantity.

CRANDALLITE - DELTAITE SERIES

Mrose (155, p. 354) notes the possible occurrence of the crandallite-deltaite series among the late hydrothermal minerals at the Palermo mine, North Groton. The associated minerals include siderite, beraunite, whitlockite, brazilianite, apatite and quartz crystals.

Use or Importance: None is known.

CROCIDOLITE (See Amphibole Group)

"CYMATOLITE" (See under Spodumene in the Pyroxene Group)

CYRTOLITE, $ZrSiO_4$

Cyrtolite is an alteration product of zircon that contains uranium, yttrium, and other rare elements. It occurs at the Palermo mine, North Groton, as brownish red or chocolate-colored masses up to one inch in diameter (Verrow 200, p. 208-211).

Use or Importance: None is known.

DANAITE (See under Arsenopyrite)

DANALITE, $3(Fe,Zn,Mn)BeSiO_4.ZnS$

It has been found associated with magnetite and quartz in the iron mine at Bartlett (13, p. 436).

Use or Importance: It is of no commercial importance.

DIABANTITE (See under Chlorite Group)

DIATOMITE

Diatomite, or diatomaceous earth, consists of accumulations of siliceous shells of microscopic aquatic organisms, principally diatoms and radiolaria. These shells are composed of a hydrous or opalescent form of silica. The deposits may form wherever there is an abundance of these microscopic organisms, either in fresh or saline water. At present, material is accumulating in the so-called "chalk ponds." In most places in New Hampshire the deposits are buried beneath beds of peat. Borings made in a number of peat bogs have usually revealed beds of diatomite up to a foot or more in thickness. The peat itself is seldom free from the microscopic, siliceous skeletons.

McNair (140, p. 1-9) examined deposits in Stark, Livermore, Tamworth, Madison, Ossipee, Effingham, Orange, Danbury, Springfield, Newbury, Warner, Alstead, Richmond and Fitzwilliam.

Use or Importance: Diatomite is used as an abrasive (ingredient in

some soaps, silver and metal polishes) as a filter and as material in heat and sound insulation.

DIOPSIDE (See under Pyroxene Group)

DOLOMITE, $CaMg(CO_3)_2$

Dolomite occurs in small amounts in the impure metamorphosed limestones in the western part of the state. Some impure gray dolomite is noted by Hawes in Lyman and Plainfield (103, p. 130).

Use or Importance: Dolomite is of considerable importance outside New Hampshire for building, metallurgical and agricultural purposes.

DRAVITE (See under Tourmaline Group)

DRUFRENITE, $Fe'',Fe_4''' (PO_4)_3 (OH)_5.2H_2O$

Brown to greenish radiating fibrous layers have been identified as dufrenite in a pegmatite at Deering (Holden, 115, p. 206). (Verrow 200, p. 208-211) reported dufrenite and Frondel (94, p. 523) describes radial fibrous crusts and masses of dufrenite altering from triphylite at the Palermo mine, North Groton. The color is variable; greenish-brown to olive green and bronze-brown to reddish-brown. At the Fletcher mine, North Groton, coarse greenish-black, radial fibrous masses of dufrenite occur as an alteration of triphylite (Frondel 94, p. 523). Dufrenite also occurs at the E. E. Smith mine, Alexandria.

Use or Importance: It is of no commercial value.

EOSPHORITE-CHILDRENITE SERIES

EOSPHORITE, $(Mn'',Fe''')Al(PO_4)(OH)_2.H_2O$

Eosphorite, a rare, hydrated basic phosphate of aluminum with divalent iron and manganese, was discovered by Switzer at the Parker Mountain mine, Center Strafford, where it occurs as small pale brown, poorly-formed crystals or triphylite or its alteration products (196, p. 818). Eosphorite was later identified at the Palermo mine, North Groton. The crystals have a light brown color and are associated with other iron-manganese phosphates (Hurlburt 119, p. 799-800).

The mutual substitution of iron and manganese forms a complete isomorphous series between eosphorite and childrenite. The identification of childrenite in some of the New Hampshire pegmatites is tentative.

Use or Importance: None is known.

EPIDOTE GROUP

Representatives of this group are widely distributed in the state, but usually in small amounts.

ALLANITE, $R_2''R_2''' (SiO_4)_3 (OH)$ R''=Ca,Ce,La,Na R'''=Al, Fe,Mn,Be,Mg

Allanite is a characteristic accessory mineral of the White Mountain plutonic series (71, p. 1042). It has been recognized in certain members of these plutonic series as follows: by Billings (47) and Gillson (99) in the North Conway area, R. Chapman (72) in the Percy quadrangle, and Kingsley (127) in the Ossipee Mountains. Allanite has been recognized by Dale (78, p. 182) in the Milford granite and in granite at Manchester.

Traces of allanite have been noted in each of the four plutonic series in New Hampshire, but it is most abundant in the White Mountain plutonic series in which the radioactivity is twice as great as the other plutonic series. By comparison, the White Mountain plutonic series is considerably more radioactive than rocks of similar type in North America. Billings and Keevil (53, p. 810) conclude "that the increase in radioactivity in the granitic end of the White Mountain plutonic series is due primarily to the appearance of allanite, and secondarily, to an increase in the amount of zircon."

Use or Importance: Allanite is a minor rock-forming mineral.

CLINOZOISITE, $Ca_3Al_3 (SiO_4)_3 (OH)$

This species has been identified in the trachyte of North Conway and Belknap Mountains areas (71, Table 2). Small amounts have been identified in gneiss near Plainfield (Lyons 139, p. 121).

Use or Importance: It is a minor rock-forming mineral.

EPIDOTE, $Ca_2 (Al,Fe)_3 (SiO_4)_3 (OH)$

The material given under this species may include data that should be given under other minerals of the group, as some writers may not have carried their determinations beyond the group to which their material belonged.

Hawes notes the occurrence of epidote in light-yellow acicular crystals at Lisbon. Some of the larger forms are present as well as the twin and massive types. Bannerman reports bright green epidote at Ore Hill, Lisbon (37, p. 6), and moss green

epidote at Ore Hill, Warren (37, p. 7). In Jackson, immense crystals up to 8 inches in diameter have been found. Other towns where it has been identified are Bedford, Gilmanton, Hanover, Portsmouth, and Exeter (103, p. 76).

C. Chapman has found up to 20 per cent in the Orfordville formation and 45 per cent of this mineral in the green bands of the Fitch formation (61, p. 133, 139).

Epidote has been recognized as a common secondary mineral in the volcanic rocks of the White Mountain plutonic series (71, Table 2).

Use or Importance: It is the most common species of the epidote group in New Hampshire.

ZOISITE, $Ca_2Al_3(SiO_4)_3(OH)$

Hawes (103, p. 77) reports the presence of zoisite as ash-gray, compressed, deeply striated crystals at Westmoreland. It is also present at Franconia and Hanover. Bannerman (37, p. 6) reports its presence at the Ore Hill mine at Warren. Small amounts of zoisite were identified by Chapman (69, p. 393) in the Bethlehem gneiss of the Sunapee quadrangle.

Use or Importance: It is occasionally found as a rock-forming mineral.

α-EUCRYPTITE, $LiAlSiO_4$

α-Eucryptite (Mrose 154, p. 353) occurs at the Parker Mountain mine at Center Strafford. It is intergrown with albite and both minerals are a result of the alteration of spodumene. The intergrowth of eucryptite and albite form almost perfect euhedral pseudomorphs after spodumene.

Use or Importance: None is known.

FAIRFIELDITE, $Ca(Mn,Fe)(PO_4)_2.2H_2O$

Fairfieldite is another specie of the rarely recognized phosphates found by Switzer (196, p. 816) in the Parker Mountain mine at Center Strafford. It is present as pale, salmon-pink, fine-grained masses associated with rhodochrosite and triphylite. Fairfieldite has also been recognized in sheaf-like aggregates at the Palermo mine, North Groton (Wolfe 207, p. 94-97).

Use or Importance: This mineral has no commercial value.

FAYALITE (See under Olivine Group)

FELDSPAR GROUP

The feldspar group not only is the most abundant, but at the present time it is also the most important economic mineral group in the state. Species and varieties of feldspar will be described briefly under two divisions.

A. POTASH (Orthoclase and microcline) DIVISION

ORTHOCLASE, $KAlSi_3O_8$

Orthoclase is widely distributed in New Hampshire. It is probably the most abundant potash feldspar in our granites and related acidic igneous rocks which commonly contain 30 to 50 percent orthoclase. Phenocrysts of orthoclase are both conspicuous and abundant in the Kinsman quartz monzonite and Meredith porphyritic granite, and in places they are as much as 2 inches in length (109, Vol. II, pt. II, p. 8-10; 47, p. 83; 50, p. 506-507; Chapman, 69, p. 411-414). Carlsbad twinning is common. Mineralogical specimens are reported by Hawes at Acworth and Grafton (103, p. 98).

Adularia, a colorless and transparent to translucent variety, has been identified by Stewart, (193, p. 274) near Center Strafford. Here small crystals were found replacing vesuvianite. Adularia occurs also at Hurricane Mountain, Conway, according to Millard Chandler (personal communication).

MICROCLINE, $KAlSi_3O_8$

Microcline is another type of potash feldspar and is widely distributed in New Hampshire, particularly in the pegmatites and some granites. Some of the phenocrysts in the Kinsman quartz monzonite and Meredith porphyritic granite are microcline.

Red-brown to pink microcline crystals up to 10 inches in diameter have been found by Gillson in the North Conway granite druses (99, p. 313). The green variety, *amazonstone,* or *amazonite,* has been noted by Hawes at the "Notch," presumably Crawford Notch (103, p. 102). *Anorthoclase,* soda microcline, is present as phenocrysts in the bostonite of the Moosilauke quadrangle (Billings, 50, p. 514). Graphic granite is a result of an intimate intergrowth of microcline and quartz. It occurs in most pegmatites, but in a few it forms large bodies, some of which have been mined.

"PERTHITE"

"Perthite" is a mixture of either microcline or orthoclase, and albite. Locally it is called "potash spar." The color is commonly white to cream, bluish white, gray and rarely pink or flesh colored. The albite is distributed in irregular and discontinuous ribbons or bands. "Perthite" is probably the most abundant feldspar in the pegmatites. Most of the feldspar produced in New Hampshire is mined from large bodies of perthite. At present (1955) it is mined principally at the Colony mine, Alstead; Ruggles mine, Grafton; and the Brown Lot No. 10 mine, Groton.

Microperthite is composed of microscopic intergrowths of microline and albite. It is common in many New Hampshire granites, but is the most characteristic feldspar in the acidic rocks of the White Mountain plutonic series (53, p. 803).

B. SODA-LIME (Plagioclase) DIVISION

These soda-lime feldspars form an isomorphous series varying in composition from soda-rich albite to the lime-rich anorthite.

ALBITE, $NaAlSi_3O_8$

Albite is widely distributed and commonly present in many of the low-grade metamorphic rocks, and in a number of granites and syenites and their extrusive equivalents. As noted above, considerable amounts of albite are present in perthite. Albite is the principal feldspar in some of the mica-bearing pegmatites.

Gillson has found glassy albite crystals deposited on microcline in the druses and clefts of the North Conway granite (99, p. 311). The variety, *cleavelandite,* has been noted in a few localities such as the McConnell mine in Orange (98, p. 33), and the mine on Parker Mountain, Strafford (196, p. 815). Bannerman (38, p. 3) has found white to clear well-formed crystals at the Ruggles mine, Grafton. Other cleavelandite localities are Kilton mine, Grafton; Victory (Big) mine, Gilsum; George Porter mine, Alstead; Standard mine, Orange.

OLIGOCLASE

This type of feldspar is fairly common as a rock-forming mineral in some of the low and middle grade metamorphic rocks and in certain of the volcanic and plutonic types. Hawes notes that "suitable specimens" may be obtained from Orange Summit

(103, p. 97). Larrabee reports oligoclase and albite to be the feldspar present in the Kimball Hill mine in Dorchester (133, p. 33).

In addition, oligoclase is common in the border zone of many pegmatites that occur in the Bethlehem gneiss.

ANDESINE

Andesine is present largely in the igneous rocks of the andesitic and dioritic types. Hawes reports clear, glassy, undecomposed crystals in the diorite forming Twin Falls, Dixville Notch. Some of these crystals are an inch or more in size (103, p. 96).

LABRADORITE

Labradorite is abundant in most of the basic volcanics and intrusives, often in amounts up to 40 to 50 per cent. These rocks have wide distribution in the state. Hawes reports large masses of apparently pure labradorite on Mill Mountain in Stark (103, p. 92).

BYTOWNITE

C. Chapman found an amphibolite of the Ammonoosuc volcanics in Dorchester to contain 40 per cent of this feldspar (61, p. 136).

ANORTHITE, $CaAl_2Si_2O_8$

Anorthite has been recognized in a few of the basic igneous and metamorphic rocks. The best specimens noted by Hawes are one inch crystals in diabase at East Hanover (103, p. 90). Modell found it to be quite abundant and rather widely distributed in the plutonic rocks of the Belknap Mountains area (149, p. 1897).

Use or Importance of the Feldspar Group:

Feldspar is important as the chief source of alumina used in the ceramic industry, where it is used in the making of glass, pottery, and vitrified enamels and special electrical porcelain. Much smaller amounts are used as an abrasive in scouring soaps and compounds and as a bonding agent or flux for carborundum and emery abrasive wheels.

The pottery industry demands a high grade potash feldspar free from mineral impurities, particularly iron-bearing minerals, and one that contains only small amounts of soda. Only the perthite will satisfy these specifications. At *most* mines it has to be hand cobbed to meet consumer specifications.

In the glass industry the feldspar must be free of mineral impurities, particularly iron, and be high in alumina and alkalis. Some of the pegmatites containing a high percentage of albite may be used; or some that contain perthite which does not meet the specifications of the pottery industry.

A list and location of the feldspar mines is printed on a separate map (see pocket). For a detailed discussion of the feldspar deposits of New Hampshire and a review of the industry, the reader is referred to Cameron (59) and Olson (157).

FERRIMOLYBDITE, $Fe_2(MoO_4)_3.8H_2O$ (?)

This yellow mineral is formed by the alteration of molybdenite with which it is commonly associated. Hawes (103, p. 48) has found ferrimolybdite in cavities in the molybdenite veins at Westmoreland and small amounts at Landaff and Franconia. He notes that the Westmoreland mineral contained 0.6 per cent of uranium oxide.

Use or Importance: A very minor ore of molybdenum; it is of no commercial importance in New Hampshire.

FLUORAPATITE (See under Apatite Group)

FLUORITE, CaF_2

New Hampshire fluorite is quite widely distributed. It is found disseminated in granite, as crystals in quartz veins, and in Chesterfield and Westmoreland it is concentrated sufficiently to have been mined (Bannerman, 40, p. 1-9).

Disseminated fluorite has been noted in several of our granites, and has been found by Chapman and Williams (71) in the acid volcanic and intrusive rocks of the White Mountain plutonic series. Gillson found it to be commonly present in the druses of the North Conway granite (99, p. 312).

Hitchcock found fluorite in the tin deposits of Jackson (110, Vol. III, pt. V, p. 66). Hawes notes sea-green octahedra in quartz veins at the "Notch," presumably Crawford Notch, and a purple type in albite at Grafton and Newbury (103, p. 35).

The largest deposits are at Westmoreland which Bannerman and Stoiber (36) describes as follows:

> "The fluorite deposits in Westmoreland, New Hampshire occur as fissure fillings in a series of tension fractures in granite gneiss. The veins being worked are from 3 to 5 feet in width, and some of them have been traced laterally 500 to 600 feet. They dip approximately 70 degrees; the foliation of the gneiss in which

> they lie is generally quite flat. The veins are banded, crustified, and replete with open cavities. The fluorite is accompanied mainly by quartz, but considerable quantities of barite, calcite, dolomite, kaolin, and sericite are present, and streaks of such sulphides as chalcopyrite, pyrite, sphalerite, and a little galena appear throughout the deposits, together with some finely crystallized malachite and smithsonite. The veins have suffered no appreciable deformation since their deposition. Data at hand suggest that they are of post-Paleozoic age — possibly Triassic."

Use or Importance: The most important users of fluorite are the manufacturers of basic open hearth steel, glass, and hydrofluoric acid.

FRANCOLITE (See Apatite Group)

FRONDELITE-ROCKBRIDGEITE SERIES

FRONDELITE, $(Mn''Fe)(Fe_4'''(PO_4)_3(OH)_5$

ROCKBRIDGEITE, $(Fe'',Mn)Fe_4'''(PO_4)_3(OH)_5$

Frondelite is a new mineral found at the Palermo and Fletcher mines, North Groton. (Lindberg 137, p. 541, 549). It is a basic phosphate of trivalent iron and of divalent manganese and iron. Frondelite is the manganese-rich form and the rockbridgeite, the iron-rich form. Rockbridgeite was identified in 1949 at the Fletcher mine, North Groton. Both minerals are secondary minerals which form as alterations of triphylite. They occur as botryoidal masses and crusts and commonly have a radial fibrous or fine-columnar structure (Palache 27, p. 867-868).

Use or Importance: None is known.

GALENA, PbS

The galena of New Hampshire is generally argentiferous and is quite widely distributed. Unfortunately the known deposits are small and none is being operated today.

The towns where galena has been found are: Alton, Bath, Dalton, Dunbarton, Ellsworth, Enfield, Epsom, Gorham, Haverhill, Hooksett, Lebanon, Lisbon, Loudon, Lyman, Lyme, Lyndeborough, Madison, Meredith, Nashua, Newmarket, Orford, Orange, Pittsburg, Pittsfield, Rumney, Sandwich, Shelburne, Surry, Tamworth, Warren, and Woodstock.

Hitchcock notes "handsome specimens" from North Woodstock (110, Vol. III, pt. V. p. 66).

Use or Importance: Galena is the chief source of lead and the argenti-

ferous variety is an important source of silver. Galena was once actively mined in Madison, Shelburne, and Lyman. Numerous small mines and prospects have been opened in the state. Stories of one sort or another describing rich silver-bearing deposits are to be heard in nearly every New Hampshire town. That such exist, often with high silver content, has been demonstrated in several instances. However, the deposits discovered so far are too small to be of commercial value.

GARNET GROUP

The members of this group comprise another widespread, accessory rock-forming mineral group. Garnet is present, often abundantly, in many of our granites, pegmatites, gneisses, and schists.

ALMANDITE, $Fe_3Al_2(SiO_4)_3$

This is the common species of garnet in New Hampshire. It is widely distributed in many types of rocks, especially our schists and gneisses. Most of the garnet which is not specifically described in our geologic literature is probably of this type.

Hadley and Chapman have obtained large crystals, up to an inch across, from the quartz schist one-half mile southwest of Etna Highlands School in Hanover (101, p. 27). Almandite from the Palermo mine, Groton, coated with some uranium mineral, probably uranochalcite, has been studied by Berman (45). The most important deposits in the state are in Wilmot, Danbury, Andover, and Bradford. Conant, who made a careful study of some New Hampshire garnet deposits, found 30 to 80 per cent concentration of garnet in certain areas. The general range in size of the crystals was from 1/8 to 1/2 inch in diameter. Ordinarily these are strongly fractured, but the individual fragments are quite hard (77, p. 387-399).

Two localities in the Cardigan quadrangle suggested as collecting sites are "due south of Taylor Hill one and one-half miles northeast of Danbury where aggregates of garnet measuring up to three inches are prominent and in the Fowler River in the road cut one mile southwest of Sugarloaf Mountain" (85, p. 21).
Use or Importance: Unfractured almandite, of proper color and clarity, is used to a limited extent as a gem stone. Its greatest importance, however, is as an abrasive. New Hampshire was an active producer of garnet abrasive for many years. Recently local production has ceased, presumably due to severe competition

offered by large producers of garnet in New York state and by artificial abrasives.

ALMANDITE-SPESSARTITE

This garnet, containing both iron and manganese, was found in a single mass several feet in diameter at Center Strafford. The color is red and individual crystals up to 2 inches in diameter were noted (196, p. 816).

ANDRADITE, $Ca_3Fe_2(SiO_4)_3$

Hawes has described deep blood red to nearly black massive andradite beautifully crystallized in geodes at Franconia (103, p. 71).
Use or Importance: It is used as a gem stone.

GROSSULARITE, $Ca_3Al_2(SiO_4)_3$

This calcium garnet ordinarily brown in color, is quite abundant at Warren and Amherst. Crystals up to 4 inches in diameter have been found in limestone or in crystallines near their contact with the limestone (103, p. 71).

A similar occurrence of grossularite has been noted by Stewart (194, p. 510) during the excavation of the site for the new Armory, Manchester.
Use or Importance: It is used as a gem stone.

SPESSARTITE, $Mn_3Al_2(SiO_4)_3$

This species of garnet is often found in mica schists. Especially fine crystals have been found in the mica schist of Springfield (103, p. 71).
Use or Importance: It may be used as a gem stone.

GOLD, Au

Gold has been found in limited amounts in a number of New Hampshire towns. It is present in gold-quartz veins, placer deposits, and as an accessory in veins containing sulphides of copper, lead, or zinc.

The area of greatest importance, which lies in Lisbon and Lyman, was called the Ammonoosuc Gold Field by Hitchcock. The gold-bearing veins contain native gold, pyrrhotite, chalcopyrite, ankerite, and galena. The Dodge mine in Lyman is reported to have produced over $46,000 in gold according to Hitchcock's report of the area in 1878 (110, Vol. III, pt. V, p. 7-31). Ross, in 1923, describes the gold veins of this same district as "small, discontinuous, and more

or less lenticular" (174, p. 291-293). In addition to the gold in veins, small amounts of placer gold have been found in the Ammonoosuc district.

Placer gold has been recovered from time to time in the headwaters of Indian Stream, Pittsburg (110, Vol. III, pt. V, p. 5), and in some of the streams in Lyme. Leggett (personal communication) reports that small amounts of gold have been panned along the Baker River, and Hurricane Brook, both in Warren.

A recent description of New Hampshire's gold deposits and the history of their development is given by Bannerman (37, p. 8-9).
Use or Importance: From the information available, it must be concluded that the gold deposits of New Hampshire are small, and, so far as discoveries to date are concerned, unimportant. High overhead, with limited and variable income, due to wide variations of value in a deposit, have caused the cessation of gold mining in the state.

GOYAZITE, $SrAl_3(PO_4)_5H_2O$

Goyazite, a hydrated basic phosphate of aluminum and strontium, is associated with palermoite as a late hydrothermal product at the Palermo mine, North Groton. It occurs in small colorless to white rhombohedral crystals.

"The mineral association includes siderite, childrenite-eosphorite, green fibrous beraunite, crandallite-deltaite, whitlockite, brazilianite, tiny white hexagonal prisms of apatite, and small quartz crystals" (Mrose, 155, p. 354).
Use or Importance: None is known.

GRAFTONITE, $(Fe,Mn,Ca)_3(PO_4)_2$

This rare mineral which bears the name of a New Hampshire town was first identified by Penfield (159, p. 20-32) in material from the south side of Melvin Mountain, Grafton. Since then Berman (45, p. 170-172) has found the mineral in the Palermo mine in Groton. Here the graftonite occurs as clear brown bands, alternating with bands of deep purple heterosite, an alteration product of triphylite.

Switzer (196, p. 814-815) has found small reddish-brown intergrowths of graftonite with triphylite near Center Strafford.

Bannerman (38, p. 3) reports salmon pink to clove brown graftonite, usually intimately intergrown with triphylite, at the Ruggles mine, Grafton.

Other graftonite localities are Draper, Nancy No. 2, Rice, and Union mines, North Groton; Balla mine, Acworth; Keyes No. 1, Orange; and the Sargeant mine, Claremont.

Use or Importance: It is of importance only as a rare pegmatite mineral.

GRAPHITE, C

Graphite in limited amounts is present in many parts of New Hampshire. It is fairly common as microscopic particles or scales in many of our schistose rocks and is occasionally found in quartz veins.

At one time a number of graphite prospects were opened and a few developed commercial production. Hitchcock (110, Vol. III, pt. V, p. 91) states that Goshen had the most extensive mine, which was formerly owned by President Pierce. The graphite was present in a pyritiferous mica schist on the flank of Sunapee Mountain.

Other towns in which graphite has been identified are Antrim, Barrington, Bedford, Bristol, Chester, Hancock, Harrisville, Hillsborough, Keene, Nelson, Orford, Salisbury, Strafford, Sutton, Troy, Walpole, Washington, and Wentworth.
Use or Importance: Graphite has many important uses, as in electric furnace electrodes, crucibles, lubricants, and lead pencils. However, the small size and grade of our known deposits prohibit commercial production in competition with large-scale production of both natural and artificial graphite elsewhere.

GREENOCKITE, CdS

A number of chemical analyses of New Hampshire sphalerite show the presence of cadmium up to three or more per cent. The presence of greenockite in the sphalerite is therefore inferred.
Use or Importance: Cadmium is used chiefly in the manufacture of bearing alloys and for electroplating. There is no commercial production of this metal in New Hampshire.

GROSSULARITE (See under Garnet Group)

GUMMITE, $UO_3.nH_2O$ (always contains PbO and usually rare earths)

A tentative determination of a bright orange-colored mineral surrounding uraninite indicates that it may be gummite. It is found quite commonly at the Ruggles mine, Grafton. A brownish-orange associate, with an index of refraction much higher than that of gummite, may be *clarkeite.*
Use or Importance: The known occurrences are not large enough to be of commercial value as an ore of uranium.

HACKMANITE (See under Sodalite)

HALITE, NaCl

Small but perfect crystals are often found along the rocky portions of the coast in partially or completely evaporated splash pools.
Use or Importance: This occurrence of halite illustrates the evaporation pan method of extracting salt from sea water.

HASTINGSITE (See Amphibole Group)

HEDENBERGITE (See Pyroxene Group)

HEMATITE, Fe_2O_3

A number of small deposits of this ore of iron have been found in New Hampshire. Hitchcock (110, Vol III, pt. V, p. 56-62) and Hawes (103, p. 38) note its presence in Bartlett, Benton, Franconia, Jackson, Lebanon, Lisbon, Piermont, and Rindge. Billings (47, p. 126) has examined the Iron Mountain mine deposit in Bartlett. He found the hematite in irregular bodies which replaced the Conway biotite granite.

The *micaceous* variety of hematite has been found in Piermont (110, p. 61).
Use or Importance: The irregularity of form and small size of the New Hampshire deposits does not permit production in competition with the far larger deposits of the Lake Superior district.

HETEROSITE, $(Fe''', Mn''')(PO_4)$

This mineral, an alteration product from triphylite, has been identified in three localities in New Hampshire. Berman (45, p. 170) found it in both the Valencia and Palermo mines near North Groton, while Switzer (196, p. 818) identified it in the pegmatite near Center Strafford. The color is generally a deep purple.
Use or Importance: This mineral has no known commercial value.

HIDDENITE (See under Spodumene, Pyroxene Group)

HORNBLENDE (See under Amphibole Group)

HURLBURTITE, $CaBe_2(PO_4)_2$

Hurlburtite, a phosphate of calcium and beryllium, occurs at the Smith mine, Newport. It forms colorless to greenish white crystals, 4 to 25 millimeters long, and has a vitreous to greasy luster. It is intimately associated with triphylite but occurs in a mineral assemblage of muscovite, albite, massive smoky quartz and triphylite. (Mrose 153, p. 296).
Use or Importance: None is known.

HYALOSIDERITE (See under Chrysolite, Olivine Group)

HYPERSTHENE (See under Pyroxene Group)

IDOCRASE (Vesuvianite), $Ca_{10}Al_4(Mg,Fe)_2Si_9O_{34}(OH)_4$

Hawes (103, p. 76) notes the presence of fine large crystals at the contact of limestones with siliceous schists in Amherst and Warren. More recently, Stewart (193, p. 274-275) found radiating columnar masses and some incomplete crystals in occasional pockets in a deposit located one mile east of Center Strafford village. Idocrase, associated with other contact minerals, is present also at the site of the new Armory at Manchester.
Use or Importance: Vesuvianite has no known commercial value.

ILMENITE, $FeTiO_3$

Ilmenite is widely distributed in small amounts in many of the rocks of the State as an accessory mineral. Chapman and Williams (71, Table 1) report 6.7 per cent present in the gabbro of Tripyramid Mountain and 5.0 per cent in the same type of rock in the Belknap Mountains.

This mineral has been found associated with hematite or magnetite, in Amherst, Bartlett, Jackson, Lisbon, Piermont, Rindge, and Unity (103, p. 39).
Use or Importance: It is of interest as a common accessory mineral in many localities.

INDICOLITE (See under Tourmaline Group)

IRON, Fe

Minute grains of native iron have been found by Hawes (103, p. 23) imbedded in chrysolitic gabbro from Mount Washington.
Use or Importance: This iron has no commercial value.

JASPER (See under Quartz Group)

KALINITE, $KAl(SO_4)_2.11H_2O$ (?)

This type of potash alum has been found as an efflorescence upon schists. It is a result of sulphuric acid acting upon feldspar. Kalinite has been noted in Bath, Bedford, and Walpole (103, p. 126).
Use or Importance: This mineral is present in such small amounts that it has no commercial value.

KAOLINITE, $Al_2Si_2O_5(OH)_4$

Kaolinite, one of the principal clay minerals is derived by the alteration of aluminum silicates, particularly feldspar. During the

last fifteen years considerable research has been done on the identification of the clay minerals with the aid of the x-ray, thermal analysis, and electron microscope. Little is known about the clay minerals contained in the glacial or glacio-marine clays of New Hampshire. However, it is reasonable to assume that kaolinite, and one or more of the other clay minerals, is present in the widespread deposits along the coast and in the deposits along the Connecticut and Merrimack river valleys.

Megathlin (144, p. 166) reports kaolinization in the pegmatites of the Alstead and Gilsum area. He found it to have occurred to a depth of 125 feet in one place. Hawes (103, p. 74) notes that the "mountain cork" present in cavities in the slaty rock at Franconia approaches kaolin in composition.

Use or Importance: At present our clay is used only in making brick. A possible future product is to use the clay as the principal ingredient in the manufacture of lightweight aggregate. If a low cost treatment could be developed to remove deleterious materials, New Hampshire clay might be used as a filler in paper.

KNEBELITE (See under Olivine Group)

KUNZITE (See under Spodumene, Pyroxene Group)

KYANITE, Al_2SiO_5

Kyanite has been found in a number of New Hampshire localities. In at least two localities it is relatively abundant. C. Chapman (61, p. 134) states that this mineral may make up 35 per cent of the kyanite schist at Signal Hill, Lebanon. Here crystals, 1 inch or more in length, are present. Crystals from Berlin, 3 inches in length and an inch across, have been identified. Some of these large crystals are enclosed by a thin layer of pyrite. In 1940 Bannerman (38, p. 3) examined and sampled this deposit to ascertain whether it warranted commercial exploitation. Hawes (103, p. 108) notes that good specimens may be found in Hanover, Jaffrey, Lyme, Orford, and Warren.

Use or Importance: Kyanite is another of the minerals that a few years ago was considered worthless. Today it is being used in increasing amounts in the refractory industry, where it is used in the manufacture of heat-resisting porcelain such as that used in spark plugs, laboratory ware, refractory bricks and other heat-resisting products.

LABRADORITE (See under Feldspar Group)

LEPIDOLITE (See under Mica Group)

LEPIDOMELANE (See under Mica Group)

LEUCOXENE (See under Sphene)

LIMONITE, $FeO(OH).n\,H_2O + Fe_2O_3.n\,H_2O$

This hydrous iron oxide has wide distribution in New Hampshire and is represented by several varieties.

The *bog ore* variety of limonite, containing impurities such as clay, silt, and organic matter, is present in a number of swamps and swampy portions of lakes. Hitchcock (110, Vol. III, pt. V, p. 61-62) lists a number of towns in which the bog ore contained 36 to 55 per cent iron. These are Barnstead, Charlestown, Eaton, Haverhill, Lancaster, Lebanon, Milford, and Pelham.

Ocherous limonite is present as brown stains on many rocks; it discolors some sand and gravel deposits, and it is often found as soft brown masses in rock resulting from the decomposition of other iron-bearing minerals.

The *compact* variety is represented on Black Mountain, Haverhill, by botryoidal limonite (103, p. 47).

Use or Importance: Limonite of the bog-iron type was the first iron ore smelted in the New England Colonies. According to Rickard, (173) in his "History of American Mining," this began in 1646 near Lynn, Massachusetts. Within the next hundred years a number of furnaces and forges were developed in the various New England states. The ore was dragged from glacial lakes or dug from bogs. It was reduced in furnaces using shells for flux and charcoal for fuel. With the finding of ores containing a higher iron content, such as hematite and magnetite, bog iron was no longer used.

LITHIOPHILITE, $Li\,(Mn'',Fe'')\,(PO_4)$

Bannerman (38, p. 3) reports clove brown lithiophilite as one of the rare minerals at the Ruggles mine, Grafton. It occurs also at the E. E. Smith mine, Alexandria.

Use or Importance: Lithiophilite is of interest as a rare mineral.

LOLLINGITE, $FeAs_2$

This rare iron diarsenide is found in the Parker Mountain mine at Center Strafford and has been described by Switzer (196, p. 816-817). It is present as tin-white, rough prismatic crystals up to 2 inches in length, and in irregular crystalline masses. A few small well-developed crystals have been found. Bannerman (37, p. 10) reports löllingite as having been found at the Globe mine in Springfield. It

also occurs at the Demott mine, Grafton, and the Palermo mine, North Groton.
Use or Importance: Löllingite has no commercial value.

LUDLAMITE, $(Fe''Mg,Mn)_3(PO_4)_2.4H_2O$

Ludlamite, a hydrated ferrous phosphate, occurs at the Palermo mine, North Groton, and the E. E. Smith mine, Alexandria. At the Palermo mine, it was "in narrow veinlets in the triphylite, which is a primary phosphate of the pegmatite — large quantities of massive ludlamite were found capping and penetrating the triphylite" (Wolfe 207, p. 94-95). Other phosphates associated with the ludlamite are reddingite, fairfieldite, whitlockite, siderite, vivianite, and the manganese oxide, wad. Ludlamite has a vitreous luster and is bright green to apple green.
Use or Importance: None is known.

MAGNETITE, Fe_3O_4

Magnetite has wide distribution in New Hampshire as an accessory mineral in many igneous and metamorphic rocks. In addition, magnetite deposits of former commercial importance are known.

Hawes (103, p. 41) gives the most comprehensive review of these deposits. He describes the Franconia Iron Mine deposit in Lisbon as a 5 to 8 foot vein in gneiss. The ore is compact, fine-grained, and of blue-gray color. It is associated with garnet, epidote, and hornblende. Some fine dodecahedral crystals of magnetite are present. Bannerman (37, p. 6) reports the finding of somewhat rounded octahedrons at this place. The most recent review of the history, general geology, and mineralogy of this mine is by Verrow (201, p. 136-139). In Winchester, magnetite associated with pyrite was worked at one time. Crystals up to 2 inches in size have been found in Amherst, and large beds associated with ilmenite are reported in Unity. The *lodestone* variety has been found on Gunstock Mountain, Gilford. Other towns reported as having appreciable deposits of magnetite are Benton, Berlin, Easton, Jackson, Lebanon, and Piermont. Hadley and Chapman (101, p. 26) refer to the magnetite at Signal Hill, Lebanon, as small but perfect octahedrons in the Post Pond member of the Orfordville formation.
Use or Importance: The known New Hampshire magnetite deposits have no commercial value at the present time. Some idea of its former local importance as an ore of iron may be gained from Hitchcock's references to the operation and production of the Franconia Iron

Mine (110, Vol. III, pt. V, p. 56). This was the largest iron mine in the state and is located on the south slope of Ore Hill, Lisbon. The mine was operated from 1811 to 1870 and produced from 250 to 500 tons of ore per year. Smelting of the ore was done at the nearby furnace in Franconia.

MALACHITE, $Cu_2CO_3(OH)_2$

This bright green mineral is present in small amounts wherever copper-bearing sulphides have been subject to weathering. It has been identified in the towns of Bath, Dalton, Franconia, Gorham, Hanover, Littleton, Lyman, Monroe, Nottingham, and Orford (103, p. 131), and Westmoreland (36, p. 6).
Use or Importance: Malachite is an ore of copper. It is present in New Hampshire in far too small amounts to be of commercial value.

MANGANOAN APATITE (See under Apatite Group)

MARCASITE, FeS_2

Hawes (103, p. 32) refers to this type of iron bisulphide as present in Haverhill. It occurs as fibrous, radiated masses associated with pyrite. Bannerman (38, p. 10) reports yellowish marcasite at the Ruggles mine, Grafton.
Use or Importance: It is a source of sulphur, but is of no present commercial importance in New Hampshire.

MELACONITE (See under Tenorite)

MELANTERITE, $FeSO_4.7H_2O$

Hawes (103, p. 126) refers to this natural green vitriol as being present in the iron ore beds of Brentwood, Gilmanton, Hopkinton, Plymouth, and Rindge. It also occurs at the Palermo mine, North Groton (Seaman 182, p. 34-37).
Use or Importance: It is of no commercial value.

MESSELITE

Lindberg (137, p. 135-141) notes the possible occurrence of messelite at the Palermo mine, North Groton. It is believed to be a hydrated phosphate of calcium and divalent iron and is associated with ludlamite, siderite, triploidite and apatite.
Use or Importance: None is known.

MICA GROUP

This group contains numerous species and is a very important one in New Hampshire, both as rock-forming minerals and for the commercial value of one of its species, muscovite. The various mica minerals will be described in alphabetical order and their importance is summarized.

BIOTITE, $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$

Biotite, or black mica, is one of the most common minerals in the group. It is present in many types of igneous and metamorphic rocks and is very abundant in some of them. Hawes (103, p. 79) has noted large crystals in the pegmatites of Acworth, Alstead, Grafton, and other towns. It is interesting to note that Megathlin (144, p. 174) points out that biotite is absent, or present in limited amounts, in the Gilsum area wherever black tourmaline is abundant.

Biotite occurs in large strips or blade-like crystals in some pegmatites and commonly is intergrown with small amounts of muscovite. At the Victory (Big) mine, Alstead, the crystals are as much as 5 feet long and 6 inches wide; at the Brown Lot No. 10 mine, strips are up to 10 feet long, 4 feet wide, and 2 to 3 inches thick.

Upon weathering, biotite often becomes bronze-colored and metallic in appearance so that it has frequently been mistaken for a metallic ore.

LEPIDOLITE, $K_2Li_3Al_4Si_7O_{21}(OH,F)_3$

This lithium-bearing mica has been found by Frost (98, p. 49) as small crystals associated with spodumene in the pegmatite at the Turner mine in Marlow. Bannerman (38, p. 3) reports small lemon-colored spangles of lepidolite at the Ruggles mine, Grafton. It has been identified also at the Chandler Mills mine, Claremont and the E. E. Smith mine, Alexandria. Its limited occurrence in New Hampshire is noteworthy in view of its commonness in many of the Maine pegmatites.

LEPIDOMELANE (Iron-rich biotite)

This biotite-like mica, rich in ferric iron, is rather widely distributed in New Hampshire according to Hawes (103, p. 81). Such occurrences probably are identified incorrectly as biotite. It can be distinguished from biotite only by chemical analysis.

Bannerman (38, p. 3) reports resplendent black lepidomelane at the Ruggles mine, Grafton.

MUSCOVITE, $KAl_2Si_3O_{10}(OH)_2$

Muscovite, common white mica, is another abundant mineral in New Hampshire. It is present in large amounts in many schists and to a limited extent in some granites. Large crystals, often up to 12 inches or more across, are found in pegmatite dikes. A number of towns in which large crystals are common are Alexandria, Alstead, Canaan, Gilsum, Grafton, Groton, Orange, Springfield, Strafford, Sullivan, and Walpole. The color of the mica may be white, light green, or a light to dark rum color. Hawes (103, p. 82) reports rose-colored muscovite at Walpole. Many of the larger crystals are "ruled," a structure which reduces the commercial value of the mica.

The *pinite* variety of muscovite is reported by Hawes (103, p. 116) to exist in the metamorphic rocks in and about Littleton.

Sericite is a fine-grained, platy form of muscovite, commonly produced in the alteration of feldspars, and present, often in considerable amounts, in the low-grade metamorphic rocks. Billings (47, p. 81) found it an abundant mineral in the Intervale clay slates of the North Conway area.

ZINNWALDITE

This iron-lithia mica of uncertain composition has been found at the Palermo mine, Groton by Sterrett (192, p. 133). The crystal he describes had a clear brown core with an exterior of bluish green.

Use or Importance of the Mica Group: Muscovite and biotite are abundant as rock-forming minerals. In addition, muscovite is an important commercial mineral. The other species have been identified in limited amounts only.

The first commercial production of muscovite mica in the United States was in 1803 at the Ruggles mine, Grafton. Since that time, New Hampshire has been one of the principal producers of sheet mica, and has also produced considerable amounts of ground mica. In recent years, an increased demand for ground mica has led to mining and grinding of certain mica schists. In New Hampshire commercial production of mica from schist has been attempted by several companies, but the operations have been short lived.

At present (1955) a few mica mines are producing strategic mica for stockpiling under the Defense Minerals Exploration Administration. During World Wars I and II considerable amounts of high grade sheet mica were produced in New Hampshire.

The principal use of sheet mica is as an electric insulator in transformers, condensers, armatures, commutators and certain parts of television apparatus. Ground mica is used chiefly in paint and wallpaper, certain ceramic products, and as a dusting powder for rubber products and roofing paper.

Lepidolite has not been found in commercial quantities in New Hampshire but is mined for its lithium content in Southern Rhodesia and South-west Africa.

MICROCLINE (See under Feldspar Group)

MICROPERTHITE (See under Feldspar Group)

MOLYBDENITE, MoS_2

The best known deposit of molybdenite is in Westmoreland where attempts to mine the mineral met with failure. Other towns where molybdenite has been found are Alstead, Effingham, Franconia, Grafton, Grantham, Jackson, Landaff, Lyme, New London, Newport, Warren, and Whitefield (103, p. 27). It is also found at the Weeks mine, Wakefield and the Colony mine, Alstead.

Use or Importance: Molybdenite is the principal ore of molybdenum which is used in the manufacture of alloy steels. No deposits of commercial importance are known in New Hampshire.

MOLYBDITE (Now known as Ferrimolybdite)

MONTMORILLONITE, $(Al,Mg)_8 (Si_4O_{10})_3 (OH)_{10}.12H_2O$

This pink kaolin-like mineral is found at the Ruggles mine, Grafton (Fowler-Billings and Kingsley, 84, p. 1382).

Use or Importance: This mineral has no known local commercial value.

MORGANITE (See under Beryl)

MORION (See under Quartz)

MUSCOVITE (See under Mica Group)

NEPHELINE, $(Na,K) (Al,Si)_2O_4$

Billings and Williams (49, p. 12), finding nepheline in the Franconia area, refer to it as one of the unusual minerals of the White

Mountain magma series. Small amounts are present in the Belknap Mountains, as noted by Modell (149, p. 1897). The largest known deposits of the state are at Red Hill, Moultonborough. Quinn (167, p. 385) found up to 31 per cent in the nepheline-sodalite syenite of this locality.

Use or Importance: Nepheline is another of the once valueless minerals now being used in increasing amounts. It is successfully competing with feldspar in glass manufacture because of its high alumina content. Bowles (55, p. 26) notes that the Red Hill area has been prospected but did not seem capable of producing a commercial product. Improved milling techniques in the nonmetallic mineral industry in recent years might make the deposits at Red Hill more amenable to a treatment which would remove the iron-bearing minerals.

NONTRONITE (See under Chloropal)

OCTAHEDRITE (See Anatase)

OLIGOCLASE (See under Feldspar Group)

OLIVINE GROUP

CHRYSOLITE, $(Mg,Fe)_2SiO_4$

Hawes (103, p. 70) reports small grains of this mineral to be present in basic igneous rocks of the state.

Chapman and Williams (71, p. 511) note 10 per cent of the iron-rich variety *hyalosiderite* present in the gabbro of Tripyramid Mountain.

FAYALITE, Fe_2SiO_4

Fayalite is a rather uncommon mineral. However, it has been identified in a number of localities in granites and syenites of the White Mountain magma series. It has been found by Williams and Billings (206, p. 1042; 49, p. 12) in the Franconia area, and in the Percy and Cherry Mountain areas by R. Chapman (72, p. 426; 73, p. 181).

KNEBELITE, $(Fe,Mn)_2SiO_4$

According to Shortle, this rare species of olivine, similar in many respects to fayalite, has been found only at Long Mountain in the town of Stark (personal communication). Verrow (202, p. 255-260) describes a black or brownish-black mass of

knebelite from Long Mountain as 12 inches long, 4 inches wide and several inches thick. It is embedded in graphic granite and is associated with Smoky quartz, amethyst, microcline crystals, and albite.

Use or Importance: Rock-forming minerals.

OPAL (See Diatomite)

ORTHOCLASE (See under Feldspar Group)

PALERMOITE, $(Li,Na)_4SrAl_9(PO_4)_8(OH)_9$

Palermoite is a new mineral found at the Palermo mine, North Groton, associated with goyazite. Mrose (155, p. 354) described it as a late hydrothermal product which occurs in open cavities. Palermoite occurs in small prismatic crystals, is colorless to white, and has a vitreous to subadamantine luster. It fluoresces white in a direct x-ray beam. "The mineral association includes siderite, childrenite-eosphorite, green fibrous beraunite, crandallite-deltaite (?), whitlockite, brazilianite, tiny white hexagonal prisms of apatite, and small quartz crystals." (Mrose 155, p. 354).

Use or Importance: None is known.

PARSONITE, $Pb_2(UO_2)(PO_4)_2.2H_2O$

Parsonite, a hydrated phosphate of lead and uranium, is described from the Ruggles mine, Grafton. It occurs as pale citron, yellow crusts of microscopic monoclinic crystals "in massive feldspar and quartz in the vicinity of uraninite and gummite masses." (Frondel 97, p. 247). It is associated with autunite and phosphuranylite.

Use or Importance: None is known.

PENNINITE (See under Chlorite Group)

PENTLANDITE (See under Pyrrhotite)

PERTHITE (See under Feldspar Group)

PHARMACOSIDERITE, $Fe_3(AsO_4)_2(OH)_3.5H_2O$

Pharmacosiderite is reported in but one locality in the state. Hitchcock (110, Vol. III, pt. V, p. 66) records its presence at the Tin mine in Jackson.

Use or Importance: It is of no commercial value.

PHENACITE, Be_2SiO_4

Fine crystals of phenacite, associated with topaz, perthitic feldspar, and smoky quartz, have been found on the east slope of South

Baldface Mountain, Chatham. The crystals grew in miarolitic openings and have been collected from the openings or from talus slopes. Forty crystals, collected by E. C. Andrews, are in the Harvard University Collection, and have been described by Billings (46, p. 173-179).

Use or Importance: It is used occasionally as a gem stone.

PHOSPHURANYLITE

Phosphuranylite, a hydrated phosphate of calcium and uranium of uncertain formula, is a secondary mineral associated with autunite at the Ruggles mine, Grafton. It "occurs as thin films or coatings that appear dense, earthy, or minutely scaley to the unaided eye, and that are seen to be composed of thin scales with a rectangular outline under the microscope." (Frondel 96, p. 757).

Use or Importance: None is known.

PINITE (See under Muscovite, Mica Group)

PITCHBLENDE (See under Uraninite Group)

POWELLITE, $CaMoO_4$

Powellite, a calcium molybdate, occurs in small amounts in scheelite-bearing quartz veins at Holts Ledge, Lyme, where it is associated with scheelite, molybdenite, quartz, and bismuthinite. (Flint, field notes for the N. H. State Planning and Development Commission).

Use or Importance: A possible source of molybdenum but has not been found in commercial quantities.

PREHNITE, $Ca_2Al_2Si_3O_{10}(OH)_2$

Hawes (103, p. 112) has reported the finding of thin crusts of prehnite associated with trap rock at Franconia. It was noted at the Franconia Iron mine by Verrow (201, p. 136-139).

Use or Importance: It is a fairly common secondary mineral in basic sills and flows, but is of no commercial value.

PROCHLORITE (See under Chlorite Group)

PSILOMELANE, $H_4R_2Mn_8O_{20}$ (R is chiefly barium)

Hawes (103, p. 48) reports psilomelane at Winchester. It is an alteration mineral from rhodonite.

Bog manganese, an impure variety of psilomelane, has been found in a number of deposits associated with bog iron ore. Hitch-

cock (110, Vol. III, pt. V, p. 68) reports it in Gilmanton, Grafton, Haverhill, Laconia, Lisbon, Nelson, and Rindge.

The variety *wad* is found occasionally in gravel pits as a soft black coating on pebbles. This coating is restricted, generally, to a horizontal horizon a few inches in thickness, which may grade into a limonite-coated band of gravel.

Use or Importance: Psilomelane is one of the ores of manganese, an important metal, used in the iron and steel industry. Manganese dioxide is used in the battery industry in the manufacture of dry cells. The known deposits of New Hampshire are too small to be of commercial value.

PYRITE, FeS_2

Minute amounts of pyrite may be found in most of our rocks. It is common and often abundant, in metal-bearing veins in Berlin, Claremont, Croydon, Enfield, Hanover, Lebanon, Lyman, Lyme, Milan, Monroe, Moultonborough, Orford, Richmond, Shelburne, Unity, and Warren (103, p. 31).

Use or Importance: Pyrite has long been used in sulphuric acid manufacture. Its use has been greatly restricted in recent years due to the use of native sulphur in acid making and the production of by-product sulphuric acid at smelters.

PYROLUSITE, MnO_2

Pyrolusite is present at Winchester and Hinsdale as a secondary mineral from rhodonite. At Northwood tuberous and mammillary specimens have been found in granite (103, p. 46).

Use or Importance: See under psilomelane.

PYROXENE GROUP

The pyroxene group is one of the important rock-forming mineral groups of the state. It contains several species and subspecies which are considered below.

HYPERSTHENE, $(MgFe)_2Si_2O_6$

Hypersthene is present occasionally in ferromagnesian rocks. Chapman and Williams (71, Table 1) as well as Hawes (103, p. 54) note it at Tripyramid Mountain, Waterville. The norite here contains about 6 per cent hypersthene. In the Pawtuckaway Mountains Freedman (90, p. 468) describes hypersthene in the hypersthene gabbro and the hypersthene monzonite of the White Mountain plutonic series.

PYROXENE (Metasilicates of magnesium, iron, manganese and calcium with double silicates of sodium or lithium and aluminum or ferric iron)

Pyroxene is common in basic rocks, in many syenites, and has been found in schist and the lime silicate rocks of the Pawtuckaway, Sunapee, Mt. Cube, Littleton, Moosilauke, Mt. Washington, Mascoma, Wolfeboro quadrangles and in the Claremont-Newport area. Hawes (103, p. 55) refers to fine crystals associated with vesuvianite and grossularite in the limestone at Amherst, to fine crystals at Warren, and to beautiful green crystals with grossularite at Haverhill. More recent workers have identified many subspecies of pyroxene, which are listed below:

Acmite (Aegirite) is referred to by Chapman and Williams (71, Table 1) as one of the accessory minerals in the nepheline syenite at Red Hill, Moultonborough.

Aegirinaugite has been found in amounts up to 5 per cent in the outer coarse syenite at Red Hill by Quinn (167, p. 383) and occasionally in the nepheline-sodalite syenite (167, p. 385).

Augite is present commonly in amounts up to 20 per cent of many ferromagnesian rocks. Chapman and Williams (71, Table 1) record that 18 per cent of the gabbro of the Belknap Mountains consists of this mineral.

Augite-diopside is present in the basalt of the Ossipee Mountains according to Kingsley (127, p. 155).

Diopside is noted as abundant in a striking white diopside rock of the Montalban schists of the North Conway area by Billings (47, p. 78). Stewart (193) found it associated with vesuvianite at Center Strafford. A limited amount of clear diopside is present in the syenite porphyry of the Percy area (72, p. 424). It is present in the norite and monzonite of Tripyramid Mountain (71, Table 1).

Hedenbergite is present in small amounts in many of the acidic plutonic rock types of the White Mountain plutonic series. Billings found it in the North Conway area (47, p. 105ff.) and, with Williams, found it in the Franconia area (206, p. 1020). R. Chapman found it both in the Cherry Mountain syenite (73, p. 180) and in several rock types in the Percy area (72, p. 424ff).

RHODONITE, $MnSiO_3$

Pink to brown rhodonite is reported near the top of Stony Mountain, Winchester. Another deposit 7 feet thick is present one

mile southeast of Hinsdale. Other smaller deposits have been found in the same part of the state. Psilomelane and pyrolusite are the characteristic alteration products present (103, p. 58).

SPODUMENE, $LiAlSi_2O_6$

Spodumene has been identified at three localities in New Hampshire but probably occurs at several unreported localities. Frost reports its occurrence in the Chickering mine, Walpole and in the Turner mine, Marlow (98, p. 7, 49). Hawes (103, p. 60) refers to good white tabular crystals which have been found at Winchester. Megathlin (144) gives a very complete description of the spodumene which he found in the French mine, Alstead. The crystals here appeared to be of the order of several feet in length. These were much altered to a soft powdery material of a light pink color. The spodumene crystals are colorless to white, pink, or light green. Megathlin suggests that the pink variety may be *kunzite* and the green may be *hiddenite*.

The intergrowth of muscovite and albite, is known as *"cymatolite."* The muscovite is derived by the alteration of *α-eucryptite* which is commonly the first alteration product of spodumene.

Use or Importance of the Pyroxene Group: The pyroxene group consists principally of rock-forming species. Rhodonite is used occasionally as a gem or ornamental stone. Spodumene is an important ore of lithium whose compounds are used in the ceramic and chemical industries. Certain varieties of spodumene, such as kunzite, are important as gem stones. Commercial quantities of spodumene have not been found in New Hampshire.

PYRRHOTITE, $Fe_{1-x}S$

Pyrrhotite has been found in a number of veins, some of which are several feet across. The largest ones observed are in the towns of Enfield, Grafton, Hanover, Haverhill, Lyman, and Orford. Recently a water well driven into bedrock at the Bliven property in Rochester encountered considerable pyrrhotite. The area adjacent to the well was traversed in 1954 by an airborne magnetometer of the U. S. Geological Survey. A magnetic anomaly was indicated which trends northeasterly into southwestern Maine. Maps of this airborne survey are on open file at the office of the N. H. State Planning and Development Commission, Concord, and the Department of Geology, University of New Hampshire, Durham. Hawes (103, p. 31) found nickel in many of the specimens tested. The nickel is present probably as

small grains of pentlandite enclosed in the pyrrhotite. Bannerman (37, p. 7) reports a little pyrrhotite at the Ore Hill mine, Warren. More than 100 pounds of pyrrhotite has been removed from pegmatite at the Pattuck mine, Alexandria.

Use or Importance: Pyrrhotite, when its nickel content is high, is an important ore of nickel. The known nickel content of the pyrrhotite deposits is too low for commercial development. If considerable tonnages of pyrrhotite without any nickel were found, the mineral might be mined for its sulfur content. At present, pyrrhotite is being recovered as a separate mineral at the Elizabeth mine, South Stratford, Vermont, and shipped to the Brown Paper Company in Berlin, New Hampshire where it is used in making sulfurous acid.

QUARTZ, SiO_2

Quartz is one of our most abundant minerals. It is present in igneous rocks such as granite, rhyolite, and granite pegmatite, and is an abundant or predominating mineral in certain metamorphics like quartzite, quartz conglomerate, and some varieties of schist. The quartz in the above rocks is generally clear and colorless. Occasionally it is smoky or milky.

Quartz veins and lenses are common, and often of considerable size. The large veins are usually barren of metal content but the smaller ones are sometimes metalliferous. Some of the largest quartz deposits, essentially of the vein type, are in the towns of Alstead, Amherst, Bedford, Hancock, Hooksett, Londonderry, Lyndeborough, Manchester, Northwood, Ossipee, Raymond, Sandwich, and Strafford (110, Vol. III, pt. V, p. 5; 103, p. 49).

Pegmatites, often associated with vein deposits, as just noted, and producing commercial amounts of feldspar and mica, contain large amounts of quartz. Some of the towns where this is true are Acworth, Alexandria, Alstead, Gilsum, Grafton, Groton, Marlow, Orange, Springfield, Sullivan, and Wilmot.

A number of distinct varieties of quartz have been described and are listed below:

Actinolated Quartz. Verrow (201, p. 134-139) noted the occurrence of actinolated quartz in the Franconia Iron Mine at Lisbon. It is a rare type of quartz containing minute needles of the mineral actinolite.

Amethyst. Hawes (103, p. 49) refers to fine crystals of this variety at Westmoreland, and additional deposits at Mount Crawford, Surry, and Waterville. Amethystine quartz is present on Mount Kearsarge,

and a recent find near Berlin has produced some beautiful crystals.

Buhrstone. It is a flint-like variety with numerous cavities and is noted by Hawes (103, p. 49) as present at Littleton.

Jasper. This is associated with red and yellow quartz crystals and has been found at Francestown, Gilmanton, and Hanover (103, p. 49). It is present also at Jasper Cave, Berlin.

Morion. This variety is represented by the jet black quartz found in the druses of the North Conway granite by Gillson (99, p. 312).

Rock Crystal. This is widely distributed as imperfect and clouded specimens. Hawes (103, p. 49) refers to some fine large crystals, which have been found on Moose Mountain, Hanover, and to other deposits in Bartlett, Benton, Hanover, Raymond, Warren, and Westmoreland. Bannerman (37, p. 11) notes fine, clear, and smoky crystals of quartz at the Ruggles mine, Grafton.

Rose Quartz. According to Hawes (103, p. 49), it is present in mica schist in the White Mountains and is abundant on Mount Washington. It is present also at Acworth, Alstead, Andover, Keene, and Raymond and is abundant in places on Mount Kearsarge.

Rutilated Quartz. Hawes reported that in Orford quartz crystals have been found that contain minute needles of rutile. "Handsome specimens have been found near Hanover and at Cornish. In the last named place, a large, smooth rounded pebble of quartz, as large as a man's head and filled with little needles of rutile, was found a long time ago and was broken up and distributed among mineralogists. Rounded pebbles of quartz with needles of rutile, have been found in the river-bed at Lebanon." (Hawes, 103, p. 45).

Smoky Quartz. This is present at Bartlett, Cornish, and Crawford Notch. Mutilated specimens were noted at Cornish (103, p. 49).

Use or Importance: In addition to its importance as a rock-forming mineral, quartz has many other uses. Amethyst, Jasper, Morion, Rock Crystal, and Rose Quartz are used in limited amounts as gem stones or as ornamental materials. Ground quartz is used in large amounts as an abrasive and in the ceramic industry. For the latter purpose, quartz should have high chemical purity. It is interesting to note that New Hampshire is again producing quartz for commercial use. The first known production was used about 1780, in New Hampshire's first glass plant on the north slope of Kidder Mountain in the town of Temple (178, p. 304).

REDDINGITE, $(Mn,Fe)_3(PO_4)_2.3H_2O$

Reddingite, a hydrated phosphate of divalent manganese and

iron, has been described at the Palermo mine, North Groton, by Wolfe (207, p. 94) as "small crystals on ludlamite." Reddingite is pinkish white or pale rose pink to yellowish white and colorless. It is associated with fairfieldite, vivianite, and triphylite (Palache 27, p. 728).

Use or Importance: None is known.

RHODOCHROSITE, $MnCO_3$

Light rose-colored rhodochrosite has been found at Winchester. The outer part is blackened by weathering (103, p. 131). Switzer (196, p. 816) describes a pale pink, fine-grained type which occurs in veins cutting triphylite at Center Strafford. It is found also in small amounts at the Palermo mine, North Groton.

Use or Importance: It is an ore of manganese but the known New Hampshire deposits are of no commercial importance.

RHODONITE (See under Pyroxene Group)

RIPIDOLITE (See under Chlorite Group — equals Prochlorite)

RIEBECKITE (See under Amphibole Group)

ROCK CRYSTAL (See under Quartz)

ROSE QUARTZ (See under Quartz)

RUTILATED QUARTZ (See under Quartz)

RUTILE, TiO_2

Hawes (103, p. 45) refers to a number of occurrences of this mineral. The largest deposit is at Merrimack on the Souhegan River, where some of the red, massive rutile which is present here has been mined. Crystals of rutile have been obtained in the soapstone quarries at Richmond. It has been found also in Lyme, and Warren. In the latter area, Bannerman (37, p. 7) found occasional small crystals. Minute crystals are fairly common in granites and schists.

Use or Importance: Rutile is one of the minerals from which titanium is extracted, however most rutile produced is used for welding rod coatings. Some titanium derived from rutile is used in alloys, for electrodes in arc lights, and to give a yellow color to porcelain. The making of titanium metal is a recent development and should be in commercial production in a very short time. Its significance lies in its lightness, strength, and good resistance to corrosion by sea water and many acids. It is used in jet engines as a substitute for stainless

steel and "has the advantage of being about half the weight of steel and about three times as strong." (Johnstone 17, p. 574).

SAMARSKITE (Complex oxide of the rare earths)

Samarskite is an oxide (or columbite-tantalite) principally of the rare earths, calcium, iron, uranium, and thorium, with columbium, tantalum and titanium. At the Weeks Feldspar Quarry, Wakefield, Cameron (59, p. 107) reports that "masses of intergrown columbite and samarskite weighing as much as 60 pounds occur in albite, which is discolored reddish brown at the contacts.

Use or Importance: In large enough quantities, samarskite might be a source of the rare earth elements.

SARCOPSIDE, $(Fe,Mn,Ca)_7(PO_4)_4F_2$ (?)

Sarcopside is a rare phosphate of iron, calcium, and manganese which has been found in a pegmatite at Deering by Holden (114, p. 99-102; 115, p. 205-207). This is the first known occurrence of the mineral in America. When fresh, the sarcopside is flesh-red to lavender in color but alters on exposure to blue, green, or brown. The surface alteration mineral may be vivianite. The general occurrence is as irregular slat-like masses with a fibrous appearance.

Use or Importance: It is of interest as the only known American occurrence of a very rare mineral, but has no commercial value.

SCAPOLITE

Scapolite has been identified by Stewart (194, p. 510) from material excavated for the new Armory, Manchester. It is associated with quartz, idocrase, and grossularite garnet. At Merry Hill in Northwood, Freedman (90, p. 463) notes the occurrence of scapolite associated with diopside and apatite.

Use or Importance: None is known.

SCHEELITE, $CaWO_4$

Scheelite, a calcium tungstate, occurs at Holts Ledge, Lyme; at the Palermo mine, North Groton; and in the towns of Alstead, Benton and Hinsdale. Several quartz veins at Holts Ledge contain considerable amounts of scheelite but prospecting has not proved commercial quantities. Associated with the scheelite are molybdenite, powellite, bismuthinite, tourmaline, potash feldspar, calcite, pyrite and magnetite. (Field notes for the New Hampshire State Planning and Development Commission: N. K. Flint).

Use or Importance: The most important uses of tungsten are for making tough, high speed tool steels and for electric lamp filaments.

SCHORL (See under Tourmaline)

SERICITE (See under Muscovite, Mica Group)

SERPENTINE, $Mg_3Si_2O_5(OH)_4$

Small amounts of serpentine are reported as present along the Connecticut Valley and in the town of Pittsburg (103, p. 114).

Use or Importance: It is used as an ornamental stone and is an important type of asbestos when fibrous. No deposits of importance are known in New Hampshire.

SICKLERITE SERIES

FERRI-SICKLERITE $(Li,Fe''',Mn'')(PO_4)$

Ferri-sicklerite, a phosphate of lithium, trivalent iron and divalent manganese, is reported at the Palermo mine, North Groton, and the Parker Mountain mine at Center Strafford. It is a yellowish brown to dark brown massive mineral formed through the alteration of triphylite (Palache 27, p. 672-673).

Use or Importance: None is known.

SICKLERITE $(Li,Mn'',Fe''')(PO_4)$

Sicklerite, a phosphate of lithium, divalent manganese, and trivalent iron, occurs at the E. E. Smith mine, Alexandria, as an alteration of lithiophilite. Its physical characteristics are the same as ferri-sicklerite (Palache 27, p. 672-673).

Use or Importance: None is known.

SIDERITE, $FeCO_3$

Siderite is present in the druses of the North Conway granite where Gillson (99, p. 312) found it to be one of the last minerals of magmatic origin to form. Larrabee (133, p. 84) notes its presence in the ore of the old Shelburne Lead mine, Shelburne. Siderite occurs in small amounts at the Palermo mine, North Groton; Smith mine, Raymond; and the Chandler Mills mine, Newport.

Use or Importance: When present in abundance it is an ore of iron.

SILLIMANITE, Al_2SiO_5

Sillimanite has long been recognized as an abundant mineral in the Fibrolite (sillimanite) schist of Hitchcock (110, Vol. II, pt. II, p. 674). More recently geologists have demonstrated that sillimanite

is not only abundant in the high grade metamorphic zone of most formations in New Hampshire, but it is widely distributed, particularly in the Littleton formation.

In 1940 Bannerman made a survey of some sillimanite occurrences in the Rumney and Cardigan areas. One locality in Rumney was sampled for laboratory tests. "The results of the tests made by the Bureau of Mines show that despite the coarseness of the sillimanite grain, biotite, garnet, and other iron minerals are so intimately intermixed with it that the sillimanite cannot be separated satisfactorily." (38, p. 3).

Sillimanite deposits at Gap Mountain and Cobb Hill in the Monadnock region appear to contain sufficient tonnages and are of a quality that warrant further exploration and laboratory tests (Fowler-Billings, 86, p. 14).

Use or Importance: Sillimanite is one of the most important minerals used in refractory products such as brick for lining all types of furnaces. In the ceramic industry sillimanite may be added to kaolin and clay for making certain types of ceramic ware.

SILVER, Ag

Silver is present, probably as argentite, in varying amounts in much of the galena of the state. (See under Galena). A doubtful occurrence of filaments of native silver is reported in an iron ore which occurs on West River Mountain (103, p. 23).

Use or Importance: There is no commercial production of silver in New Hampshire.

SMITHSONITE, $ZnCO_3$

Smithsonite, a zinc carbonate, occurs in small amounts as an alteration of sphalerite in some of the fluorite veins in Westmoreland (Bannerman 40, p. 4). It is associated with barite, calcite, fluorite, and sulfides, such as chalcopyrite, pyrite, galena, sphalerite, and bornite.

Use or Importance: A source of zinc.

SMOKY QUARTZ (See under Quartz)

SOAPSTONE (See under Talc)

SODALITE, $Na_4Al_3Si_3O_{12}Cl$

The sodalite-bearing rock at Red Hill, Moultonborough, has recently been studied by Quinn (167, p. 386). Sodalite is present in amounts up to 30 per cent of the nepheline-sodalite syenite of this locality. The mineral is grayish or greenish to bluish-gray. It is relatively pure with possibly a small amount of *hackmanite*. Sodalite fluoresces under ultra-violet light, which property was used by Quinn to quickly distinguish it from the associated, similar appearing, but non-fluorescing, nepheline.

Use or Importance: Sodalite has no commercial value.

SPESSARTITE (See under Garnet Group)

SPHALERITE, ZnS

A number of deposits of sphalerite are known in New Hampshire, a few of which have been operated commercially. It is invariably associated with one or more sulphides such as pyrite, chalcopyrite, or galena. The usual color is dark brown to black. However, light yellowish brown sphalerite is present at the Madison mine.

Use or Importance: Sphalerite is the most important ore of zinc. This mineral was generally present in the ore of the old copper and silver-lead mines, frequently being discarded as a gangue mineral. Two mines in which sphalerite was the dominant ore mineral are the Ore Hill mine in Warren described by Hitchcock (110, Vol. III, pt. V, p. 48-49) and Weed (203, p. 17), and the Milan mine described by Emmons (81). Small deposits have been noted at Croydon, Enfield, Haverhill, Laconia, Monroe, Rumney, and Shelburne.

SPHENE (Titanite), $CaTiSiO_5$

Sphene is widely distributed in minute amounts as an accessory mineral in igneous and metamorphic rocks. Quinn (167, p. 383) refers to it as an abundant accessory in the outer coarse syenite at Red Hill. According to Fowler-Billings and Page (85, p. 22) "visible grains of brownish titanite" occur in granite on Downing Mountain and Eagle Cliff, east of Stinson Lake in the towns of Ellsworth and Rumney.

Leucoxene is "a name loosely applied to dull, fine-grained, yellowish to brown alteration products high in titanium." (Palache 27, Vol. I, p. 560).

Use or Importance: Commercial deposits are unknown in New Hampshire.

SPINEL, $MgAl_2O_4$

Hawes (103, p. 39) refers to bright red octahedra in the limestone on Saddleback Mountain as spinel.

Use or Importance: Some spinel is used as a gem stone.

SPODUMENE (See under Pyroxene Group)

STAUROLITE, $Fe''Al_4Si_2O_{10}(OH)_2$

An excellent description of New Hampshire staurolite is given by Billings (50, p. 491) in his description of its occurrence in the Littleton-Moosilauke area. "Staurolite, one of the most striking minerals in the middle-grade zone, is best seen on a barren hill three-quarters of a mile due west of the summit of Garnet Hill. The staurolite commonly is found as diversely oriented porphyroblasts 1 to 10 centimeters long. The crystals are generally euhedral and are bounded by the unit prism and the side pinacoid; terminal faces were not found. Twinned crystals are fairly common, particularly those that cross at 60 degrees, the twin plane being (232); in a few places, six-pointed twins were seen. A few rectangular crosses, twinned on (132) have been observed. The staurolite is generally relatively free from foreign inclusions, but, in places, it encloses large quantities of other minerals." Hadley and Chapman (101, p. 26) found abundant staurolite in the Orfordville formation in the town of Orford where it is present at the top, and southeast side of Blackberry Hill, and at the west side of Strawberry Hill. At both localities large brown crystals several inches long may be found imbedded in schist. Small dark staurolite crystals, up to an inch in length, have been found in the Gonic formation, Rochester, by Katz (125, p. 172).

At Park Hill, Westmoreland and from near the summit of Bare Hill, Putney, unaltered staurolite crystals as much as 2 to 3 inches long, may be found (Moore 152, p. 25). Chapman (69, p. 27) noted staurolite crystals 3 to 4 inches long on Mount Tug just south of the Sugar River and near the west border of the Sunapee quadrangle.

Use or Importance: None is known.

STEWARTITE

Stewartite is essentially a hydrated phosphate of manganese which has been identified at the Palermo and Fletcher mines, North Groton. At the Palermo mine, Wolfe (207, p. 94-97) noted that it occurred in platy orange-brown crystals.

Use or Importance: None is known.

STRENGITE, $Fe(PO_4).2H_2O$

Strengite, a hydrated phosphate of ferrous iron, occurs at the Palermo mine, North Groton as an alteration product of triphylite. The color is commonly peach-blossom-red, carmine, violet, but may be colorless.

Metastrengite, a hydrated phosphate of ferric iron, also occurs at these same mines (Palache 27, Vol. II, p. 756-760).

Use or Importance: None is known.

STRIGOVITE (See under Chlorite Group)

SULFUR, S

Hawes (103, p. 25) has found secondary sulfur from the decomposition of a sulphide at Brentwood. He noted it also in tremolite in Chester.

Use or Importance: The traces of sulfur that have been found are of academic interest only.

TALC, $Mg_3Si_4O_{10}(OH)_2$

The *soapstone* variety of talc is present in many localities. At Francestown, where soapstone was produced commercially for many years, the stone contains abundant spherical radial aggregates of talc crystals and some disseminated pyrrhotite (110, Vol. III, pt. V, p. 86). Another important locality, where several mines once operated, is in Orford. Hadley and Chapman (101, p. 24-25) report that a considerable amount of fair quality material is still available here. Other deposits referred to by Hawes (103, p. 113) and Hitchcock (110, Vol. III, pt. V, p. 86-88) are Canterbury, Haverhill, Keene, Lancaster, Richmond, Swanzey, Warner, and Weare.

Use or Importance: Apparently most of the New Hampshire soapstone was used in stoves and as hearthstones. Some was ground and used as packing material. The mineral has not been mined for many years.

TENORITE, CuO

The variety *melaconite* is described by Hawes (103, p. 37) as present at Orford. It is a soft, black mineral produced through the alteration of chalcopyrite.

Use or Importance: This mineral is of no commercial importance.

THURINGITE, $8FeO_4(Al,Fe)_2O_3.6SiO_2.9H_2O$

This mineral, closely related to the chlorites, has been identified by Carleton Chapman in the black, garnet-mica schists of the Orfordville formation. It has been converted partly into garnet (61, p. 172).

Use or Importance: This mineral has no commercial value.

TITANITE (See Sphene)

TOPAZ, $Al_2SiO_4(F,OH)_2$

Many beautiful crystals of topaz have been found on the east slope of South Baldface Mountain, Chatham. Billings (46, p. 173-178) gives an excellent description of the occurrence and nature of the crystals after a careful study of the 200 crystals in the Harvard University collection. The crystals, collected by E. C. Andrews of Chatham, about 1900, range up to 9 by 6 centimeters in size. Some are doubly terminated. They were collected from pockets in the miarolitic alkaline biotite granite of South Baldface Mountain, at an elevation of approximately 2900 feet, or from the nearby talus slopes. Topaz is associated with phenacite, perthitic feldspar, and smoky quartz. The crystals are clear and either pink or colorless, sometimes with a bluish border. These crystals are of added interest in that Billings found on them new and rare crystal faces. Bannerman (37, p. 12) reports small clear well-formed crystals at the Ruggles mine, Grafton. Topaz crystals have also been found at Green Ledges, Milan, and at Victor Head, Stark. The largest crystal reported by Verrow (202, p. 255-260) was 4 inches long and 2 inches in diameter. According to Leggett and Weeks (personal communication) recent excavations at Conway in the Lovejoy "gravel pits" — weathered Conway granite, locally called "rottenstone" — have encountered "pockets" containing excellent crystals of topaz associated with smoky quartz and microcline (amazonite) crystals.

Use or Importance: This is a well-known gem stone.

TORBERNITE, $Cu(UO_2)_2(PO_4)_2 \cdot 8\text{-}12H_2O$

Minute amounts of this rare uranium-bearing phosphate have been found at the Ruggles mine, Grafton. It occurs as small, thin, dark-green scales on feldspar. Bannerman (38, p. 3) recently reports finding little clusters of emerald to grass green crystals of torbernite in this same locality.

Use or Importance: It is of interest as a rare mineral.

TOURMALINE, $WX_3B_3Al_3(AlSi_2O_9)_3(O,OH,F)$ W=Na,Ca
X=Al,Fe‴Li,Mg

This complex silicate of boron and aluminum is found widely distributed in New Hampshire. The black iron-bearing tourmaline, *schorl* is the most abundant variety. Large crystals are common in many of our pegmatites. These are commonly three to four inches in diameter, and occasionally six inches or more across. Thin, plate-like crystals are found at times in muscovite crystals. When thin

enough these plates show pleochroism in polarized light. Slender black crystals have been found in white quartz at Gilmanton, Hanover, Haverhill, Newfields, and Northwood. Bladed crystals are noted by Hawes (103, p. 104) at Lebanon and by Hitchcock (110, Vol. III, pt. V, p. 34) at Newmarket. Black fibrous tourmaline has been collected at both of the last named localities. Interesting jet-black tourmaline crystals with cores of clear quartz have been found by Stewart (personal communication) at Sanders Ledge in the Blue Hills Range.

Large brown crystals of tourmaline, presumably the variety *dravite,* are present in the talc at Orford. Hawes (103, p. 103) also refers to the blue variety, *indicolite,* as present at Hinsdale and in a granite near Winchester. Frost (98, p. 7) reports its presence at the Chickering mine, Walpole. Larrabee (133) reports green tourmaline in the Walpole district.

Use or Importance: Tourmaline is used as a gem stone when clear, unfractured, and of proper color. The strong piezoelectric property of tourmaline makes it useful in the manufacture of pressure gauges.

TREMOLITE (See under Amphibole Group)

TRIPHYLITE, $Li(Fe'',Mn)(PO_4)$

Once believed to be a rare mineral pegmatite in New Hampshire, triphylite has been discovered in many places in recent years. Penfield (158) was the first to identify triphylite in New Hampshire at Grafton in 1877. Since then it has been discovered in many pegmatites. The largest crystals have been reported at the Palermo No. 1 mine, North Groton where "single crystals of triphylite range up to fourteen feet or more in length." (Frondel 93, p. 136). A large nodular mass of triphylite ten feet across was described by Switzer (196, p. 814) at the Parker Mountain mine, Center Strafford. Frost (37, p. 7) found it at the Chickering mine, Walpole. Well developed crystals at the Chandler Mills ("Smith") mine were first described by Chapman (64, p. 90-98). Some of the crystals were several inches across. In addition, triphylite has been identified at the following mines or prospects: Balla, Acworth; Demott, Grafton; Eight Ball, Rumney; Fletcher, North Groton; Globe, Springfield; Keyes No. 1, Orange; Nancy No. 2, North Groton; Pattuck, Alexandria; Palermo No. 3, North Groton; Rice, North Groton; Ruggles, Grafton; Sargeant, Claremont; Smith, Raymond; E. E. Smith, Alexandria; G. F. Smith, Newport; Standard, Orange; Stinson-Craig, North Groton; Union, North Groton; Valencia, North Groton.

Use or Importance: It is of interest as a rare mineral.

TRIPLITE, $(Mn'',Fe'', Mg,Ca)_2 (PO_4) (F,OH)$

Heinrich (106, p. 268) reports that triplite, a fluo-phosphate chiefly of divalent iron and manganese, with smaller amounts of calcium and magnesium, has been found at the Palermo mine, North Groton. Its color is commonly dark brown or chestnut brown, also reddish brown to flesh brown, and is salmon pink in highly manganoan material (Palache 27, p. 849).

Use or Importance: None is known.

TRIPLOIDITE GROUP

Triploidite $(Mn'',Fe'')_2 (PO_4) (OH)$ and Wolfeite $(Fe''Mn'')_2 (PO_4) (H)$ are believed to form a complete series by substitution of manganese and iron.

TRIPLOIDITE, $(Mn''Fe'')_2 (PO_4) (OH)$

Frondel and Lindberg (93, p. 135-141) report that triploidite is one of the minerals formed by the hydrothermal solutions which attacked some of the triphylite at the Palermo mine, North Groton. The color of the manganese-rich triploidite is usually pinkish, wine yellow to yellow brown.

Use or Importance: None is known.

WOLFEITE, $(Fe'',Mn'') (PO_4) (OH)$

Frondel (95, p. 692-705) describes wolfeite at the Palermo mine, North Groton, as a reddish brown cleavable mineral which occurs as grains in triphylite. It is an alteration of triphylite and is associated with veinlets that contain chlorite, sphalerite, pyrite, and arsenopyrite.

Use or Importance: None is known.

URANINITE (Pitchblende) — complex uranium oxide

The best-known occurrence of uraninite in New Hampshire is at the Ruggles mine, Grafton. This deposit has been studied by Shaub (185, p. 334-341). The mineral is present chiefly as a three-dimensional intergrowth with perthitic feldspar. In addition, there are some skeletal crystals present, especially in albite which is associated with the perthite. Individual crystals are associated chiefly with granular albite and apatite. Some of the uraninite collected by Shaub was analyzed by Frederick Hecht of Vienna. From the lead-uranium ratio of the analysis, the age of the deposit was calculated. It is 304 millions of years old, which places its origin in late Devonian time.

Another locality where uraninite has been found is at the Golding-Keene mine in Alstead. This occurrence is reported by Hammond (personal communication) and is associated with the characteristic alteration minerals, gummite, uranophane and autunite.

Use or Importance: Uraninite is one of the principal ores of uranium and radium. No commercial deposits have been discovered, but specimens from the Ruggles mine probably occur in most of the museums in the world and in most private mineral collections.

URANOCHALCITE — uranium sulfate (?)

Uranochalcite is apparently the uranium mineral coating the almandite garnet at the Palermo mine, Groton, according to Berman (45, p. 171).

Use or Importance: It is of no commercial value.

URANOPHANE, $CaU_2O_3Si_2O.7H_2O$

Uranophane is one of the alteration products from uraninite, and is found associated with gummite. It has been collected at the Ruggles mine, Grafton. It has been reported by Hammond (personal communication) at the Golding-Keene mine, Alstead. A recent report by Bannerman (37, p. 11) notes uranophane at the Grafton locality, confirming the author's findings.

Use or Importance: It is of interest as one of the rather rare uranium-bearing minerals. It has no commercial importance in New Hampshire.

URANOSPINITE, $Ca (UO_2)_2 (AsO_4)_2.8H_2O$

Uranospinite, a hydrated arsenate of calcium and uranium, occurs at the Ruggles mine, Grafton (Seaman 182, p. 34-37). It is a cleavable lemon-yellow to sisken-green mineral.

Use or Importance: None is known.

VIVIANITE, $Fe''_3 (PO_4)_2.8H_2O$

Narrow bands of vivianite have been found in triphylite by Berman (45, p. 172) at the Palermo mine, Groton. Switzer (196, p. 817) noted vivianite at Center Strafford. It is present as a deep blue alteration product of triphylite. It occurs as thin films on the triphylite, as small masses of powdery material, and rarely as small rough crystals. Most of the triphylite occurrences listed above contain vivianite.

Use or Importance: This mineral has no commercial value.

VOELCKERITE (See under Apatite Group)

WAD (See under Psilomelane)

WARDITE, $CaAl_3(PO_4)_2(OH).2H_2O$

In addition to beryl, Hurlburt (120, p. 296) reports that several interesting minerals have been found at Beryl Mountain near West Andover. "The most unusual for this pegmatite is a single specimen composed mostly of quartz with an area on one side about 10 by 15 centimeters, coated with white to colorless crystals of wardite. This is the third locality in the world for wardite." It is a hydrated basic phosphate of sodium and aluminum.

Use or Importance: None is known.

WAVELLITE, $Al_3(OH)_3(PO_4)_2.5H_2O$

Wavellite has been reported, probably incorrectly, from the tin mine at Jackson (103, p. 125).

WHITLOCKITE, $Ca_3(PO_4)_2$

Whitlockite, a tricalcium phosphate, was found originally at the Palermo mine, North Groton, and is associated with siderite, quartz, apatite, ludlamite, fairfieldite, xanthoxenite and triphylite (Frondel 91, p. 227-228). It is colorless to white, gray or yellowish. Crystals are commonly rhombohedral and are without any cleavage. Some whitlockite occurs in coarse-granular to earthy masses (Palache 27, p. 684).

Use or Importance: None is known.

WOHLERITE, $Na,Ca_2(Zr,Cb)FSi_2O_8$

This rare and complex silicate has been found at the Horne "Quarry," Red Hill by both Pirsson and Washington (163, p. 270-271) and by Quinn (167, p. 387).

Use or Importance: It is of interest as a very rare mineral.

WOLFRAMITE, $(Fe,Mn)WO_4$

Small amounts of wolframite are reported present in the tin veins at Jackson (103, p. 126).

Use or Importance: So far as known this ore of tungsten is present in New Hampshire in such small amounts that it has no commercial value.

XANTHOXENITE, $Ca_2Fe(PO_4)_2(OH).1\frac{1}{2}H_2O$

The hydrated basic phosphate of trivalent iron, xanthoxenite, is one of the last minerals to form during the hydrothermal alteration of triphylite. At the Palermo mine, North Groton, it is usually found deposited in cavities on other minerals such as whitlockite, eosphorite-childrenite, rockbridgeite, and other phosphates in those pegmatites that contain an abundance of triphylite (Wolfe 207, p. 692-705).

Crystals and massive material are pale yellow to brownish.

Use or Importance: None is known.

ZEOLITE (See Analcite)

ZINNWALDITE (See under Mica Group)

ZIRCON, $ZrSiO_4$

Zircon is widely distributed as minute crystals in many igneous rocks, especially the acidic ones such as the granites and syenites. Quinn (167, p. 388) found it to be an abundant accessory mineral in the Watson Ledge quartz syenite at Red Hill. Zircon is present, in limited amounts, in the druses of the North Conway granite (99, p. 311), and as small grains in pegmatite stringers in the wall rock of the Gilsum area pegmatite dikes (144, p. 176). Bannerman (38, p. 10) has found small cinnamon brown crystals of zircon at the Ruggles mine, Grafton.

Use or Importance: Zircon is used chiefly in the ceramic, refractory chemical and metallurgical industries, and occasionally as a gem stone.

ZOISITE (See under Epidote Group)

DISTRIBUTION OF NEW HAMPSHIRE MINERALS BY TOWNS OR REGIONS

The information compiled below is restricted to localities cited in this report and does not include the most common minerals unless reference is made to some special locality. However, it is felt that this gives a fairly accurate cross-sectional view of our knowledge of the distribution of New Hampshire minerals. This distribution is definitely "spotty." In part this is due to irregular distribution of mineral types. In addition, it shows that our knowledge of our minerals and their distribution is still far from complete.

ACWORTH:
autunite, beryl, biotite, columbite, orthoclase, perthite, quartz (rose)

ALBANY:
andalusite

ALEXANDRIA:
arsenopyrite, apatite, autunite, beryl, chalcopyrite, columbite-tantalite, dufrenite, feldspar, heterosite, lithiophilite, muscovite, pyrite, pyrrhotite, quartz, sicklerite, tourmaline, triphylite, vivianite

ALSTEAD:
andalusite, andradite, autunite, biotite, columbite, ferri-molybdite, kaolin, molybdenite, muscovite, perthite, pyrite, quartz, scheelite, spodumene, uraninite, uranophane

ALTON:
arsenopyrite, galena

AMHERST:
calcite, grossularite, ilmenite, idocrase (vesuvianite) magnetite, microcline, oligoclase, pyroxene, pyrrhotite, quartz

ANDOVER:
almandite, andalusite, bertrandite, beryl, columbite, quartz (rose) wardite.

ANTRIM:
graphite

BARNSTEAD:
limonite

BARRINGTON:
graphite

BARTLETT:
danalite, hematite, ilmenite, quartz (rock crystal and smoky)

BATH:
azurite, chalcopyrite, galena, kalinite, malachite

BELKNAP MOUNTAINS:
anorthite, corundum, hastingsite, ilmenite, nepheline, pyroxene (augite), sillimanite

BELLOWS FALLS QUADRANGLE:
allanite, amphibole, apatite, beryl, biotite, calcite, chlorite, epidote, garnet, graphite, ilmenite, leucoxene, limonite, magnetite, muscovite, plagioclase, potash feldspar, pyrite, pyroxene, quartz, rutile, sillimanite, sphene, staurolite, tourmaline, zircon, zoisite

BENTON:
hematite, magnetite, quartz (rock crystal) scheelite

BERLIN:
chalcopyrite, columbite, cordierite, kyanite, magnetite, molybdenite, pyrite, quartz (amethyst and jasper)

BRADFORD:
almandite

BRENTWOOD:
melanterite, sulfur

BRISTOL:
graphite

CAMPTON:
beryl, feldspar, garnet, muscovite, perthite, pyrite

CAMPTON FALLS:
analcite

CANAAN:
beryl, feldspar, garnet, muscovite, tourmaline

CANTERBURY:
talc (soapstone)

CARDIGAN QUADRANGLE:
apatite, beryl, biotite, chlorite, garnet, magnetite, muscovite, orthoclase, plagioclase (andesine), pyrite, quartz, sillimanite, zircon

CHARLESTOWN:
andalusite, limonite

CHATHAM:
beryl, phenacite, topaz

CHERRY MOUNTAIN:
fayalite, hornblende, perthite, pyroxene (hedenbergite)

CHESTER:
graphite, sulfur

CLAREMONT:
apatite, feldspar, garnet, graftonite, heterosite, muscovite, pyrite, tourmaline, triphylite, vivianite

CONWAY:
microcline, quartz (rose), riebeckite, topaz

CORNISH:
argentite, quartz (smoky), rutile

CRAWFORD NOTCH:
fluorite, microcline (amazonstone), quartz (rose)

CROYDON:
chalcopyrite, cordierite, pyrite, sphalerite

DALTON:
bornite, galena, malachite

DANBURY:
almandite, autunite, beryl, garnet, muscovite

DEERING:
cacoxenite, dufrenite, sarcopside

DIXVILLE NOTCH:
andesine

DORCHESTER:
bytownite, garnet, muscovite, oligoclase, tourmaline

DOVER:
penninite

DUBLIN:
chromite

DUNBARTON:
galena

EASTON:
magnetite

EATON:
limonite

EFFINGHAM:
molybdenite

ELLSWORTH:
galena, sphene

ENFIELD:
galena, pyrite, pyrrhotite

EPSOM:
galena

EXETER:
epidote, hornblende

FARMINGTON:
andalusite

FRANCESTOWN:
arsenopyrite, quartz (jasper), talc (soapstone)

FRANCONIA QUADRANGLE:
cordierite, fayalite, hastingsite, nepheline, pyroxene (hedenbergite), riebeckite, sillimanite, tremolite

FRANCONIA:
andradite, arsenopyrite (danaite), azurite, chalcopyrite, ferrimolybdite, hematite, kaolin, malachite, molybdenite, prehnite, zoisite

GILFORD:
magnetite (lodestone)

GILMANTON:
epidote, melanterite, psilomelane (bog manganese), quartz (jasper), tremolite, tourmaline (schorl)

GILSUM:
beryl, kaolin, microcline, muscovite, perthite, quartz, zircon

GORHAM:
bornite, galena, malachite

GOSHEN:
graphite

GRAFTON:
almandite, autunite, beryl, biotite, chrysoberyl, columbite, cyrtolite, fluorapatite, fluorite, graftonite, gummite, lepidolite, lepidomelane, lithiophilite, lollingite, marcasite, molybdenite, montmorillonite, muscovite, orthoclase, parsonite, perthite, phosphuranylite, psilomelane (bog manganese), pyrite, pyrrhotite, quartz, staurolite, topaz, torbenite, triphylite, voelckerite, uraninite, uranophane, zircon

GRANTHAM:
molybdenite

GROTON:
almandite, amblygonite, apatite, arsenopyrite, augelite, autunite, beraunite, beryl, brazilianite, chalcopyrite, childrenite-eosphorite, chlorite, crandallite-deltaite, cyrtolite, dufrenite, fairfieldite, ferri-sicklerite, frondelite, goyazite, graftonite, gummite, heterosite, lazulite, limonite, lollingite, ludlamite, manganite, melanterite, messelite (?), muscovite, palermoite, perthite, psilomelane, pyrite, quartz, reddingite, rhodochrosite, rockbridgeite, siderite, sphalerite, stewartite, strengite, triplite, triphylite, triploidite, uranochalcite, uranophane, vivianite, whitlockite, wolfeite, xanthoxenite, zeolite, zinnwaldite

HANCOCK:
graphite, quartz

HANOVER:
anorthite, almandite, epidote, hornblende, kyanite, malachite, pyrite, pyrrhotite, quartz (jasper and rock crystal), rutile, tourmaline (schorl), zoisite

HARRISVILLE:
graphite

HAVERHILL:
arsenic, arsenopyrite, calcite, chalcopyrite, galena, limonite, marcasite, psilomelane (bog manganese), pyroxene, pyrrhotite, sphalerite, talc (soapstone), tourmaline (schorl)

HILLSBOROUGH:
graphite

HINSDALE:
pyrolusite, rhodonite, scheelite, tourmaline (indicolite)

HOOKSETT:
galena, quartz

HOPKINTON:
melanterite

JACKSON:
arsenic, arsenopyrite, bornite, cassiterite, chalcopyrite, copper, epidote, fluorite, hematite, ilmenite, magnetite, molybdenite, pharmocosiderite, wavellite (?), wolframite

JAFFREY:
kyanite

KEENE:
graphite, quartz (rose), talc (soapstone)

KEENE-BRATTLEBORO QUADRANGLE:
actinolite, allanite, anthophyllite, apatite, barite, biotite, calcite, chalcopyrite, chlorite, diopside, epidote, fluorite, galena, garnet, graphite, hematite, hornblende, kyanite, leucoxene, magnetite, magnetite-ilmenite, muscovite, plagioclase, potash-feldspar, pyrite, pyroxene, quartz, rutile, sericite, sillimanite, soapstone, sphalerite, sphene, staurolite, tourmaline, zircon, zoisite

LACONIA:
psilomelane (bog manganese), sphalerite

LANCASTER:
limonite, talc (soapstone)

LANDAFF:
ferrimolybdite, molybdenite

LANGDON:
andalusite

LEBANON:
arsenopyrite, galena, hematite, kyanite, limonite, magnetite, pyrite, tourmaline (schorl) (fibrous), tremolite

LISBON:
actinolated quartz, andalusite (chiastolite), ankerite, arsenopyrite, azurite, calcite, chalcopyrite, epidote, galena, garnet, hematite, hornblende, ilmenite, kyanite, magnetite, malachite, oligoclase, prehnite, prochlorite, pyrite, psilomelane (bog manganese), scheelite, staurolite, stilbite, tremolite, zoisite

LITTLETON-MOOSILAUKE QUADRANGLE:
actinolite, ankerite, anorthoclase, azurite, barkevikite, calcite, chalcopyrite, diabantite, hornblende, malachite, muscovite (pinite), orthoclase, quartz (buhrstone), staurolite

LONDONDERRY:
quartz

LOUDON:
galena

LOVEWELL MOUNTAIN QUADRANGLE:
actinolite, andesine, anorthite, apatite, beryl, biotite, bytownite, calcite, chlorite, cordierite, diopside, epidote, garnet, graphite, hornblende, kyanite, magnetite, magnetite-ilimenite, monazite, melanterite (?), microcline and orthoclase, muscovite, oligoclase, pyrite, quartz, rutile, sillimanite, sphene, spodumene, tourmaline, zircon, zoisite

LYMAN:
ankerite, arsenopyrite, azurite, chalcopyrite, copper, dolomite, galena, gold, malachite, pyrite, pyrrhotite

LYME:
bismuthinite, calcite, cassiterite, chalcopyrite, galena, gold, hornblende, kyanite, magnetite, molybdenite, potash feldspar, powellite, pyrite, rutile, scheelite, tourmaline

LYNDEBOROUGH:
galena, quartz

MADISON:
chalcopyrite, galena, sphalerite

MANCHESTER:
allanite, idocrase (vesuvianite), quartz, scapolite

MARLOW:
feldspar, lepidolite, spodumene, quartz

MASCOMA QUADRANGLE:
epidote, penninite, prochlorite, sillimanite, thuringite

MEREDITH:
calcite, galena

MERRIMACK:
rutile

MIDDLETON:
arsenopyrite

MILAN:
amethyst, beryl, bornite, chalcocite, chalcopyrite, chlorite, microcline, molybdenite, muscovite, sphalerite, topaz

MILFORD:
allanite, limonite

MILLSFIELD:
beryl

MONADNOCK QUADRANGLE:
actinolite, apatite, biotite, bog iron ore, chlorite, chloritoid, diatomite (silica), epidote, garnet, graphite, hornblende, kyanite, muscovite, oligoclase-andesine, potash feldspar, pyrite, quartz, sericite, sillimanite, sphene, tourmaline, zircon

MONROE:
azurite, chalcopyrite, malachite, pyrite, sphalerite

MOULTONBOROUGH:
hornblende, pyrite

MOUNT MONADNOCK:
tremolite

MT. CHOCORUA QUADRANGLE:
amphibole, biotite, chlorite, fayalite, garnet, grunerite, hasting-

site, hedenbergite, ilmenite, muscovite, nepheline, olivine, plagioclase, potash-feldspar, pyroxene, quartz, sillimanite, sodalite

MT. CRAWFORD:
quartz (amethyst)

MT. CUBE QUADRANGLE:
actinolite, allanite, amphibole, apatite, augite, biotite, calcite, chlorite, clinozoisite, diopside, epidote, garnet, graphite, ilmenite, kyanite, leucoxene, magnetite, molybdenite, muscovite, orthoclase, ottrelite, plagioclase, pyrite, pyrrhotite, quartz, rutile, scapolite, scheelite, serpentine, soapstone, sphene, staurolite, tourmaline, tremolite, zircon, zoisite

MT. KEARSARGE:
quartz (amethyst and rose)

MT. PAWTUCKAWAY QUADRANGLE:
actinolite, amphibole, apatite, beryl, biotite, calcite, chlorite, clinozoisite, diopside, garnet, hypersthene, ilmenite, leucoxene, limonite, magnetite, microcline, microperthite, muscovite, orthoclase, plagioclase, pyrite, pyroxene, quartz, rutile, scapolite, sericite, sillimanite, sphene, staurolite, tourmaline, uralite, zircon

MT. WASHINGTON QUADRANGLE:
actinolite, andalusite, apatite, biotite, chlorite, clinozoisite, diopside, epidote, garnet, hornblende, ilmenite, iron, leucoxene, magnetite, muscovite, orthoclase and microcline, plagioclase, prochlorite, pyrite, pyroxene, quartz (rose), sillimanite, sphene, staurolite, tourmaline, zircon

NASHUA:
galena

NELSON:
graphite, psilomelane (bog manganese)

NEWBURY:
fluorite

NEWCASTLE:
calcite

NEWFIELDS:
tourmaline (schorl and fibrous)

NEW IPSWICH:
beryl

NEW LONDON:
beryl, molybdenite

NEWMARKET:
galena

NEWPORT:
amblygonite, apatite, augelite, beryllonite, brazilianite, calcite, cleavelandite, hurlburtite, lazulite, molybdenite, pyrite, siderite, triphylite

NORTH CONWAY:
albite, allanite, anatase, andalusite, astrophyllite, brookite, chloropal (nontronite), clinozoisite, fluorapatite, fluorite, hastingsite, microcline, muscovite (sericite), orthoclase, prochlorite, pyroxene (diopside and hedenbergite), riebeckite, quartz (morion, amethyst, and smoky), siderite, sillimanite, strigovite, zircon

NORTHWOOD:
pyrolusite, quartz, tourmaline (schorl)

NOTTINGHAM:
columbite, malachite

ORANGE:
albite (cleavelandite), apatite, beryl, chalcopyrite, chrysoberyl, feldspar, galena, garnet, graftonite, muscovite, oligoclase, pyrite, pyrrhotite, quartz, spodumene, tourmaline, triphylite, vivianite

ORFORD:
calcite, chalcocite, chalcopyrite, copper, feldspar, galena, garnet, graphite, kyanite, malachite, muscovite, pyrite, pyrrhotite, staurolite, talc (soapstone), tenorite (melaconite), tourmaline (dravite)

OSSIPEE:
allanite, beryl, cassiterite, columbite, quartz

OSSIPEE MTNS.:
pyroxene (augite-diopside)

PELHAM:
limonite

PERCY QUADRANGLE:
albite, allanite, almandite garnet, andesine, apatite, astrophyllite, biotite, chlorite, chloritoid, epidote, fayalite, hastingsite, hedenbergite, hematite, hornblende, labradorite, magnetite, muscovite, oligoclase, pyrite, quartz, riebeckite, sericite, sillimanite, sphene, staurolite, tourmaline, zircon

PIERMONT:
barite, hematite, ilmenite, magnetite

PITTSBURG:
chalcopyrite, galena, gold, serpentine

PITTSFIELD:
galena

PLAINFIELD:
amesite, chalcopyrite, dolomite

PLYMOUTH QUADRANGLE:
actinolite, beryl, biotite, chalcopyrite, columbite, diatomite (silica), diopside, fayalite, galena, garnet, hastingsite, hedenbergite, hornblende, melanterite, muscovite, plagioclase, potash feldspar, pyrite, pyrrhotite, quartz, sillimanite, sphalerite

PORTSMOUTH:
calcite, epidote

PYRAMID MTN.:
hypersthene, ilmenite

RAYMOND:
almandite garnet, arsenopyrite, autunite, bertrandite, beryl (morganite), chalcopyrite, columbite, fluorite, goethite, gummite, lepidolite, manganapatite, palermoite (?), pyrite, pyrrhotite, quartz (rose and amethyst), spodumene, tourmaline, triphylite, uraninite, uranophane

RED HILL:
hastingsite, hornblende, nepheline, pyroxene (acmite and aegirinaugite), sodalite, sphene, wohlerite, zircon

RICHMOND:
anthophyllite, chlorophyllite, cordierite, pyrite, rutile, talc (soapstone)

RINDGE:
hematite, ilmenite, melanterite, psilomelane (bog manganese)

ROCHESTER:
andalusite, chiastolite, pyrrhotite, staurolite

RUMNEY:
apatite, beryl, galena, garnet, graftonite, muscovite, sillimanite, sphalerite, sphene, tourmaline, triphylite

RYE:
andalusite, calcite

SADDLEBACK MTN.:
spinel

SALISBURY:
graphite

SANDWICH:
galena, quartz

SHELBURNE:
bornite, chalcopyrite, galena, pyrite, siderite, sphalerite

SPRINGFIELD:
apatite, autunite, beryl, feldspar, lollingite, muscovite, quartz (rose), spessartite, topaz, tourmaline

STARK:
knebelite, labradorite, microcline, quartz (smoky), topaz

STODDARD:
cordierite, lazulite

STRAFFORD:
albite (cleavelandite), almandite (spessartite), amblygonite, autunite, beryl, cassiterite, columbite, eosphorite, fairfieldite, feldspar, ferri-sicklerite (?), fluorapatite, graftonite, graphite, heterosite, idocrase (vesuvianite), lollingite, microcline (perthite), muscovite, orthoclase (adularia), pyroxene (diopside), quartz, rhodochrosite, spodumene, tourmaline (schorl), triphylite, vivianite

SULLIVAN:
beryl, feldspar, muscovite, quartz

SUNAPEE:
apatite, beryl, feldspar, garnet, muscovite, tourmaline

SUNAPEE QUADRANGLE:
actinolite, allanite, apatite, biotite, bismuth, chlorite, cordierite, diopside, epidote, garnet, graphite, hornblende, ilmenite, magnetite, microcline, muscovite, pargasite, plagioclase, pyrite, quartz, rutile, sillimanite, sphene, staurolite, tourmaline, zircon, zoisite

SURRY:
calcite, galena, hematite, quartz (amethyst), turgite

SUTTON:
graphite

SWANZEY:
feldspar, talc (soapstone)

TAMWORTH:
galena

THORNTON:
muscovite, oligoclase, pyrite, pyrrhotite

TRIPYRAMID MOUNTAIN:
chrysolite (hyalosiderite)

TROY:
andalusite, graphite

UNITY:
actinolite, chalcopyrite, chlorophyllite, cordierite, ilmenite, magnetite, pyrite

WAKEFIELD:
beryl, chrysoberyl, cleavelandite, columbite, garnet, molybdenite, tourmaline (indicolite), samarskite

WALPOLE:
amblygonite, andalusite, feldspar, graphite, kalinite, muscovite, spodumene, tourmaline (indicolite), triphylite

WARNER:
talc (soapstone)

WARREN:
beryl, calcite, chalcopyrite, epidote, galena, garnet, gold, grossularite, hornblende, idocrase (vesuvianite), kyanite, molybdenite, pyrite, pyrrhotite, pyroxene, quartz (rock crystal), rutile, sphalerite, tourmaline, tremolite, zoisite

WASHINGTON:
graphite

WATERVILLE:
quartz (amethyst)

WEARE:
arsenopyrite, talc (soapstone)

WENTWORTH:
beryl, feldspar, garnet, graphite, muscovite

WESTMORELAND:
barite, bornite, chalcopyrite, ferrimolybdite, fluorite, galena, kaolinite, kyanite, limonite, malachite, molybdenite, pyrite, quartz (amethyst and rock crystal), sericite, smithsonite, sphalerite, staurolite, zoisite

WHITEFIELD:
molybdenite

WILMOT:
almandite, apatite, beryl, chrysoberyl, feldspar, muscovite, quartz, tourmaline

WINCHESTER:
magnetite, psilomelane, pyrolusite, rhodochrosite, rhodonite, sillimanite, spodumene, tourmaline (indicolite)

WINNIPESAUKEE QUADRANGLE:
augite, biotite, garnet, hastingsite, hornblende, ilmenite, muscovite, nepheline, plagioclase, potash feldspar, pyroxene, quartz, sillimanite, sodalite

WOLFEBORO QUADRANGLE:
actinolite, apatite, beryl, biotite, calcite, chlorite, clinozoisite, columbite, diopside, garnet, hastingsite, hornblende, magnetite, muscovite, plagioclase, potash feldspar, pyroxene, quartz

WOODSTOCK:
galena

SUMMARY OF NEW HAMPSHIRE'S MINERAL INDUSTRIES

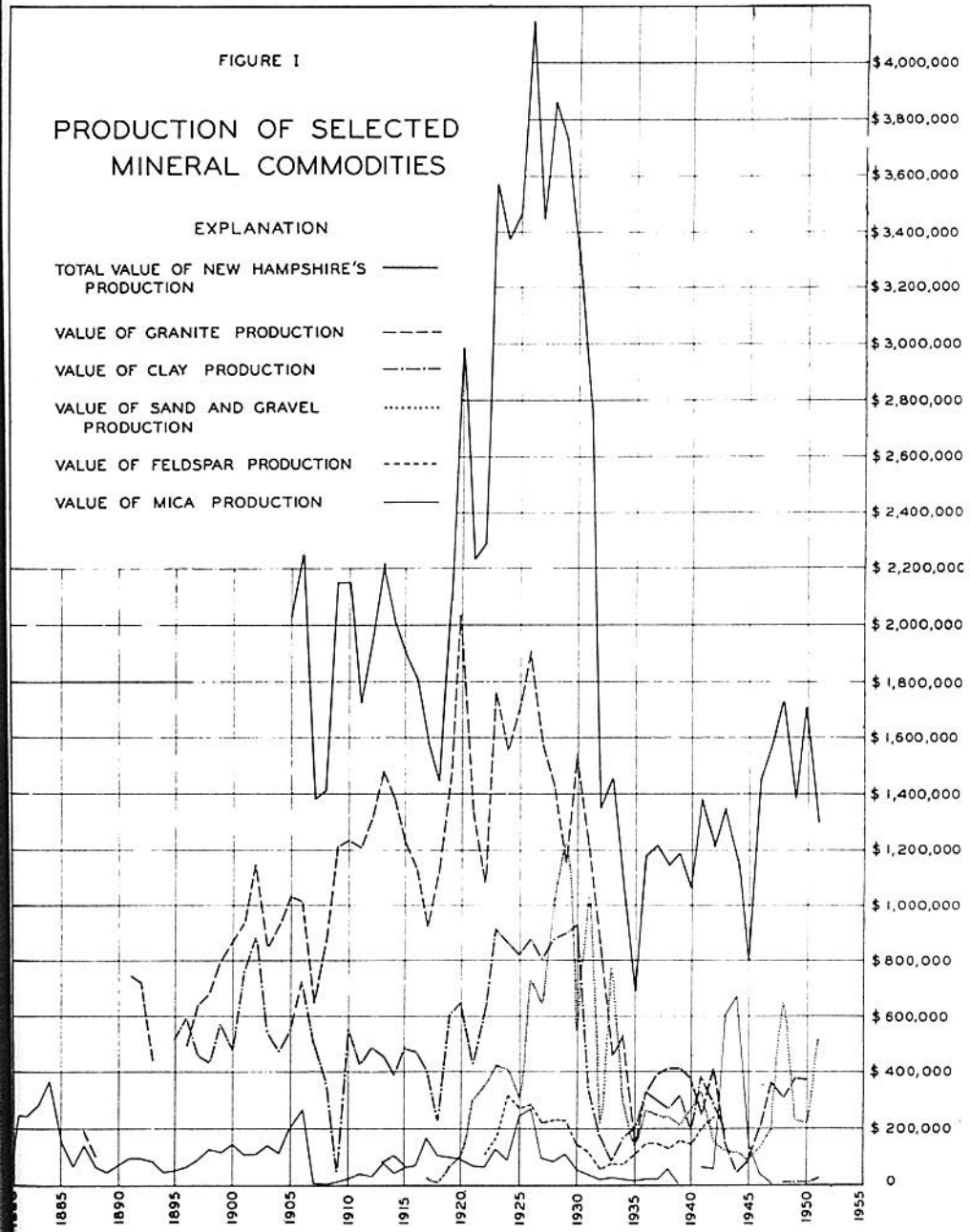
Brief Review of Present and Past Production

Probably the number and variety of minerals found in New Hampshire by mineral collectors is surpassed by only a few states — perhaps none. Yet in 1951 (25), the value of New Hampshire's mineral production was exceeded by all states except Rhode Island, Delaware, and the District of Columbia. Possibly this is due in part to the limited interest and application of modern methods of prospecting and exploration to prove whether or not commercially exploitable mineral deposits are present.

New Hampshire's principal mineral products in 1951 were, in the order of value, sand and gravel, feldspar, stone, and clay. In addition, small quantities of beryl and strategic sheet mica were sold to the Government Purchasing Depot in Franklin for the National Stockpile. The value of some of New Hampshire's mineral commodities have been plotted in relation to the total mineral production of the state (See Figure 1). Data are incomplete, but major trends are apparent, such as the relationship of granite production to the total mineral production. In 1951 New Hampshire produced 0.01 per cent of the total mineral production of the United States. Of the six New England states in 1951, New Hampshire was fifth, outranking Rhode Island by a very slight margin.

Three of New Hampshire's industries, clay, granite, and mica, have been active for many years, long before the beginning of production records. Probably clay and granite were produced in small amounts shortly after the first coastal settlements in the early 1600's because both materials were accessible. It was not until 1803 that mica was first produced commercially in the United States at the Ruggles mine, Grafton.

In addition to the early clay, granite, and mica industries many other mineral commodities were produced during the 18th and 19th centuries. Most of these mineral industries were short-lived because metal-bearing deposits appear to have been too small or too expensive and low grade to work in competition with those deposits which were continually being opened as people migrated westward. Although some of the mineral deposits may have been exhausted, the mineral-



ized areas should not only be reevaluated by modern methods of prospecting and exploration, but also in view of modern mineral technology.

Bog iron was produced in the late 1600's in some coastal communities and in places along the Merrimack and Connecticut River valleys. Iron production increased by the discovery of the magnetite ore at Lisbon. The ore was smelted at furnaces at Franconia for more than 60 years. The initial furnaces were built in 1811. The local limestone (marble) was quarried at Lisbon and in several other nearby towns for use as a flux in the smelting. Also, this same stone was quarried in small amounts for agricultural uses. The discovery of the "Ammonoosuc Gold District" and the "rush" to purchase property in the towns of Lyman, Bath, Lisbon, and Littleton produced great excitement, but only small quantities of the precious metal. Small quantities of tin ore were mined in Jackson.

Copper, lead, and zinc mines were active in the late 1800's and early 1900's. At the Milan mine, Milan, both pyrite for making sulfuric acid and copper and zinc ore were produced; at Ore Hill, Warren, zinc and lead were mined, with small amounts of gold and silver as byproducts; at the Madison mine, Madison, both zinc and lead and the byproducts gold and silver were produced. Smaller base metal mines were opened in the towns of Croydon, Gorham, Woodstock, Lebanon, and Unity. Other early mining ventures were made for molybdenite at several places, principally at the Lincoln mine, Westmoreland. Graphite was mined in small amounts at Goshen and Antrim.

Certain types of metamorphic rocks have been quarried for many years for use as natural sharpening stones. This industry is still active despite competition from synthetic abrasives. Although feldspar had been produced in Connecticut and Maine since the early 1800's, New Hampshire's deposits were not mined until 1914. At present, New Hampshire is the leading New England producer of feldspar and one of the nation's principal producing states.

During the period between 1885 and 1923, the production of mineral water was listed as one of New Hampshire's mineral industries. In 1893, production reached a maximum of 1,409,125 gallons and was valued at $702,281. During the first half of the 19th century considerable amounts of soapstone were quarried, principally at Francestown and Richmond. At about the same time a reputable glass industry was active at Lyndeboro. Quartz was taken from the nearby

deposits. Diatomite has been produced at Fitzwilliam and several other places for use as an ingredient in silver polish, as a filter, and for insulating material.

Peat bogs have been worked intermittently in the towns of Barnstead, Hampton, and Milford, to mention only a few. Between 1908 and 1923 more than 6000 tons of fluorite were mined in Westmoreland and Chesterfield. During intermittent operations between 1910 and 1935 considerable quantities of garnet were produced at Wilmot. The mine was closed due to the competition from New York mines, not because the deposits were depleted.

Specific production of five commodities is shown in Figure 1.

Future Possibilities in the Mineral Industry

It would be unwise to predict that New Hampshire will become an important base metal producing state. However, during the past year some of the major mining companies of the United States and Canada have been doing reconnaissance work in the northern, northwestern, and southeastern parts of the state. One of the reasons for this recent interest is probably the successful exploration and development of base metals in New Brunswick and exploratory work in Maine. Even greater interest may be shown when used with the Geologic Map of New Hampshire released by the U. S. Geological Survey in June 1955. This map, together with the detailed quadrangle maps, should provide considerable data for guiding airborne geophysical prospecting by either magnetic or electromagnetic methods. In addition, the use of the accompanying map, which shows the location of most New Hampshire mines, is printed on the same scale as the geologic map and should be a further guide to serious prospecting and checking some of the major trends in mineralization.

If large bodies of pyrrhotite were found associated with mineable quantities of base metals, it might be an incentive for the production of sulfur (See *Pyrrhotite* for description of recent discovery).

In considering nonmetallic mineral products, it can be stated that much of the peat used in New England for poultry litter and as a soil conditioner is imported. Some of the larger and better quality bogs in New Hampshire might be reexamined as possible sources of marketable peat. Although much of the high-grade aluminous refractories are currently made by the fusion of artificial materials, the deposits of sillimanite and andalusite in New Hampshire should not

be overlooked in view of improved beneficiation by modern milling methods.

Some of the larger pegmatites which do not indicate mineable quantities of feldspar at the surface might be explored by use of the diamond drill. One of these so-called "barren" pegmatites in Alstead is being diamond drilled in 1955. Diamond drilling in search for additional reserves of feldspar was done at the Ruggles mine, Grafton following World War II. Several successful diamond drilling programs were carried out during World War II by the U. S. Bureau of Mines and U. S. Geological Survey to locate additional reserves of strategic mica. One of the mica mines in Alstead was reopened in 1955 because information on the location of mica reserves had been obtained by earlier mining and diamond drilling.

Probably one of the most significant developments in the construction industry in recent years has been the use of lightweight aggregates. Some of New Hampshire's clay deposits, and possibly some of the slates, should be investigated for making bloated clay products. Chapman has made some preliminary investigations (70).

Initial work on the possible use of some of the sand deposits for special purposes, such as foundry sands, has been made by Meyers (147). Further studies might be undertaken by private industries.

The nepheline syenite deposits at Red Hill, Moultonboro, should be investigated to ascertain whether modern milling methods could reduce the iron content of this rock to such a small amount that the rock might provide a new source of alumina for the glass industry. Large quantities are mined in Canada and imported to the United States.

Research in Geochemistry

In addition to geophysical prospecting for metals, more data should be made available by means of geochemical prospecting. Considerable research has been done in certain areas of known mineralization in the western United States and in Canada. Some of the techniques used in unglaciated regions might have to be modified to be successful in New Hampshire where all of the mantle rock, or over-burden, is a result of glacial deposition. Water sampling and testing might be more effective for preliminary investigations. Such a program has been initiated in the Ore Hill area in Warren by Illsley (unpublished manuscript).

Preliminary studies of the content and distribution of the trace elements in some of the igneous and metamorphic rocks of New Hampshire have been made by Billings (54), Chapman and Schweitzer (66), Stoll (195), Shimer (189), and Shaw (187). This type of study, and similar work done in the future, may prove to be of considerable significance in the development of ideas about the origin and distribution of New Hampshire's mineral deposits.

The work of Billings and Keevil (53) has been of considerable interest and value in making tentative suggestions about the content and distribution of radioactive minerals in the granitic rocks of New Hampshire.

Mine Map of New Hampshire

The mine map which accompanies this report has been compiled largely from survey reports by Larrabee (133), Frost (98), Olson (156) and (157), and Cameron (59).

Most of the mines are closed; some have been inactive for many years. In 1955, feldspar and mica mines and some granite and crushed stone quarries are operating. Only quarries known to be recently active have been located on the map; clay and sand and gravel pits are not included.

Selected Mineral Associations

The mineral associations at a copper, fluorite, iron, and zinc mine are listed in Table 1 along with those from a number of feldspar and mica mines. It should be noted that no attempt was made to list all of the known minerals at any particular mine; only those minerals which have a mineralogical or geological interest are included.

Table 1 may be of interest to the professional mineralogist and geologist, and, at the same time, it will serve as a guide to the mineral collector.

Table 1

Selected Localities for Collecting Rare and Interesting Minerals*

	Chandler, Raymond	Chandler Mills, Newport	Demott, Grafton	Eight Ball, Rumney	Fletcher, Groton	Fluorite mines, Westmoreland	Franconia Iron mine, Lisbon	Keyes No. 1, Alexandria	Milan mine, Milan	Ore Hill, Warren	Palermo No. 1, Groton	Parker Mountain, Strafford	Pattuck, Alexandria	Ruggles, Grafton	Sargeant, Claremont	Smith, Raymond	E. E. Smith, Alexandria	G. F. Smith, Newport	Weeks, Wakefield
amblygonite		—																	
arsenopyrite							—				—								
augelite		—									—	—				—	—		
autunite							—												
azurite						—													
barite											—								
beraunite																—			
bertrandite	—																		
beryl (morganite)				—															
beryl (white)		—																	
beryllonite						—			—		—								
bornite		—									—								
brazilianite						—	—												
calcite												—							
cassiterite									—										
chalcocite		—				—	—		—	—	—		—			—			
chalcopyrite											—								—
chlorite																			—
chrysoberyl	—											—					—	—	
columbite-tantalite												—							
cookeite											—								
crandallite-deltaite (?)												—							
"cymatolite"											—								
cyrtolite						—					—	—					—		
dufrenite											—	—							
eosphorite-childrenite (?)							—				—								
epidote												—							
α-eucryptite											—	—							
fairfieldite											—	—							
ferri-sicklerite						—									—		—		
fluorite		—																	
francolite											—								
frondelite-rockbridgeite																			

	Chandler, Raymond	Chandler Mills, Newport	Demott, Grafton	Eight Ball, Rumney	Fletcher, Groton	Fluorite mines, Westmoreland	Franconia Iron mine, Lisbon	Keyes No. 1, Alexandria	Milan mine, Milan	Ore Hill, Warren	Palermo No. 1, Groton	Parker Mountain, Strafford	Pattuck, Alexandria	Ruggles, Grafton	Sergeant, Claremont	Smith, Raymond	E. E. Smith, Alexandria	G. F. Smith, Newport	Weeks, Wakefield
galena						—				—									
goyazite											—								
graftonite			—					—			—	—			—				
gummite											—			—		—			
hematite							—												
herderite					—						—								
heterosite			—	—	—						—	—					—	—	
hornblende							—												
hurlburtite		—																	
ilmenite							—												
lazulite		—									—								
lepidolite	—																—		
lithiophyllite													—				—		
löllingite			—								—								
ludlamite											—						—		
magnetite							—			—									
malachite						—	—												
manganoan apatite												—			—				
manganite											—								
marcasite														—					
melanerite											—								
messelite (?)											—								
molybdenite						—												—	
montmorillonite													—						
palermoite											—								
parsonite													—						
phosphuranylite											—		—						
prehnite						—													
prochlorite						—													
psilomelane											—								
purpurite				—								—							
pyrite		—			—	—	—	—	—	—			—	—					
pyrrhotite		—					—	—				—			—				
quartz (actinolated)						—													
quartz (green)						—													

	Chandler, Raymond	Chandler Mills, Newport	Demott, Grafton	Eight Ball, Rumney	Fletcher, Groton	Fluorite mines, Westmoreland	Franconia Iron mine, Lisbon	Keyes No. 1, Alexandria	Milan mine, Milan	Ore Hill, Warren	Palermo No. 1, Groton	Parker Mountain, Strafford	Pattuck, Alexandria	Ruggles, Grafton	Sargeant, Claremont	Smith, Raymond	E. E. Smith, Alexandria	G. F. Smith, Newport	Weeks, Wakefield
reddingite											—								
rhodochrosite											—	—							
samarskite																			—
scheelite							—												
sicklerite																	—		
siderite		—									—					—			
smithsonite						—													
sphalerite						—			—	—									
spodumene	—											—				—			
stilbite							—												
stewartite (?)											—								
strengite					—						—								
tobernite														—					
topaz														—					
tremolite							—			—									
triphylite			—	—	—		—				—	—	—	—	—	—	—	—	
triplite											—								
triploidite											—								
uraninite														—		—			
uranochalcite											—								
uranophane														—		—			
uranospinite														—					
voelckerite		—																	
vivianite			—	—	—		—				—		—	—	—		—	—	
wad											—								
wolfeite											—								
whitlockite											—								
xanthoxenite											—								
zinnwaldite											—								
zircon														—					
zoisite							—			—									

*NOTE: In addition to the minerals listed above most of the feldspar and mica mines contain several types of feldspar and quartz, as well as muscovite, biotite, tourmaline, garnet, and apatite; many contain small amounts of common beryl.

BIBLIOGRAPHY

Numbers given in the body of the report refer to the references listed numerically below.

A. SELECTED BOOKS FOR BEGINNERS

1. English, G. L.
   Getting Acquainted with Minerals. Rochester, N. Y. Mineralogical Publishing Co., 1934.
2. Hawkins, A. C.
   The Book of Minerals. John Wiley & Sons, 1935.
3. Hurlburt, C. S., Jr.
   Minerals and How to Study Them. John Wiley & Sons, 3d Ed., 1949.
4. Loomis, F. B.
   Field Book of Common Rocks and Minerals. G. P. Putnam's Sons, 1948.
5. Pearl, R. M.
   How to Know Minerals and Rocks. McGraw-Hill Book Co., Inc., 1955.
6. Pearl, R. M.
   Popular Gemology. John Wiley & Sons, 1949.
7. Pough, F. H.
   A Field Guide to Rocks and Minerals. Houghton-Mifflin Co., 1953.

B. SELECTED BOOKS OF MINERALOGY, ECONOMIC GEOLOGY AND GEMOLOGY

8. American Institute of Mining and Metallurgical Engineers.
   Industrial Minerals and Rocks, 2nd Ed., 1949.
9. Bateman, A. M.
   The Formation of Mineral Deposits. John Wiley & Sons, 1951.
10. Bateman, A. M.
    Economic Mineral Deposits. John Wiley & Sons, 2nd Ed., 1950.
11. Bowles, Oliver
    The Stone Industries. McGraw-Hill Book Co., Inc., 1939.
12. Brush, G. J. and Penfield, S. L.
    Manual of Determinative Mineralogy and Blowpipe Analysis. John Wiley & Sons, 1926.

13. Dana, E. S.
A System of Mineralogy with Appendices I, II, and III. John Wiley & Sons, 1920.
14. DeMent, J. A. and Dake, H. C.
Handbook of Uranium Minerals. The Mineralogist Pub. Co., Portland, Oregon, 1948.
15. Ford, W. E.
Dana's Textbook of Mineralogy, 4th Ed. John Wiley & Sons, 1932.
16. Hurlburt, C. S., Jr.
Dana's Manual of Mineralogy, 16th Ed. John Wiley & Sons, 1953.
17. Johnstone, S. J.
Minerals for the Chemical and Allied Industries. John Wiley & Sons, 1954.
18. Kraus, E. H., Hunt, W. F., Ramsdell, L. S.
Mineralogy, 4th Ed. McGraw-Hill Book Co., Inc., 1954.
19. Kraus, E. H. and Slawson, C. B.
Gem and Gem Materials. McGraw-Hill Book Co., Inc., 1947.
20. Ladoo, R. B. and Myers, W. M.
Non-Metallic Minerals. McGraw-Hill Book Co., Inc., 1951.
21. Larsen, E. S. and Berman, H.
The Microscopic Determination of the Nonopaque Minerals. U. S. Geological Survey Bulletin 848, 1934.
22. Lindgren, W.
Mineral Deposits. McGraw-Hill Book Co., Inc., 1933.
23. **Mineral Resources of the U. S., 1882-1923,** U. S. Geological Survey (1894-1899) published as a part of the 16th-21st Annual Reports.
24. **Mineral Resources of the U. S., 1923-1931,** U. S. Bureau of Mines.
25. **Minerals Yearbook, 1932-1951,** U. S. Bureau of Mines.
26. Nininger, R. D.
Minerals for Atomic Energy. D. Van Nostrand Co., N. Y., 1954.
27. Palache, C., Berman, H., and Frondel, C.
Dana's System of Mineralogy, 7th Ed., Vol. I (1944) II (1951).

28. Rogers, A. F., and Kerr, P. F.
Optical Mineralogy, 2nd Ed. McGraw-Hill Book Co., Inc., 1942.
29. Rogers, A. F.
Introduction to the Study of Minerals, 3rd Ed. McGraw-Hill Book Co., Inc., 1937.
30. Short, M. N.
Microscopic Determination of the Ore Minerals. U. S. Geological Survey Bulletin 825, 1931.
31. Smith, Orsino
Identification and Qualitative Chemical Analyses of Minerals, 2nd Ed. D. Van Nostrand Co., N. Y., 1953.
31a. U. S. Atomic Energy Commission and U. S. Geological Survey
Prospecting for Uranium.
32. Wahlstrom, E. E.
Petrographic Mineralogy. John Wiley & Sons, N. Y., 1955.
33. Winchell, A. N.
Elements of Mineralogy. Prentice-Hall, N. Y., 1942.
34. Winchell, A. N.
Elements of Optical Mineralogy, Part I, 5th Ed.; Part II, 4th Ed.; Part III, 2nd Ed. John Wiley & Sons.
34a. Wright, Robert J.
Prospecting with a Counter. U. S. Atomic Energy Commission (Office of Technical Services, Department of Commerce)

C. NEW HAMPSHIRE REFERENCES

35. Allen, Robert D., 1952
Variations in Chemical and Physical Properties of Fluorite. American Mineralogist, v. 37, p. 910-930.
36. Bannerman, H. M. and Stoiber, R. E., 1937
Fluorite Deposits in Westmoreland, New Hampshire. Geological Society of America, Abstract of Papers. Fiftieth Annual Meeting, p. 6.
37. Bannerman, Harold M., 1939
Mines and Minerals of New Hampshire. Report; New England Association of Chemistry Teachers, v. 41, No. 1, p. 4-14.

38. Bannerman, Harold M., 1940
Some Interesting Mineral Occurrences within Lake Sunapee Region. Echoes, v. 1, p. 2; p. 10.

39. Bannerman, Harold M., 1941
Sillimanite, Andalusite, and Kyanite, Preliminary Report. Mineral Resource Survey, Pt. IV, N. H. State Planning and Development Commission, 1941. Reprinted 1949. 5 p.

40. Bannerman, Harold M., 1941
The Fluorite Deposits of Cheshire County, N. H. Mineral Resource Survey, Pt. V, N. H. State Planning and Development Commission, 1941. Reprinted 1949. 9 p. illus.

41. Bannerman, Harold M., 1943
Structural and Economic Features of Some New Hampshire Pegmatites. Mineral Resource Survey, Pt. VII, N. H. State Planning and Development Commission. 1943. Reprinted 1950. 22 p.

42. Bannerman, H. M., and Cameron, E. N., 1946
The New England Mica Industry. Mining Technology T. P. 2024, v. 10, No. 3, 8 p.

43. Bardill, J. D., 1943
Weeks Feldspar Quarry, Carroll County, New Hampshire. U. S. Bur. Mines War Mineral Rept. 81, 6 p.

44. Bardill, J. D., 1946
Exploration of the Stoddard Fluorite Mine, Cheshire County, New Hampshire. U. S. Bur. Mines Rept. Inv. 3937, 6 p.

45. Berman, Harry, 1927
Graftonite from a New Locality in New Hampshire. American Mineralogist, v. 12, No. 4, p. 170-172.

46. Billings, Marland P., 1927
Topaz and Phenacite from Baldface Mountain, Chatham, New Hampshire. American Mineralogist, v. 12, No. 4, p. 173-179.

47. Billings, Marland P., 1928
The Petrology of the North Conway Quadrangle in the White Mountains of New Hampshire. Proceedings, American Academy of Arts and Sciences, v. 63, No. 3, p. 67-137.

48. Billings, Marland P., 1935
Geology of the Littleton-Moosilauke Quadrangles, New Hampshire. State Planning and Development Commission, Concord, New Hampshire. 51 p. illus.

49. Billings, Marland P. and Williams, Charles R., 1935
Geology of the Franconia Quadrangle, New Hampshire. State Planning and Development Commission, Concord, New Hampshire. 35 p. illus.

50. Billings, Marland P., 1937
Regional Metamorphism of the Littleton-Moosilauke Area, New Hampshire. Bulletin, Geological Society of America, v. 48, p. 463-566.

51. Billings, Marland P., 1941
Structure and Metamorphism of the Mount Washington Area, New Hampshire. Bulletin, Geological Society of America, v. 52, p. 863-936.

52. Billings, Marland P., 1945
Mechanics of Igneous Intrusion. American Journal of Science, v. 243-A, Daly Volume, p. 40-68.

53. Billings, M. P. and Keevil, N. B., 1946
Petrography and Radioactivity of Four Paleozoic Magma Series in New Hampshire. Bulletin, Geological Society of America, v. 57, p. 797-828.

54. Billings, M. P. and Rabbitt, J. C., 1947
Chemical Analyses and Calculated Modes of the Oliverian Magma Series, Mt. Washington Quadrangle, New Hampshire. Bulletin, Geological Society of America, v. 58, p. 573-596.

55. Bowles, Oliver, 1939
New Products, New Processes, New Uses for the Nonmetallics. Mining and Metallurgy, p. 22-28.

56. Burbank, Benjamin B., 1933
Ruggles Mica Mine, Grafton, New Hampshire. Mineralogical Society Southern Calif., Bull., v. 2, No. 5, p. 1-2.

57. Cameron, E. N., Larrabee, D. M., McNair, A. H., Page, J. J., Shainin, V. E., and Stewart, G. W., 1945
Structural and Economic Characteristics of New England Mica Deposits. Economic Geology, v. 40, p. 369-393.

58. Cameron, E. N., Jahns, R. H., McNair, A. H., Page, L. R., 1949

Internal Structure of Granitic Pegmatites. Economic Geology Mon. 2, 115 p.

59. Cameron, E. N., Larrabee, D. M., McNair, A. H., Page, J. J., Stewart, G. W., and Shainin, V. E., 1955
Pegmatite Investigations, 1942-45, New England. U. S. Geological Survey Prof. Paper 255, p. 1-56, 106-295.

60. Carper, J. B., 1909
The Milan Mine, New Hampshire. Engineering and Mining Journal, v. 87, p. 318. (A brief note giving metal contents of ore shipments from the Milan mine).

61. Chapman, Carleton A., 1939
Geology of the Mascoma Quadrangle, New Hampshire. Bulletin, Geological Society of America, v. 50, p. 127-180.

62. Chapman, Carleton A., 1941
The Tectonic Significance of Some Pegmatites in New Hampshire. Jour. Geology, v. 49, p. 370-381.

63. Chapman, Carleton A., 1942
Intrusive Domes of the Claremont-Newport Area, New Hampshire. Bulletin, Geological Society of America, v. 53, p. 889-916.

64. Chapman, Carleton A., 1943
Large Magnesia-rich Triphylite Crystals in Pegmatite. American Mineralogist, v. 28, p. 90-98.

65. Chapman, C. A., Billings, M. P., and Chapman, R. W., 1944
Petrology and Structure of the Oliverian Magma Series in the Mount Washington Quadrangle, New Hampshire. Bulletin, Geological Society of America, v. 55, p. 497-516.

66. Chapman, C. A., and Schweitzer, G. K., 1947
Trace Elements in the Rocks of the Oliverian Magma Series of New Hampshire. American Journal of Science, v. 245, p. 597-613.

67. Chapman, Carleton A., 1950
Quartz Veins Formed by Metamorphic Differentiation of Aluminous Schists. American Mineralogist, v. 35, p. 693-710.

68. Chapman, Carleton A., 1952
Structure and Petrology of the Sunapee Quadrangle, New Hampshire. Bulletin, Geological Society of America, v. 63, p. 381-425.

69. Chapman, Carleton A., 1953
The Geology of the Sunapee Quadrangle, New Hampshire. State Planning and Development Commission, Concord, New Hampshire, 29 p.

70. Chapman, Donald H., 1950
Preliminary Report on the Clays of New Hampshire. Mineral Resource Survey, Pt. XII, State Planning and Development Commission, Concord, New Hampshire, 25 p.

71. Chapman, Randolph W., and Williams, Charles R.
Evolution of the White Mountain Magma Series. American Mineralogist, v. 20, No. 7, p. 502-530.

72. Chapman, Randolph W., 1935
Percy Ring-dike Complex. American Journal of Science, v. 30, p. 401-431.

73. Chapman, Randolph W., 1937
Petrology of the Syenite Stock at Cherry Mountain, New Hampshire, (Carroll and Jefferson townships). American Journal of Science, v. 33, p. 174-186.

74. Chapman, Randolph W., 1948
Petrology and Structure of the Percy Quadrangle, New Hampshire. Bulletin, Geological Society of America, v. 59, p. 1059-1100.

75. Chayes, Felix, 1944
Occurrence of Chrysoberyl at Wakefield, Carroll County, New Hampshire. American Mineralogist, v. 29, p. 320-322.

76. Conant, Louis C., 1935
Optically Positive Cordierite from New Hampshire. American Mineralogist, v. 20, No. 4, p. 310-311.

77. Conant, Louis C., 1935
The New Hampshire Garnet Deposits. Economic Geology, v. 30, No. 4, p. 387-399.

78. Dale, T. Nelson, 1923
The Commercial Granites of New England. U. S. Geological Survey Bull. 738.

79. Dubois, H. B., 1940
Development and Growth of the Feldspar Industry. American Ceramic Society Bull. 19, p. 206-213.

80. Earl, K. M., 1950
Investigation of the Milan Copper Deposit, Coos County, New Hampshire. U. S. Bur. Mines Rept. Inv. 4718, 9 p.

81. Emmons, William H., 1910
Some Ore Deposits in Maine and the Milan Mine, New Hampshire. U. S. Geological Survey Bull., No. 432.
82. Fairbanks, E. E., 1948
"Hottest" Collecting Spot in East. (N. H.). American Mineralogist, v. 16, p. 507-508.
83. Flint, George M., 1919
Famous mineral localities: Beryl Hill, Grafton, New Hampshire. American Mineralogist, v. 4, p. 21-22.
84. Fowler-Billings, Katherine, and Kingsley, Louise, 1937
Geology of the Cardigan Quadrangle, New Hampshire. Bulletin, Geological Society of America, v. 48, p. 1363-1386.
85. Fowler-Billings, Katherine and Page, L. R., 1942
The Geology of the Cardigan and Rumney Quadrangles, New Hampshire. N. H. State Planning and Development Commission, Concord, New Hampshire. 30 p.
86. Fowler-Billings, Katherine, 1944
Sillimanite Deposits in the Monadnock Quadrangle, New Hampshire. Mineral Resource Survey, Pt. VIII, N. H. State Planning and Development Commission, Concord, New Hampshire, 14 p.
87. Fowler-Billings, Katherine, 1949
The Geology of the Monadnock Quadrangle, New Hampshire. N. H. State Planning and Development Commission, Concord, New Hampshire, 41 p.
88. Fowler-Billings, Katherine, 1949
Geology of the Monadnock Region of New Hampshire. Bulletin, Geological Society of America, v. 60, p. 1249-1280.
89. Freedman, Jacob, 1950
The Geology of the Mt. Pawtuckaway Quadrangle, New Hampshire. N. H. State Planning and Development Commission, Concord, New Hampshire. 31 p.
90. Freedman, Jacob, 1950
Stratigraphy and Structure of the Mt. Pawtuckaway Quadrangle, Southeastern New Hampshire. Bulletin, Geological Society of America, v. 61, p. 449-492.
91. Frondel, Clifford, 1941
Whitlockite: a New Calcium Phosphate, $Ca_3(PO_4)_2$. American Mineralogist, v. 26, p. 145-152.

92. Frondel, Clifford, 1943
Mineralogy of the Calcium Phosphates in Insular Phosphate Rock. American Mineralogist, v. 28, p. 215-232.
93. Frondel, Clifford and Lindberg, Marie, 1948
Second Occurrence of Brazilianite. American Mineralogist, v. 33, p. 135-141.
94. Frondel, Clifford, 1949
The Dufrenite Problem. American Mineralogist, v. 34, p. 513-540.
95. Frondel, Clifford, 1949
Wolfeite, Xanthoxenite and Whitlockite from the Palermo Mine, New Hampshire. American Mineralogist, v. 34, p. 692-705.
96. Frondel, Clifford, 1950
Studies of Uranium Minerals (V); Phosphuranylite. American Mineralogist, v. 35, p. 756-763.
97. Frondel, Clifford, 1950
Studies of Uranium Minerals (I); Parsonite and Randite. American Mineralogist, v. 35, p. 245-250.
98. Frost, Leonard R., 1934
Mine Survey Report (Manuscript). New Hampshire State Planning and Development Commission, Concord.
99. Gillson, Joseph L., 1927
The Granite of Conway, New Hampshire, and its Druse Minerals. American Mineralogist, v. 12, No. 8, p. 307-319.
100. Goldthwait, J. W., Goldthwait, L., and Goldthwait, R. P., 1951
The Geology of New Hampshire: Pt. 1, Surficial Geology. N. H. State Planning and Development Commission, Concord, New Hampshire. 81 p.
101. Hadley, Jarvis B. and Chapman, Carleton A., 1939
The Geology of the Mt. Cube and Mascoma Quadrangles, New Hampshire. N. H. State Planning and Development Commission, Concord. 28 p.
102. Hadley, Jarvis B., 1942
Stratigraphy, Structure, and Petrology of the Mt. Cube Area, New Hampshire. Bulletin, Geological Society of America, v. 53, p. 113-176.
103. Hawes, George W., 1878
Geology of New Hampshire, Vol. III, Part IV. Mineralogy and Lithology, Concord.

104. Heald, M. T., 1950
The Geology of the Lovewell Mountain Quadrangle, New Hampshire. N. H. State Planning and Development Commission, Concord. 26 p.
105. Heald, M. T., 1950
Structure and Petrology of the Lovewell Mountain Quadrangle, New Hampshire. Bulletin, Geological Society of America, v. 61, p. 43-89.
106. Heinrich, E. William, 1951
Mineralogy of Triplite. American Mineralogist, v. 36, p. 256-271.
107. Hermance, H. P., and Mosier, McHenry, 1948
Investigation of the Ore Hill Zinc-Lead Mine, Grafton County, New Hampshire. U. S. Bur. Mines Rept. Inv. 4328, 13 p.
108. Hess, F. L., Whitney, R. J., Trefethen, J., and Slavin, H., 1943
The Rare Alkalis in New England. U. S. Bur. Mines Inf. Circ. 7232, 51 p.
109. Hitchcock, Charles H., 1877
Geology of New Hampshire, Vol. II, Part II, **Stratigraphical Geology.** Concord.
110. Hitchcock, Charles H., 1878
Geology of New Hampshire, Vol. III, Part V, Economic Geology. Concord.
111. Hitchcock, Charles H., 1904
New Studies in the Ammonoosuc District of New Hampshire. Bulletin, Geological Society of America, v. 15, p. 461-482.
112. Hodge, James Thacher, 1853
Report on the Mining Properties at Shelburne, New Hampshire. Mining Magazine, v. 1, p. 27-34.
113. Holden, Edward F., 1918
Famous Mineral Localities: Beryl Mountain, Acworth, New Hampshire. American Mineralogist, v. 3, p. 199-200.
114. Holden, Edward F., 1920
An American Occurrence of Sarcopside (Deering, New Hampshire). American Mineralogist, v. 5, No. 5, p. 89-102.
115. Holden, Edward F., 1924
Further Note on Sarcopside. American Mineralogist, v. 9, No. 10, p. 205-207.

116. Hubbard, Oliver P., 1851
On the Rutile and Chlorite in Quartz. American Association for the Advancement of Science, Proceedings 4, p. 25-28.
117. Hubbard, Oliver P., 1852
Beryls in Grafton, New Hampshire. American Journal of Science, 2, 4: 264-265.
118. Huntington, E., 1880
On the Iron Ore of Bartlett, New Hampshire. Boston Society Natural History, Proceedings 20, p. 288-292.
119. Hurlburt, Cornelius S., Jr., 1950
Childrenite-eosphorite Series. American Mineralogist, v. 35, p. 793-805.
120. Hurlburt, Cornelius S., Jr., 1952
Wardite from Beryl Mountain, New Hampshire. American Mineralogist, v. 37, p. 849-852.
121. Jackson, Charles T., 1844
Final Report of the Geology and Mineralogy of the State of New Hampshire. Concord.
122. Jackson, Charles T., 1853
Shelburne, New Hampshire Lead Mine. Mining Magazine, v. 1, p. 245-250.
123. Jackson, Charles T., 1856
On the Geology of Alger's Beryl Hill, Grafton, New Hampshire. Boston Society Natural History Proceedings 6, p. 23.
124. Kaiser, E. P., 1938
Geology of the Lebanon Granite, Hanover, New Hampshire. Jour. Geology, v. 36, p. 107-136.
125. Katz, Frank J., 1917
Stratigraphy in Southwestern Maine and Southeastern New Hampshire. U. S. Geological Survey Prof. Paper 108-I. p. 165-177.
126. Kindle, Edward M., 1935
Manganese Concretions in Nova Scotia Lakes, with a Comparative List of Diatoms from the Lake Ossipee, New Hampshire, Concretion and a Ship Harbor Lake, N. S., Concretion by Kenneth E. Lohmann. Royal Society of Canada, Proceedings and Transactions, Third series, v. 39, sec. 5, p. 163-180. (Contains a list of 78 species of

diatoms found in an iron manganese concretion, Lake Ossipee, New Hampshire).

127. Kingsley, Louise, 1931
Cauldron-subsidence of the Ossipee Mountains. American Journal of Science, v. 22, p. 139-168.

128. Kirk, H. N., 1930
Prospecting for Mica in New Hampshire. Rock Products, v. 33, No. 13, p. 68-69.

129. Kruger, F. C., 1946
Structure and Metamorphism of the Bellows Falls Quadrangle, New Hampshire and Vermont. Bulletin, Geological Society of America, v. 57, p. 161-206.

130. Kruger, F. C., 1946
The Geology of the Bellows Falls Quadrangle, New Hampshire and Vermont. N. H. State Planning and Development Commission, Concord. 19 p.

131. Ladoo, R. B., 1922
Feldspar Mining and Milling in New Hampshire. Rock Products, v. 25, No. 23, p. 25-27.

132. Lamb, F. D., 1947
Beneficiation of New England Beryllium Ores. U. S. Bur. Mines Rept. Inv. 4040, 9 p.

133. Larrabee, D. M., 1929
Report on Mines and Minerals (Manuscript). N. H. State Planning and Development Commission. Concord.

134. Levin, S. B., 1948
Beryl Mountain, Sullivan County, New Hampshire. U. S. Bur. Mines Rept. Inv. 4216, 3 p.

135. Levin, S. B., and Mosier, McHenry, 1949
Investigation of the Blister Mica Mine, Cheshire County, New Hampshire. U. S. Bur. Mines Rept. Inv. 4409, 12 p.

136. Levin, S. B., and Mosier, McHenry, 1949
Investigation of Big Mica Mine, Cheshire County, New Hampshire. U. S. Bur. Mines Rept. Inv. 4410, 16 p.

137. Lindberg, Marie Louise Lange, 1949
Frondelite, and the Frondelite-rockbridgeite Series. American Mineralogist, v. 34, p. 541-549.

138. Lisle, T. O., 1947
Beryl Hunting in New Hampshire. Rocks and Minerals, v. 22, p. 1018-1022.

139. Lyons, J. B., 1955
Geology of the Hanover Quadrangle, New Hampshire and Vermont. Bulletin, Geological Society of America, v. 66, p. 106-146.

140. McNair, A. H., 1941
Diatomaceous Earth: Mineral Resource Survey, Pt. II, N. H. State Planning and Development Commission, Concord. 6 p.

141. McNair, A. H., 1949
The Geologic Story of Franconia Notch and the Flume. N. H. State Planning and Development Commission, Concord. 14 p.

142. McNair, A. H., 1949
The Geologic Story of Kinsman Notch and Lost River. N. H. State Planning and Development Commission, Concord. 14 p.

143. Megathlin, G. R., 1928
Autunite and Spodumene from Alstead, New Hampshire. American Mineralogist, v. 13, No. 12, p. 578-579.

144. Megathlin, G. R., 1929
The Pegmatite Dikes of the Gilsum Area, New Hampshire. Economic Geology, v. 24, No. 2, p. 163-181.

145. Myers, T. R., 1941
Some New Hampshire Quartz Deposits. Preliminary Report. Mineral Resource Survey, Pt. VI, N. H. State Planning and Development Commission, Concord. 21 p.

146. Myers, T. R., 1948
Green Lazulite from Stoddard, New Hampshire. American Mineralogist, v. 33, p. 366-368.

147. Meyers, T. R., 1950
Foundry Sands of New Hampshire. Preliminary Report. Mineral Resource Survey, Pt. XIII, N. H. State Planning and Development Commission, Concord. 30 p.

148. Modell, David, 1931
The Pegmatites near Gilsum, New Hampshire. Rocks and Minerals, v. 6, No. 1, p. 18-22.

149. Modell, David, 1936
Ring-dike Complex of the Belknap Mountains, New Hampshire. Bulletin, Geological Society of America, v. 47, p. 1885-1932.

150. Moke, C. B., 1946
The Geology of the Plymouth Quadrangle, New Hampshire. N. H. State Planning and Development Commission, Concord. 21 p.
151. Moore, G. E., Jr., 1949
Structure and Metamorphism of the Keene-Brattleboro Area, New Hampshire and Vermont. Bulletin, Geological Society of America, v. 60, p. 1613-1670.
152. Moore, G. E., Jr., 1949
The Geology of the Keene-Brattleboro Quadrangle, New Hampshire and Vermont. N. H. State Planning and Development Commission, Concord. 29 p.
153. Mrose, Mary E., 1952
Hurlburtite, $CaBe_2(PO_4)_2$, a New Mineral. American Mineralogist, v. 37, p. 931-940.
154. Mrose, Mary E., 1953
α-Eucryptite Problem. American Mineralogist (abstract) v. 38, p. 353.
155. Mrose, Mary E., 1953
Palermoite and Goyazite, Two Strontium Minerals from the Palermo Mine, North Groton, New Hampshire. American Mineralogist (abstract), v. 38, p. 354.
156. Olson, J. C., 1942
Mica-bearing Pegmatites of New Hampshire. U. S. Geological Survey Bulletin 931-P. p. 363-403.
157. Olson, J. C., 1950
Feldspar and Associated Pegmatite Minerals in New Hampshire. Mineral Resource Survey, Pt. XIV, N. H. State Planning and Development Commission, Concord. p. 1-50.
158. Penfield, S. L., 1877
On the Chemical Composition of Triphylite from Grafton, New Hampshire. American Journal of Science, 3rd series, v. 13, p. 425-427.
159. Penfield, S. L., 1900
On Graftonite, a New Mineral from Grafton, New Hampshire, and Its Intergrowth with Triphylite. American Journal of Science, v. 9, p. 20-32.
160. Perry, J. H., 1903
Notes of the Geology of Mt. Kearsarge. Journal of Geology, v. 2, p. 403-412.

161. Pirsson, L. V., and Washington, H. S., 1905
Contributions to the Geology of New Hampshire, I. Geology of the Belknap Mountains. American Journal of Science, 4th series, v. 20, p. 344-352.
162. Pirsson, L. V., and Washington, H. S., 1906
Contributions to the Geology of New Hampshire, II. Petrography of the Belknap Mountains. American Journal of Science, 4th series, v. 22, p. 439-457.
163. Pirsson, L. V., and Washington, H. S., 1907
Contributions to the Geology of New Hampshire, III. On Red Hill, Moultonboro. American Journal of Science, 4th series, v. 23, p. 257-276, 433-447.
164. Pirsson, L. V., and Rice, W. N., 1911
Contributions to the Geology of New Hampshire, IV. Geology of Tripyramid Mountain. American Journal of Science, 4th series, v. 31, p. 269-291, 405-431.
165. Pirsson, L. V., 1911
Contributions to the Geology of New Hampshire, V. Petrography of Tripyramid Mountain. American Journal of Science, 4th series, v. 31, p. 405-431.
166. Pulsifer, H. B., 1914
New Hampshire Mica Deposits Near Grafton. Mining and Engineering World, v. 41, p. 141-143.
167. Quinn, Alonzo, 1937
Petrology of the Alkaline Rocks at Red Hill, New Hampshire. Bulletin, Geological Society of America, v. 48, p. 373-402.
168. Quinn, Alonzo, 1941
The Geology of Winnipesaukee Quadrangle, New Hampshire. N. H. State Planning and Development Commission, Concord. 20 p.
169. Quinn, Alonzo, 1953
The Geology of the Wolfeboro Quadrangle, New Hampshire. N. H. State Planning and Development Commission, Concord. 24 p.
170. Ransom, George, 1927
Golding-Keene Company Builds Around Mica, Feldspar, and White Quartz. Pit and Quarry, v. 14, No. 9, p. 73-77.
171. Rice, C. F., 1901
Description of Mica Mining Company in Grafton County, New Hampshire. Min. and Sci. Press, v. 82, p. 104.

172. Richardson, Charles S., 1854
The Great Silver-lead Mine, Shelburne, New Hampshire. Mining Magazine, v. 3, p. 481-489.

173. Rickard, T. A., 1932
A History of American Mining. New York.

174. Ross, C. P., 1923
The Geology of a Part of the Ammonoosuc Mining District, New Hampshire. American Journal of Science, v. 5, p. 267-302.

175. Ross, Clarence S. and Kerr, Paul F., 1931
The Kaolin Minerals. U. S. Geological Survey Prof. Paper No. 165E, p. 151-176.

176. Rowley, Elmer, 1936
Collecting at New Hampshire Mica Mine. The Mineralogist, v. 4, No. 10, p. 35.

177. Schaller, W. T., 1911
Phenacite from New Hampshire. U. S. Geological Survey Bulletin 490, p. 53-54.

178. Scientific American, 1908.
Supplement No. 1688, p. 304. **(First Glass Manufacture in New Hampshire).**

179. Seaman, David M., 1943
Pegmatites. Rocks and Minerals, v. 18, p. 200-207.

180. Seaman, David M., 1949
Some Recent Finds in Maine and New Hampshire. Rocks and Minerals, v. 24, p. 608-609.

181. Seaman, David M., 1953
Augelite from Pegmatites in New Hampshire. American Mineralogist, v. 38, p. 728-729.

182. Seaman, David M., 1955
Pegmatite Minerals of the U. S., Part 3: fluorides, carbonates, sulfates, arsenates, vanadates, tungstates, and molybdates. Rocks and Minerals, v. 30, p. 34-37.

183. Seaman, David M., 1955
Pegmatites of the U. S., Part 4: Phosphates. Rocks and Minerals, v. 30, p. 137-140.

184. Shaub, B. M., 1937
Age of the Uraninite from Ruggles Mine, Grafton Center, New Hampshire. Science, N. S., v. 86, p. 156.

185. Shaub, B. M., 1938
The Occurrence, Crystal Habit and Composition of the Uraninite from Ruggles Mine, near Grafton Center, New Hampshire. American Mineralogist, v. 23, No. 5, p. 334-341.

186. Shaub, B. M., 1946
Paragenesis of the Chickering Pegmatite near Walpole, New Hampshire. Bulletin, Geological Society of America, (abstract) v. 57, p. 1294-1295.

187. Shaw, Denis M., 1954
Trace Elements in Pelitic Rocks. Part I: Variation During Metamorphism. Part II: Geochemical Relations. Bulletin of the Geological Society of America, v. 65, p. 1151-1166, 1167-1182.

188. Shepard, C. V., 1830
Mineralogical Journey in the Northern Part of New England. American Journal of Science, 1st series, v. 17, p. 353-360; v. 18, p. 293-303.

189. Shimer, J. A., 1943
Spectrographic Analysis of New England Granites and Pegmatites. Bulletin, Geological Society of America, v. 54, p. 1049-1066.

190. Shortle, Walter C., 1936
Radioactive Minerals, New Hampshire. Mineralogist, v. 4, p. 3-4.

191. Smith, Althea Page, Kingsley, Louise, and Quinn, Alonzo, 1939
Geology of the Mt. Chocorua Quadrangle, New Hampshire. N. H. State Planning and Development Commission, Concord, 24 p.

192. Sterrett, Douglas B., 1923
Mica Deposits of the United States. U. S. Geological Survey Bulletin 740, 342 p.

193. Stewart, Glenn W., 1939
Vesuvianite and Fluorescent Apatite from Center Strafford, New Hampshire. American Mineralogist, v. 24, p. 274-275.

194. Stewart, Glenn W., 1941
Idocrase and Scapolite from Manchester, New Hampshire. American Mineralogist, v. 26, p. 509-511.

195. Stoll, W. C., 1945
The Presence of Beryllium and Associated Chemical Elements in the Wall Rocks of Some New England Pegmatites. Economic Geology, v. 40, p. 136-141.
196. Switzer, George, 1938
Paragenesis of the Center Strafford, New Hampshire, Pegmatite. American Mineralogist, v. 23, p. 811-820.
197. Teschemacher, James Englebert, 1844
On the Beryls from Acworth, New Hampshire. Boston Society of Natural History, Proceedings, v. 1, p. 191-192.
198. Teschemacher, James Englebert, 1845
On the Occurrence of Uranium in the Beryl Locality of Acworth, New Hampshire. Boston Journal of Natural History, v. 5, p. 87-89.
199. Ulrich, J. M., 1937
Minerals and Mines of Springfield, New Hampshire. Rocks and Minerals, v. 12, p. 308-309.
200. Verrow, Harold J., 1941
Pegmatite Minerals of the Palermo Quarry, North Groton, New Hampshire. Rocks and Minerals, v. 16, p. 208-211.
201. Verrow, Harold J., 1942
Franconia Iron Mine, Lisbon, New Hampshire. Rocks and Minerals, v. 17, p. 136-139.
202. Verrow, Harold J., 1945
Amethyst - Smoky Quartz - Topaz in Northern New Hampshire. Rocks and Minerals, v. 20, p. 255-260.
203. Weed, W. H., 1911
Copper Deposits of the Appalachian States. U. S. Geological Survey Bulletin No. 455.
204. White, G. W., 1941
Peat Deposits, Preliminary Report. Mineral Resource Survey. N. H. State Planning and Development Commission, Concord. 16 p.
205. White, W. S. and Billings, M. P., 1951
Geology of the Woodsville Quadrangle, New Hampshire and Vermont. Bulletin, Geological Society of America, v. 62, p. 647-696.
206. Williams, Charles R., and Billings, M. P., 1938
Petrology and Structure of the Franconia Quadrangle, New Hampshire. Bulletin, Geological Society of America, v. 49, p. 1011-1044.
207. Wolfe, Caleb Wroe, 1940
Ludlamite from the Palermo Mine, North Groton, New Hampshire. American Mineralogist, v. 34, p. 94-97.
208. Wolfe, Caleb Wroe, 1952
Outstanding Pegmatites of Maine and New Hampshire. Geological Society of America, Guidebook for Field Trips in New England, p. 76-99.

PUBLICATIONS ON THE GEOLOGY OF NEW HAMPSHIRE

All Geological publications are allowed a discount of 20% if purchased in quantities of 10 or more of the same publication.

Remittance should be made by postal money, express order or check (payable to the State of New Hampshire.) Do not send stamps. Currency may be sent at sendor's risk. Address request to: N. H. Department of Resources and Economic Development, Division of Economic Development, State House Annex, Concord, New Hampshire.

QUADRANGLE REPORTS

Geology of the Alton Quadrangle. Glenn W. Stewart. 1961. 33 p. illus. Maps. $1.50

Geology of the Bellows Falls Quadrangle. Frederick C. Kruger. 1946. 19 p. illus. Map. 1.00

Geology of the Cardigan and Rumney Quadrangles. Katherine Fowler-Billings and Lincoln R. Page. 1942. 31 p. illus. Maps. 1.00

Geology of the Dixville Quadrangle. Technical Bulletin No. 1. Norman L. Hatch, Jr. 1963. 81 p. illus. Maps. 3.50

Geology of the Franconia Quadrangle. Marland P. Billings and Charles R. Williams. 1935. 35 p. illus. Map. **Out of print.** .50

Geology of the Gilmanton Quadrangle. Milton T. Heald. 1955. 31 p. illus. Maps. 1.50

Geology of the Hanover Quadrangle. John B. Lyons. 1958. 43 p. illus. Map. 1.00

Geology of the Isles of Shoals. Katherine Fowler-Billings. 1959. 51 p. illus. Map. 1.00

Geology of the Keene-Brattleboro Quadrangle. George E. Moore, Jr. 1949. 31 p. illus. Map. 1.00

Geology of the Littleton and Moosilauke Quadrangles. Marland P. Billings. 1935. 51 p. illus. Maps. .60

Geology of Lovewell Mountain Quadrangle. Milton T. Heald. 1950. 29 p. illus. Map. 1.00

Geology of the Monadnock Quadrangle. Katherine Fowler-Billings. 1949. 43 p. illus. Map. 1.00

Geology of Mt. Chocorua Quadrangle. Althea Page Smith, Louise Kingsley, Alonzo Quinn. 1939. 24 p. illus. Map. **Out of print.** .50

Geology of the Mt. Cube and Mascoma Quadrangles. Jarvis B. Hadley and Carleton A. Chapman. 1939. 28 p. illus. Maps. .60

Geology of Mt. Pawtuckaway Quadrangle. Jacob Freedman. 1950. 34 p. illus. Map. $1.00

Geology of the Mt. Washington Quadrangle. Marland P. Billings, Katherine Fowler-Billings, Carleton A. Chapman, Randolph W. Chapman, Richard P. Goldthwait. 1946. 56 p. illus. Maps. **Out of print.** 1.00

Geology of the Percy Quadrangle. Randolph W. Chapman. 1949. 38 p. illus. Map. 1.00

Geology of the Plymouth Quadrangle. Charles B. Moke. 1946. 21 p. illus. Map. 1.00

Geology of the Sunapee Quadrangle. Carleton A. Chapman. 1953. 32 p. illus. Map. 1.00

Geology of the Winnipesaukee. Alonzo Quinn, 1941. 22 p. illus. Map. **Out of print.** .50

Geology of the Wolfeboro Quadrangle. Alonzo Quinn, 1953. 24 p. illus. Map. 1.00

GEOLOGICAL QUADRANGLE MAPS

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, Dixville, Hanover, Keene-Brattleboro, Lovewell Mountain, Mascoma, Monadnock, Mt. Chocorua, Mt. Cube, Mt. Pawtuckaway, Mt. Washington, Percy, Plymouth, Sunapee, Wolfeboro. The following quadrangle maps are **out of print:** Cardigan, Franconia, Littleton, Moosilauke, Rumney, Winnipesaukee, Woodsville.

MINERAL RESOURCE REPORTS

New Hampshire Minerals and Mines. T. R. Meyers. 1941. 49 p. Map. **Out of print.** See Geology of New Hampshire, Part III. .50

NEW HAMPSHIRE MINERAL RESOURCES SURVEY:

Part I. **General Summary.** H. M. Bannerman. 1940. 9 p. Reprinted 1960. $ .40

Part II. **Diatomaceous Earth.** Andrew H. McNair. 1941. 6 p. Map. .10

Part III. **Peat Deposits in New Hampshire.** George W. White. Analyses by Gordon P. Percival. 1941. Reprinted 1949. 16 p. Map. .25

Part IV. **Sillimanite, Andalusite, Kyanite, and Mica Schist Deposits.** H. M. Bannerman. 1941. Reprinted 1949. 5 p. .25

Part V. **Fluorite Deposits of Cheshire County.** H. M. Bannerman. 1941. Reprinted 1949. 9 p. illus. Maps. .25

Part VI. **Quartz.** T. R. Meyers. 22 p. Maps. .25

Part VII. **Structural and Economic Features of Some New Hampshire Pegmatites.** H. M. Bannerman. 22 p. Maps. 1943. Reprinted 1950. .30

Part VIII. **Sillimanite Deposits in Monadnock Quadrangle.** Katherine Fowler-Billings. 1944. Reprinted 1949. 14 p. illus. Maps. .25

Part IX. **Mineral Composition of New Hampshire Sands.** J. W. Goldthwait. 1948. 7 p. Map. .10

Part X. **Glacial Till in New Hampshire.** Lawrence Goldthwait. 1948. 11 p. Map. .10

Part XI. **Artesian Wells in New Hampshire.** Richard P. Goldthwait. Studies by J. W. Goldthwait, D. H. Chapman, L. Goldthwait. 1949. 24 p. illus. Reprinted 1958. $ .30

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 27 p. Map. .25

Part XIII. **Foundry Sands of New Hampshire.** Preliminary Report. T. R. Meyers. Mechanical analyses by Willis C. Campbell. 1950. 32 p. Map. .30

Part XIV. **Feldspar and Associated Pegmatite Minerals in New Hampshire.** J. C. Olson. 1950. 50 p. Maps. .65

Part XV. **Clays of Southeastern New Hampshire.** Preliminary Report. Lawrence Goldthwait. 1953. 15 p. Map. .50

Part XVI. **Sands of the Merrimack Valley.** Preliminary Report. Lawrence Goldthwait. 1957. 19 p. .50

Part XVII. **Lightweight Aggregate Raw Materials in New Hampshire.** Preliminary Report. Glenn W. Stewart. 1959. 30 p. 1.00

Part XVIII. **Suburban and Rural Water Supplies in Southeastern New Hampshire.** T. R. Meyers and Edward Bradley. 1960. 31 p. .75

THE GEOLOGY OF NEW HAMPSHIRE. In three volumes.

Part I. **Surficial Geology.** James W. Goldthwait, Lawrence Goldthwait, Richard P. Goldthwait. 1951. 83 p. Includes Surficial Geology map at scale of 1 inch equals 4 miles. Reprinted 1963. $1.50

Part II. **Bedrock Geology.** Marland P. Billings. 1956. 203 p. Includes Bedrock Geology Map at scale of 1 inch equals 4 miles. 3.50

Part III. **Minerals and Mines.** T. R. Meyers and Glenn W. Stewart. 1956. 107 p. Map. 1.50

MISCELLANEOUS REPORTS AND REFERENCES

Ore Hill Zinc Mine, Warren, New Hampshire. H. M. Bannerman 1943. 2 p. Map. Reprinted 1962. $ .10

Mineral Resources in the Lakes Region. Report of the Mineral Resources Committee, Lakes Region Survey. May, 1945. 10 p. Map. **Out of Print.**

Geologic Story of Franconia Notch and the Flume. Andrew H. McNair. 1949. 14 p. illus. .20

Geology Story of Kinsman Notch and Lost River. Andrew H. McNair. 1949. 14 p. illus. .20

The Mountains of New Hampshire. A directory locating the mountains and prominent elevations of the State. 1949. 145 p. illus. .50

New Hampshire Water. Governmental responsibilities and activities in relation to the water resources of New Hampshire. December 1953. Maps. Charts. 2.00

Mica-bearing Pegmatites of New Hampshire. U. S. Geological Survey Bulletin. 931 p. Preliminary Report. J. C. Olson. 1941. 41 p. Maps. Free

The following reports should be purchased directly from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.:

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

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.)

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

U. S. G. S. Quandrangle Maps. May be purchased at Division Office at 35¢ each. Large quantities of one map should be purchased directly from Director, U. S. Geological Survey, Washington 25, D. C.

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¢ each from Distribution Section, U. S. Geological Survey, Washington 25, D. C.

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.
Aeromagnetic Map of Berlin and Vicinity. Map GP 139.
Aeromagnetic Map of Littleton and Vicinity. Map GP 194.
Aeromagnetic Map of Woodsville and Vicinity. Map GP 195.
Aeromagnetic Map of Lake Tarleton and Vicinity. Map GP 196.
Aeromagnetic Map of the Mt. Cube Quadrangle and Part of the Rumney Quadrangle. Map GP 297.
Aeromagnetic Map of the Hanover Quadrangle. Map GP 298.
Aeromagnetic Map of the Mascoma Quadrangle and Part of the Cardigan Quadrangle. Map GP 299.
Aeromagnetic Map of the Claremont Quadrangle. Map GP 300.
Aeromagnetic Map of the Sunapee Quadrangle. Map GP 301.
Aeromagnetic Map of the Bellows Falls Quadrangle and Part of the Lovewell Mountain Quadrangle. Map GP 302.
Aeromagnetic Map of the Keene Quadrangle and Parts of the Brattleboro and Monadnock Quadrangles. Map GP 303.

OLDER STANDARD REFERENCES ARE

Geology and Mineralogy of the State of New Hampshire. Charles T. Jackson, 1844. **Out of print.** May be consulted at the State Library, Concord.

The Geology of New Hampshire. 3 Volumes, C. H. Hitchcock, 1874-1878. **Out of print.** May be consulted at the State Library, Concord.