Lead-Zinc-Silver Deposits Related to the White Mountain Plutonic Series in New Hampshire and Maine

By DENNIS P. COX

CONTRIBUTIONS TO ECONOMIC GEOLOGY

GEOLOGICAL SURVEY BULLETIN 1312-D

A potential target area for mineral exploration is indicated by breccia veins of argentiferous galena and sphalerite, probably introduced during igneous activity in the Jurassic

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1970

UNITED STATES DEPARTMENT OF THE INTERIOR

WALTER J. HICKEL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 25 cents (paper cover)

CONTENTS

ILLUSTRATIONS

CONTRIBUTIONS TO ECONOMIC GEOLOGY

LEAD-ZINC-SILVER DEPOSITS RELATED TO THE WHITE MOUNTAIN PLUTONIC SERIES IN NEW HAMPSHIRE AND MAINE

By Dennis P. Cox

ABSTRACT

Silver-bearing galena and sphalerite occur in mesothermal and epithermal deposits in post-Acadian fault-breccia veins in eastern New Hampshire and southwestern Maine. For the most part, the deposits cut Silurian-Devonian schist and granite and are in a north-trending belt that coincides with the belt of plutons of the White Mountain Plutonic Series of Triassic or Jurassic age. The Conway Granite, the youngest formation of the series, is proposed as the source of the deposits. The most important deposits are at Silver Lake in Madison, Carroll County, N.H., and at the Mascot mine in Gorham, Coos County, N.H.

The Silver Lake deposit contains galena, sphalerite, quartz, chlorite, fluorite, sphene, hematite, and danalite(?). These same minerals occur in a beryllium-iron deposit that cuts Conway Granite in Bartlett, Carroll County, N.H. Chlorite, fluorite, and danalite(?) also coat small open fractures in the Conway Granite. Solutions rising from deeply buried parts of the Conway Granite plutons are believed to have caused mineralization of the chilled outer zones and to have formed all the breccia veins of the group.

INTRODUCTION

The lead-zinc-silver deposits of eastern New Hampshire and southwestern Maine (fig. 1) have been known since the early 19th century. Several of them were described by Jackson (1844) and Hitchcock (1878), and many have been included in mineral and economic studies of New Hampshire (Larrabee, 1929;[1] Meyers, 1941; Pearre and Calkins, 1957). The deposits have not been worked since World War I, and even in their most active periods of exploitation, they did not con-

[1] Larrabee, D. M., 1929, Preliminary mineral survey of New Hampshire: Boston, Mass., New England Power Assoc., 150 p. (Unpublished report available at New Hampshire State Plan. and Develop. Comm., Concord, N.H.)

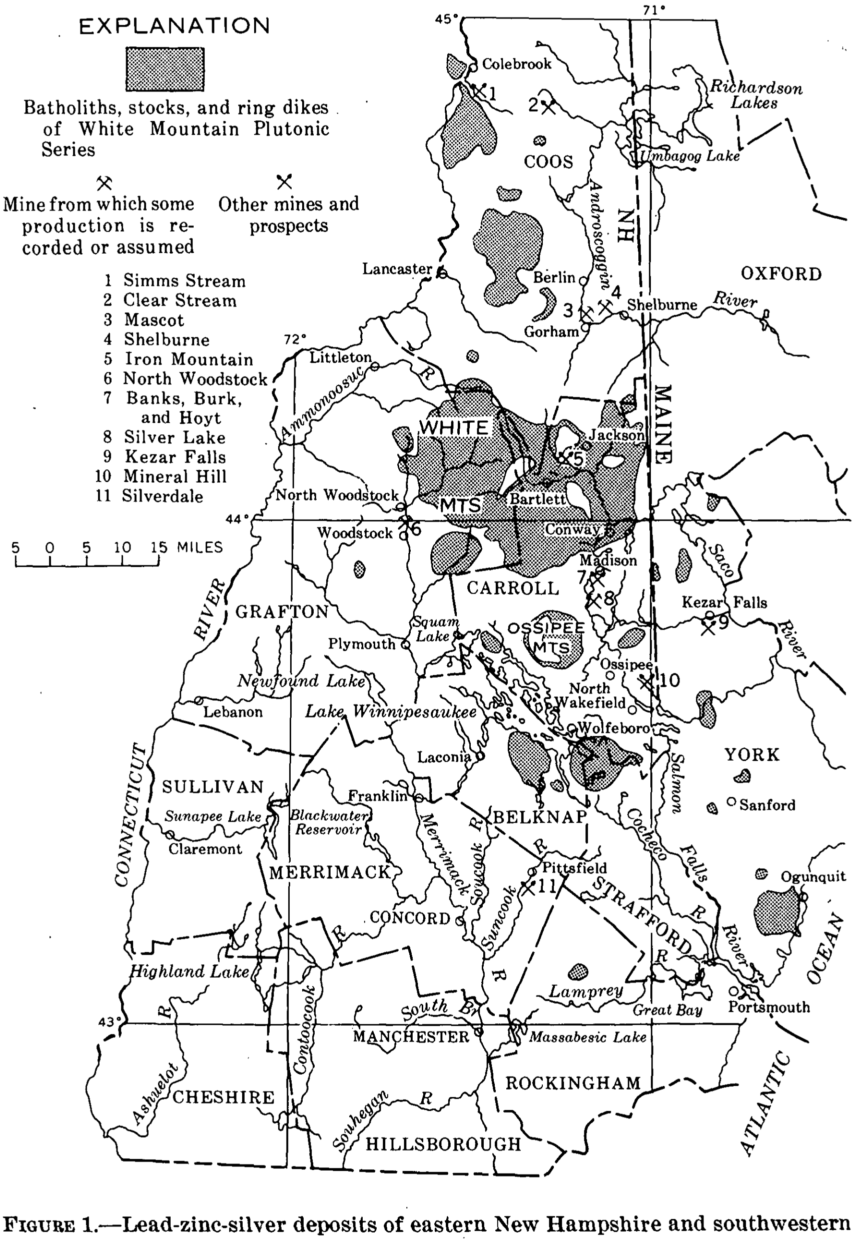

FIGURE 1.—Lead-zinc-silver deposits of eastern New Hampshire and southwestern Maine and their relation to intrusive rocks of the White Mountain Plutonic Series.

tribute importantly to national mineral production. They are of interest, however, because their distribution outlines an area in which mesothermal and epithermal silver deposits are targets for exploration. Moreover, the deposits represent a period of mineralization that can be shown to be post-Acadian and probably Mesozoic in age. The relation between copper, silver, and barite mineralization and Triassic faulting and volcanism has long been known in western Connecticut and Massachusetts, but a Mesozoic age for mineral deposits in eastern New Hampshire and southwestern Maine has not, until now, been reported.

The deposits were studied during an appraisal of silver resources of New England, part of the U.S. Geological Survey's Heavy Metals program. The writer was assisted in part of the field study by John P. D'Agostino and Allen V. Heyl. Mary E. Mrose and Ralph Christian provided mineral identifications by X-ray diffraction and X-ray fluorescence methods.

Because of the reconnaissance nature of the study, only chip samples of veins and random and selected samples of dump materials were collected. Gold was determined by combined fire-assay and atomic-absorption techniques, silver by atomic-absorption spectrophotometry, and other metals by semiquantitative spectrographic analysis. Although these analyses serve well to indicate the general level of the metal content of ores and minerals, they should not be interpreted as accurate assays.

REGIONAL GEOLOGY AND AGE OF MINERALIZATION

The region in which these deposits occur is characterized by schists of Devonian and Silurian age, which were, for the most part, metamorphosed to sillimanite grade during the Acadian orogeny. These are intruded by syntectonic granite rocks of Devonian age, known as the New Hampshire Plutonic Series.

Lead-zinc-silver deposits are in a north-trending belt which crosses the strike of metamorphic and syntectonic granite rocks and which coincides roughly with the belt of posttectonic plutons of the White Mountain Plutonic Series (fig. 1). This series is of Triassic or Jurassic age and is characterized by granite, syenite, monzonite, diorite, and gabbro (Billings, 1956, p. 146). The Conway Granite, the youngest and most widespread unit of this series, has been dated at about 185 million years (Toulmin, 1961).

The deposits have many mesothermal and epithermal features and were formed in open fractures, as indicated by abundant vugs and by quartz crystals showing comb structure. The veins were formed from solutions that were out of chemical equilibrium with the wallrocks, as indicated by extensive hydrothermal alteration halos around the veins. The deposits are younger than aphanitic dike rocks, which were apparently intruded at relatively shallow depth. In addition, most mineralized fractures are characterized by extensive breccia, which suggests tensional, rather than shear, stress during their formation. All these features show that these deposits were formed most certainly after the Acadian orogeny and probably after a considerable period of uplift and erosion, at a level in the crust where open space could exist and where igneous rocks could crystallize as aphanites. Such an environment for mineral deposition probably existed during and immediately after the intrusion and crystallization of plutons and dikes of the White Mountain Series.

The deposits, for the most part, are in fractures cutting schist and syntectonic granitic rocks, but one deposit, at Iron Mountain, N.H. (fig. 1, loc. 5), is within the Conway Granite of the White Mountain Plutonic Series. The source of mineralizing solutions is probably the Conway Granite itself, as no younger thermal events capable of forming such deposits have been recognized in this part of New England. Doming of the crust in response to the intrusion of magma may have opened channelways in the country rock as well as in the early crystallized roof zones of the Conway Granite at Iron Mountain.

MINERALOGY OF THE DEPOSITS

Galena is present in all the deposits and is the main ore mineral in all but the Iron Mountain deposit. Silver content of the galena ranges from 0.02 to 0.5 percent, the highest value being found at the Shelburne mine, the lowest, at the North Woodstock and Silverdale mines (fig. 1, locs. 4, 6, 11). Galena from the other deposits contains about 0.1 percent silver. Bismuth content ranges from 0.1 to 1.5 percent in galena from Iron Mountain, Silver Lake, Kezar Falls, and Mineral Hill (fig. 1, locs. 5, 8, 9, 10); the other deposits contain little or no bismuth. Galena from Mascot (fig. 1, loc. 3) and Shelburne contains 0.01 to 0.03 percent tin.

Sphalerite is abundant in all the deposits except Iron Mountain and North Woodstock, where it is rare. At the Mascot and Shelburne deposits, sphalerite is dark brown to black, but in the other deposits the mineral is characteristically honey brown. Sphalerite from the Silver Lake, Kezar Falls, Mineral Hill, and Silverdale deposits contains 1.5 to 2 percent cadmium and 1 to 1.5 percent iron.

Chalcopyrite is a minor constituent of the ores at Mascot, Shelburne, and Mineral Hill.

Quartz, carbonate minerals, and pyrite are the predominant gangue minerals in all deposits of this group. Quartz is commonly milky and coarsely crystalline. At Shelburne, coarse comb-structured quartz masses are crossed by concentric spherical color bands with a pattern suggesting botryoidal texture of originally amorphous silica. At Kezar Falls, comb-structured quartz grades into microcrystalline quartz.

Carbonate minerals are minor constituents of veins in all deposits except at Mascot and Shelburne, where coarsely crystalline manganosiderite makes up major parts of the vein. Unidentified carbonate minerals are important alteration products in wallrocks at Mascot, Iron Mountain, North Woodstock, and Silver Lake.

Small amounts of pyrite are everywhere present, and arsenopyrite was noted in the Shelburne vein.

Kaolin, in finely crystalline masses, forms coatings on the walls of vugs in the Kezar Falls vein. This mineral, plus the above-mentioned microcrystalline quartz, indicates an epithermal classification for the Kezar Falls deposit.

A group of distinctive minerals in the Silver Lake deposit are important in determining the age and source of this deposit and, by extension, of the other deposits of this group. These minerals, hematite, sphene, fluorite, and a helvite-group mineral tentatively identified as danalite, occur in the Silver Lake deposit as well as in the Iron Mountain deposit, which cuts Conway Granite.

The two deposits are otherwise quite different in character. The Iron Mountain deposit comprises several lenses of magnetite, hematite, and beryllium minerals formed by replacement of Conway Granite along northeast-trending joints (Barton and Goldsmith, 1968, p. 58, 59). Veinlets and lenses of vuggy quartz containing galena and sphalerite are closely associated with the beryllium-iron ore. The Silver Lake deposit, more typical of the group as a whole, is a breccia vein composed of vuggy quartz and silicified granitic rock containing galena and sphalerite.

Hematite occurs as bladelike disseminations and rosettes in altered Conway Granite at Iron Mountain and in chloritized mafic dike rock at Silver Lake. At Iron Mountain, danalite occurs with phenacite in altered granite and in the vuggy quartz veinlets. At Silver Lake, danalite(?) is rare and is restricted to quartz veinlets in altered mafic dike rock (fig. 2). Very small euhedral grains of sphene are disseminated in quartz veins at Silver Lake and in altered granite at Iron Mountain. Fluorite, as coarse purple crystals, is rare in both deposits.

365-572 O—70——2

Chlorite interleaved with biotite occurs in quartz veinlets at Silver Lake and as crusts on open fractures in Conway Granite in the Madison quarry, 6.5 miles north of the Silver Lake deposit. In both occurrences the chlorite-biotite mixture has a peculiar vermiform habit (figs. 3 and 4). The fractures at Madison quarry also contain purple fluorite and rare crystals of danalite(?).

The similarities in mineral assemblages in the Silver Lake deposit and in the Iron Mountain deposit and the late fracture fillings in the Conway Granite strongly suggest a common source. All the deposits of this group are probably related to the last stages of White Mountain plutonic activity and are thus Triassic or Jurassic in age.

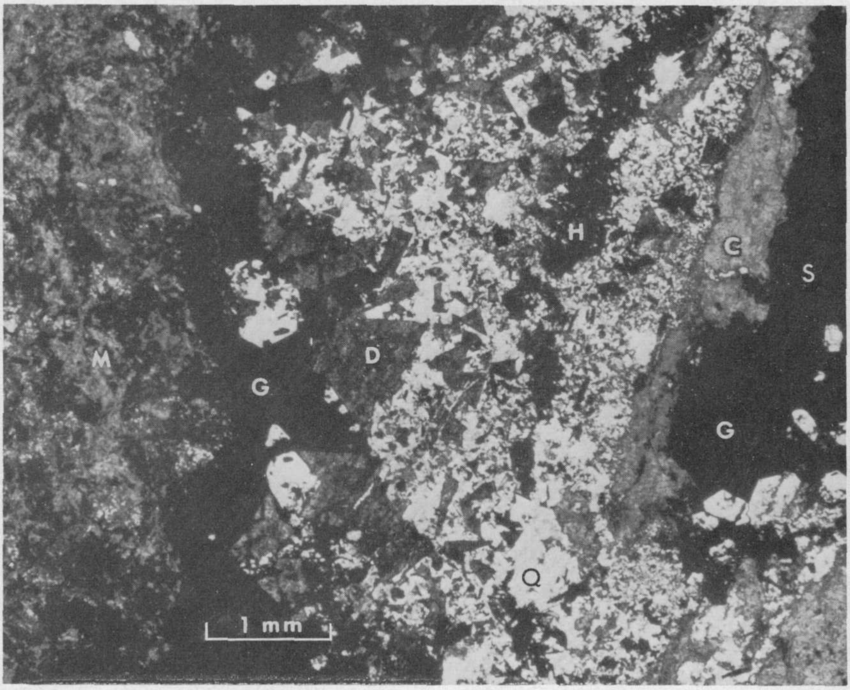

FIGURE 2.—Vein containing quartz (Q), galena (G), sphalerite (S), danalite? (D), hematite (H), chlorite (C), and finely disseminated sphene and chlorite. Vein cuts altered mafic rock (M). Silver Lake deposit. Plane-polarized light.

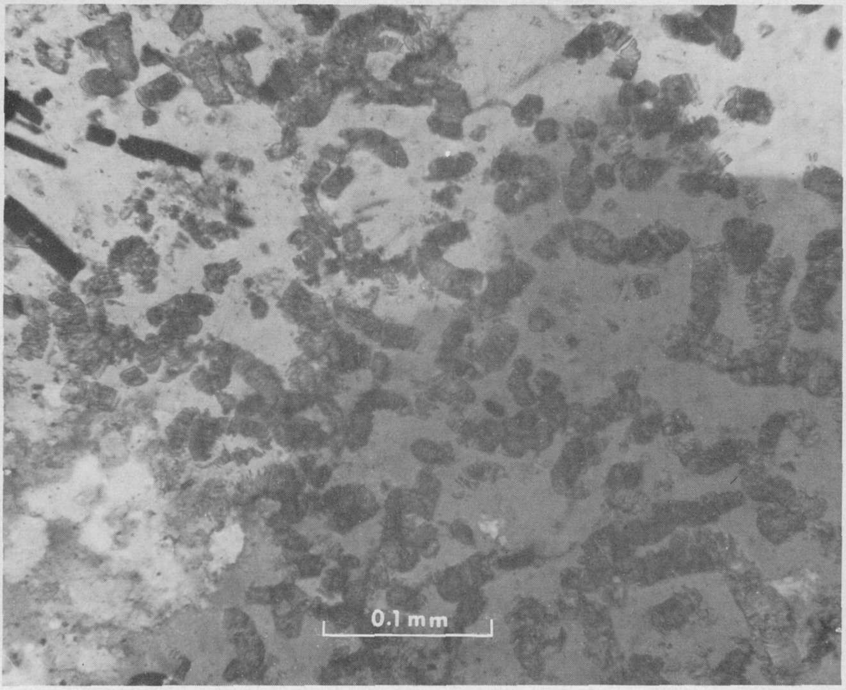

FIGURE 3.—Chlorite and biotite in vermiform aggregates in coarse vein quartz. Opaque mineral is hematite. Silver Lake deposit. Partly crossed polarizers.

INDIVIDUAL DEPOSITS

In the following descriptions, the Iron Mountain deposit, Bartlett, N.H., is omitted. A detailed account of this deposit has been given by Barton and Goldsmith (1968, p. 51–67).

DEPOSITS IN MADISON, N.H.

The largest and earliest known deposit of this group is at the Silver Lake mine in Madison Township, N.H., near the south end of Silver Lake (43°51′15″ N., 71°9′15″ W.). Three small prospect shafts—the Bank, Burke, and Hoyt mines—are near the north end of Silver Lake (43°53′30″ N., 71°9′30″ W.), and another prospect shaft is about 2 miles to the east (43°52′40″ N., 71°7′25″ W.).

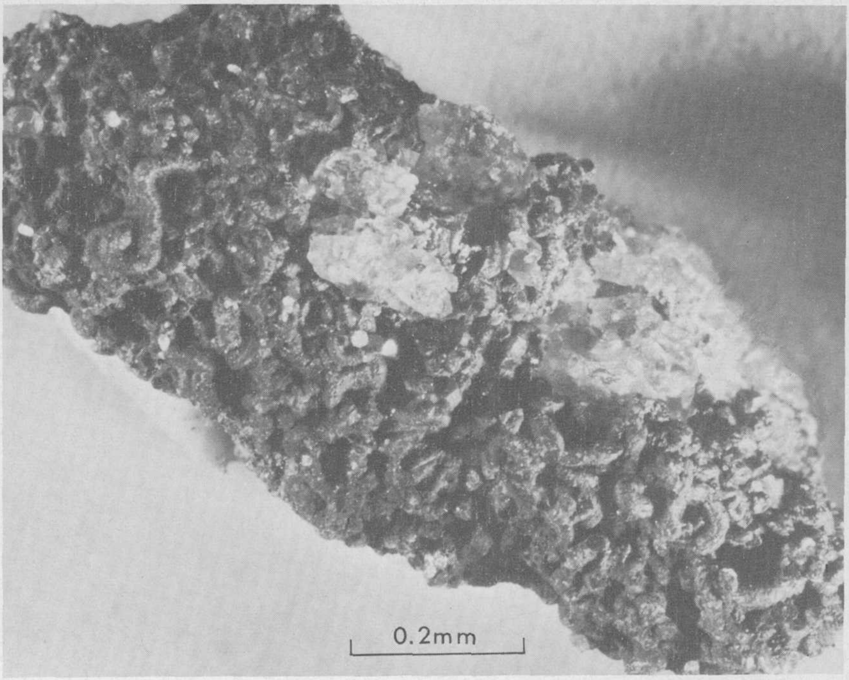

FIGURE 4.—Fluorite and vermiform aggregates of chlorite and biotite. Fracture coating in Conway Granite, Madison quarry.

The Silver Lake mine, also known as the Madison, Eaton, or Ossipee mine, was opened in 1826 and worked for a short time (Merrill, 1889, p. 806). Production and periods of activity are not precisely known for the early history of this mine, but Jackson in 1841 (1844, p. 83) reported a 40-foot shaft on the property, and Hitchcock in 1878 (p. 63) reported a daily production of one or two barrels of concentrate containing 70 percent lead.

A long period of idleness, interrupted briefly in 1906–7, ended in 1913 when a gravity mill was built by the New Hampshire Mining and Milling Co. During the period 1915 to 1918, an open pit, 170 feet by 40 feet by 60 feet deep, was developed. In 1918, the property was leased to the New Jersey Zinc Co., who did exploration work at a depth of 200 feet. Operations were suspended 6 months later. The mill burned in 1943.

The geology of the Ossipee Lake quadrangle, in which the Madison deposits are located, was described by Wilson (1965). The area is underlain by mica schist of Devonian age containing abundant pegmatite stringers and small granitic bodies. Batholiths and stocks of the New Hampshire Plutonic Series of Devonian age and Conway Granite of Triassic or Jurassic age are a few miles north and south of the deposits.

Rocks in the immediate vicinity of the Silver Lake mine are very poorly exposed. Dump materials and outcrops around the rim of the water-filled open pit indicate that galena and sphalerite are disseminated in silicified and brecciated quartz monzonite and in chloritized and brecciated mafic rock, the origin of which is not known (fig. 5).

The structure of the deposit is known only from mapping of the pit rim (fig. 6). A dominant set of fractures with steep but variable dip trends N. 20° E., and a less well developed set strikes N. 60° E. These are cut by widely spaced fractures trending N. 85° E., one of which contains an altered mafic dike about 10 feet thick. No continuation of the silicification zone or ore mineralization outward from the pit was detected, but 300 feet south of the pit, many small exposures of altered granitic rock follow a N. 35° E. trend. This trend of outcrops does not intersect the pit area.

Production of about 20,000 tons of ore containing 10 percent combined lead and zinc has been reported (McHenry Mosier, U.S. Bur. Mines, written commun., 1949). Comparison of ore and metal produc-

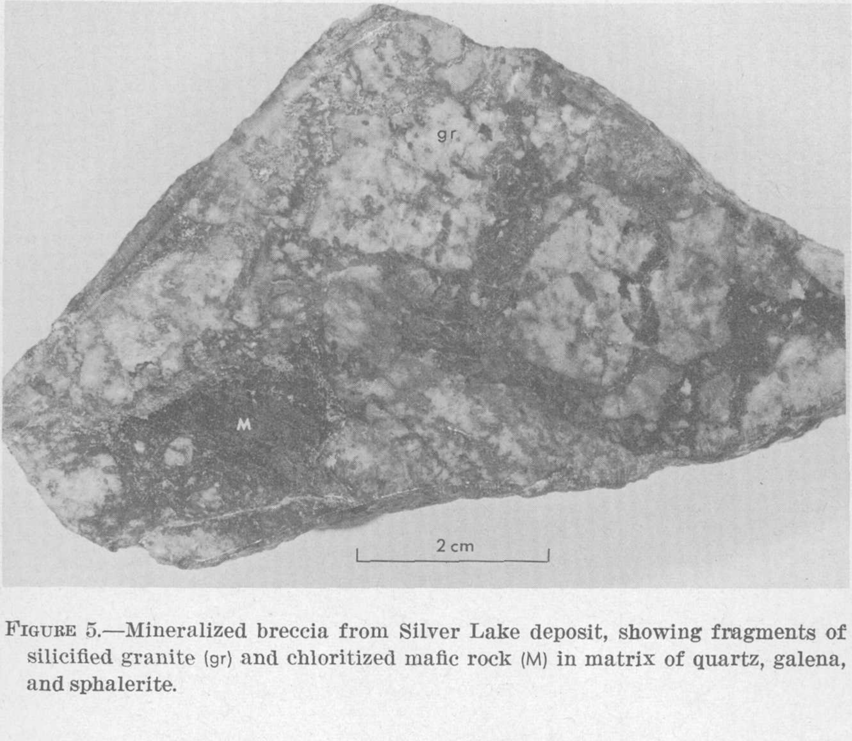

FIGURE 5.—Mineralized breccia from Silver Lake deposit, showing fragments of silicified granite (gr) and chloritized mafic rock (M) in matrix of quartz, galena, and sphalerite.

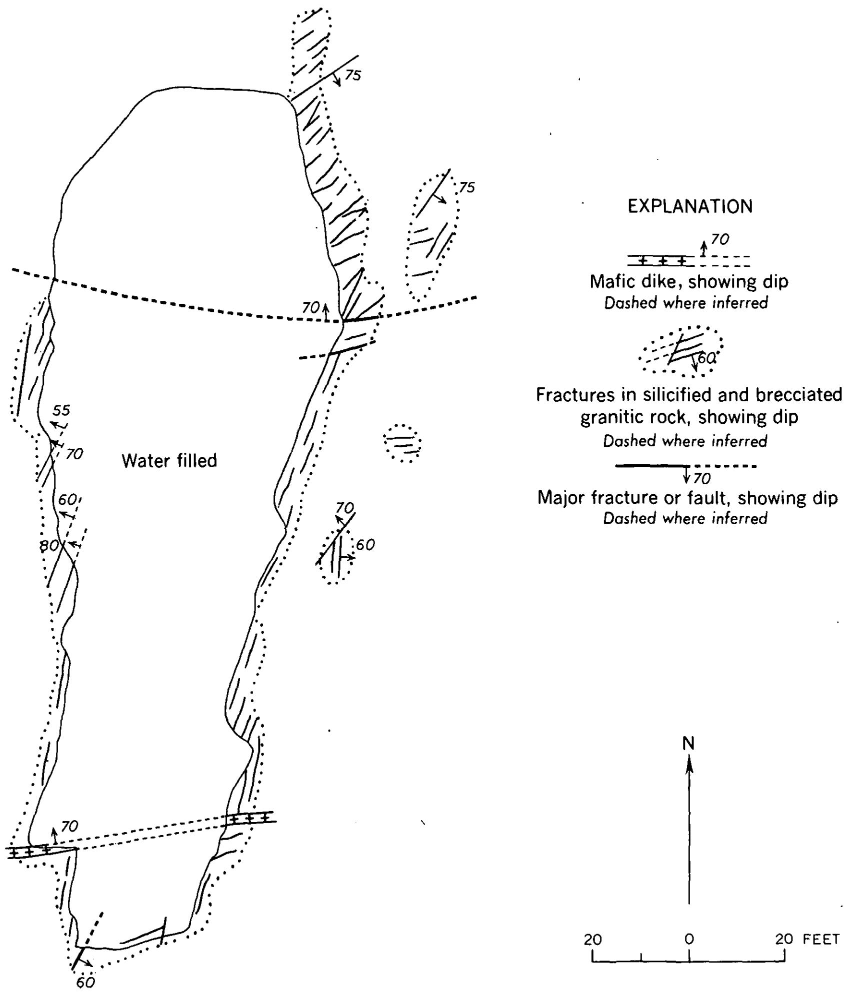

Figure 6.—Geologic map of pit rim, Silver Lake mine, Madison, N.H.

tion for 1917 (Hill, 1921, p. 58) indicates that 3 percent would be a more reliable figure. The New Jersey Zinc Co. reported 15 feet of ore containing 3.7 percent combined lead and zinc at the 200-foot level (McHenry Mosier, written commun., 1949).

One or two ounces of silver and a trace of gold were found in selected dump samples, which also contain 2 percent lead, 5 percent zinc, and minor amounts of beryllium and lanthanum. Ore in mafic rock contains as much as 0.03 percent Be, and one silicified quartz monzonite ore sample contains 0.3 percent La. Beryllium in the ore is in danalite, and lanthanum and other rare earths probably are carried by sphene.

Three trays of mineral concentrate were found in the burned ruins of the mill. These concentrates contain 5–20 ounces of silver per ton, 0.07–0.3 percent bismuth, and 0.15–2 percent cadmium. The most abundant rare earths in these concentrates are cerium, 0.02–0.07 percent, and neodymium, 0.01–0.05 percent. Beryllium content is very small.

Samples of mill tailings contain 0.15–0.5 percent lead, 1–3 percent zinc, and 0.06–0.3 ounces of silver per ton.

MASCOT AND SHELBURNE DEPOSITS, COOS COUNTY, N.H.

Lead-, zinc-, and silver-bearing minerals occur in veins cutting schist and granitic rocks of Devonian age on the slopes of Mount Hayes, in Gorham and Shelburne Townships, Coos County, N.H. Two mines have been developed on these veins: the Mascot (44°24′00″N., 71°10′40″W.), 1 mile north of Gorham, and the Shelburne (44°25′ 10″N., 71°7′50″W.), on the west fork of Leadmine Brook.

The Mascot breccia vein is exposed on a high ledge for a vertical distance of more than 200 feet. During the period 1881 to 1885, adit-drifts were driven on the vein at three levels connected by stopes (fig. 7), and about 50,000 tons of vein material was mined. A mill was constructed which produced 1½–3½ tons of concentrate per day; at least 30 tons of concentrate containing 70–82 percent lead and 28 ounces of silver per ton was reported shipped to New Jersey (Maine Mining Jour., Jan. 23, 1885). In 1906, during a second period of activity, 70 tons of lead and 174 ounces of silver were produced (McCaskey, 1908, p. 561).

The Mascot breccia vein, which strikes N. 35°–45° E. and dips 70° NW., is 10 to 20 feet wide and comprises angular fragments of altered granitic rocks with interstitial quartz and manganosiderite. In the upper drift-adit, a vertical aphanitic dike has been shifted 24 feet on three distinct faults (fig. 7).

Granitic rocks in and near the vein are sericitized; feldspar is altered to fine-grained sericite, and biotite to colorless mica clouded with rutile needles. Pyrite is disseminated throughout. Dike rocks are almost completely altered to sericite, chlorite, and carbonate minerals, but show relict phenocrysts of plagioclase and mafic minerals and relict plagioclase laths in the groundmass.

Ore minerals are commonly restricted to thin seams within the vein. These have been variously reported as galena in masses 4 inches to 10 inches thick or as three mineral bands together totaling 22 inches in thickness (Maine Mining Jour., Dec. 1, 1882; Mar. 2, 1883). Galena occurs as coarse grains having strongly deformed cleavage surfaces or as fine "steel galena." Deformation of galena indicates postdepositional movement along the vein.

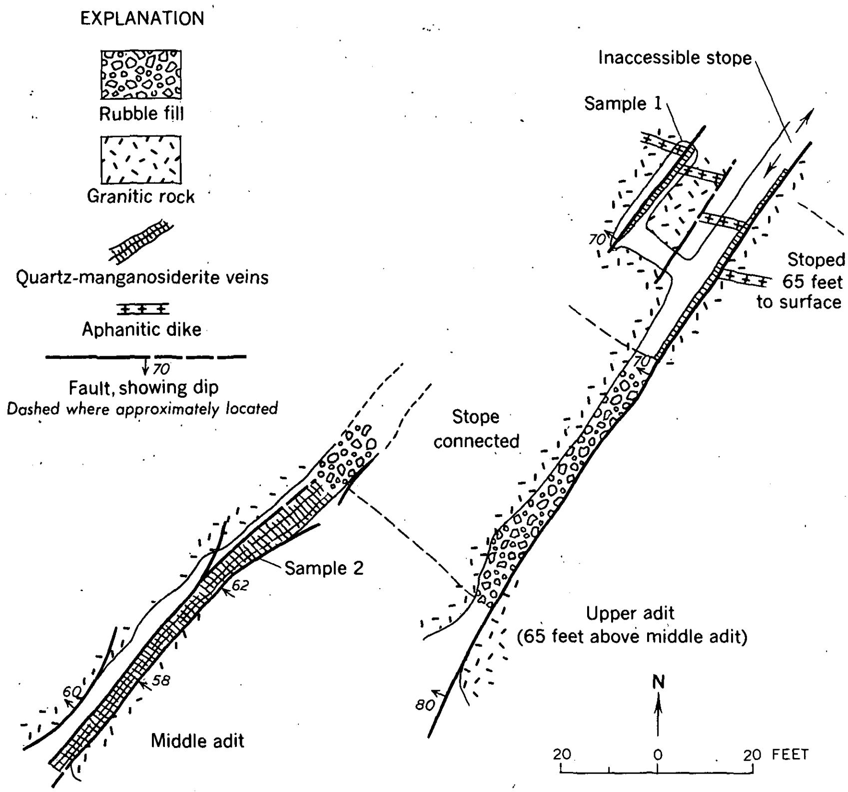

FIGURE 7.—Geologic sketch map, Mascot mine, Gorham, N.H. Note displacement of dike by faults in upper adit.

Two chip samples (fig. 7) were cut during the present study across 3 feet of vein in a short drift north of the main upper drift-adit and across 2 feet of coarse manganosiderite in the middle drift-adit. They contain, respectively:

Ore mineral		*Sample 1*	*Sample 2*
Zinc	percent	10	3
Copper	do	5	0.15
Lead	do	0.3	0.05
Silver	ounces per ton	3	0.09
Gold	do	0.009	0.002

The Shelburne vein strikes N. 75° E. along the bed of the lower part of the west fork of Lead Mine Brook. Three shafts were sunk on the exposed 300 feet of vein in the streambed, and a 30-foot adit was driven westward on the vein where the streambed diverges sharply to the north (fig. 8). One shaft has a brick collar 10 feet high, which apparently served to protect the shaft from flooding. Mining began during the late 1830's (Jackson, 1844, p. 102) and continued intermittently during the 1850's. Probably only small amounts of ore were shipped. A final attempt to work the mine in 1880 was unsuccessful.

The Shelburne vein is 10 to 15 feet wide and similar in its structure and texture to the Mascot vein. Breccia fragments of schistose and granitic rocks are enclosed in comb-structured quartz and carbonates. Sulfides occur in thin seams and patches. Figure 8 shows the outline of a stope developed on a rich part of the vein in which the combined width of sulfide seams is as much as 20 inches (Hodge, 1853, p. 30). Efforts to find other high-grade shoots were apparently unsuccessful. Chip samples were taken during the present study across high-grade parts of the vein. They contain the following values:

	Sample		
	1	*2*	*3*
Vein width .... feet	1	1	3
Lead .... percent	10	7	0.7
Zinc .... do	3	1	0.7
Tin .... do	0.003	0.003	0.001
Silver .... ounces per ton	6	9	0.9
Gold .... do	0.002	-----	0.002

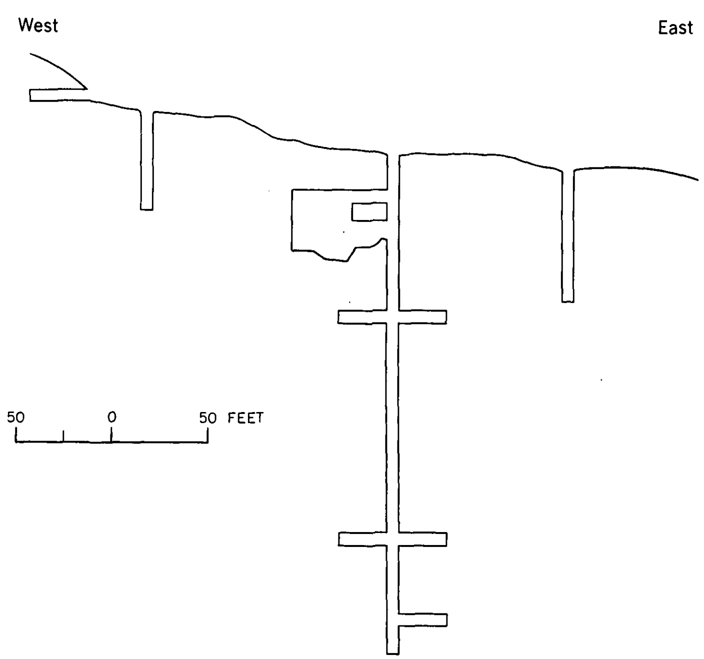

FIGURE 8.—Longitudinal section showing workings in the Shelburne mine, Shelburne, N.H. Modified from Hodge (1853, p. 30).

NORTH WOODSTOCK DEPOSIT, GRAFTON COUNTY, N.H.

The North Woodstock mine is on the south side of a steep ravine formed by Beaver Brook about 2,000 feet west of its confluence with the Pemigewasset River (43°59′30″ N., 71°41′20″ W.), in Grafton County, N.H. A 230-foot adit follows a fault, and a pocket of ore has been stoped to the surface. A mill foundation near the portal suggests that ore production was at least contemplated, though no record of production could be found.

Figure 9 is a sketch of the adit showing a contact between granitic rock and schist cut at a small angle by a fault. No true quartz vein has formed in this deposit as in others of this group. Galena and minor sphalerite and pyrite are disseminated in quartz-ankerite-sericite rock derived from alteration of the country rock. The quartz-ankerite-sericite zone is limited to a few inches along the fault where it cuts schist, but it extends nearly 10 feet out from the fault in the granitic rock. Galena, sphalerite, and pyrite are disseminated only in the altered granitic rock.

A chip sample across 7 feet of altered granitic rock contained 0.7 percent lead, and 0.13 ounces silver per ton.

MINERAL HILL DEPOSIT, CARROLL COUNTY, N.H.

The Mineral Hill deposit, in the north corner of Wakefield Township, Carroll County, N.H. (43°40′30″ N., 71°00′30″ W.), is on several veins that strike N. 60°–65° E. and dip steeply north. A shaft was sunk on a vein to a depth of 118 feet (Maine Mining Jour., Oct. 22, 1880) and a short adit-drift was opened on another. No ore production was reported.

The deposit comprises quartz veins and podlike masses of silicified breccia following a fault system. A fault exposed in the adit strikes N. 60° E. and dips 60° NW. Another fault exposed in the shaft strikes N. 75° E. and dips 70° NW. There is no apparent continuity of faults or veins, but sporadic outcrops of silicified breccia form two parallel northeast-trending bands 1,000 feet long and 300 feet apart.

The country rock is mainly quartz monzonite of Devonian age intruded by large irregular bodies of fine aplitic quartz monzonite and by thin dikes of mafic aphanitic rock. An irregular zone of hydrothermal alteration as much as 200 feet wide follows the vein. In this zone, plagioclase is partly sericitized, biotite is bleached or chloritized, and the rocks are crossed by closely spaced veinlets of quartz, some of which are iron stained.

Ore specimens collected from the main shaft dump contain patches of galena, brown sphalerite, chalcopyrite, and pyrite in coarse comb-structured quartz. Two dump samples were collected; one sample

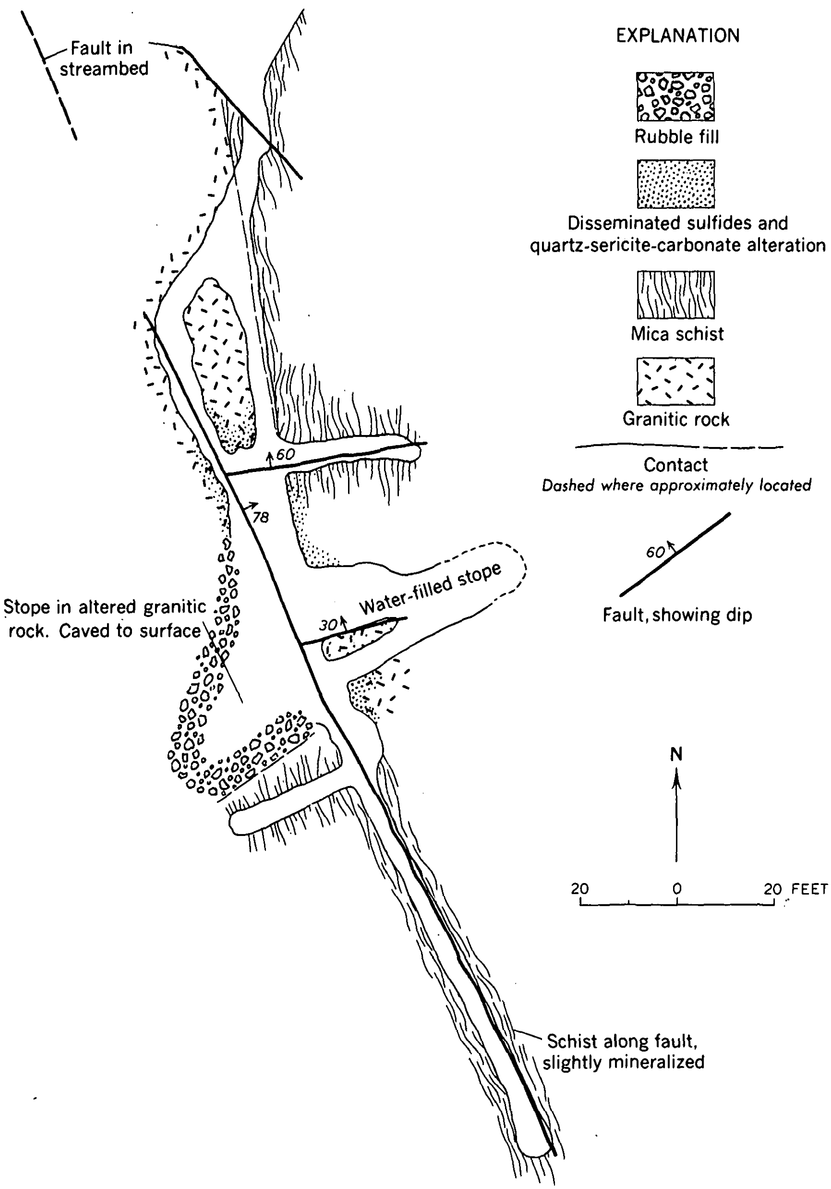

FIGURE 9.—Geologic sketch map, North Woodstock mine, North Woodstock, N.H.

was made by combining grab samples collected at intersections of a 5-foot grid pattern laid out on the dump surface; another sample comprised material from two 3-foot vertical cuts in the edge of the dump. Vertical and surface samples both contained 0.3 ounce of silver per ton, a trace of gold, 0.4 percent lead, 1.3 percent zinc, and

0.3 percent copper. If it is assumed that no ore was shipped from the mine, the values may be taken as an approximation of the metal content of the vein and its wallrocks where cut by the shaft.

KEZAR FALLS DEPOSIT, YORK COUNTY, MAINE

A small silver-lead vein is one-half mile south of Kezar Falls in Parsonfield, York County, Maine (43° 47′55″ N., 70°53′25″ W.). No record of production from this deposit was found. Mine workings consist of three shallow pits that may have been shafts. The vein strikes N. 40° E., dips 50°–55° NW. and can be traced for about 650 feet. Segments of the vein 5–100 feet long have divergent trends ranging from N. 25° E. to N. 55° E. The vein is cut by unaltered dolerite dikes. Ore minerals were not noted in the vein outcrop, but boulders dug from the dump provided a rough idea of the nature of the ore.

Galena and sphalerite occur as coarse crystals in breccia composed of fragments of dark-gray jasperoid so clouded with fine inclusions as to be opaque in thin section (fig. 10). The breccia is filled by microcrystalline quartz, fine comb-structured quartz, and kaolinite.

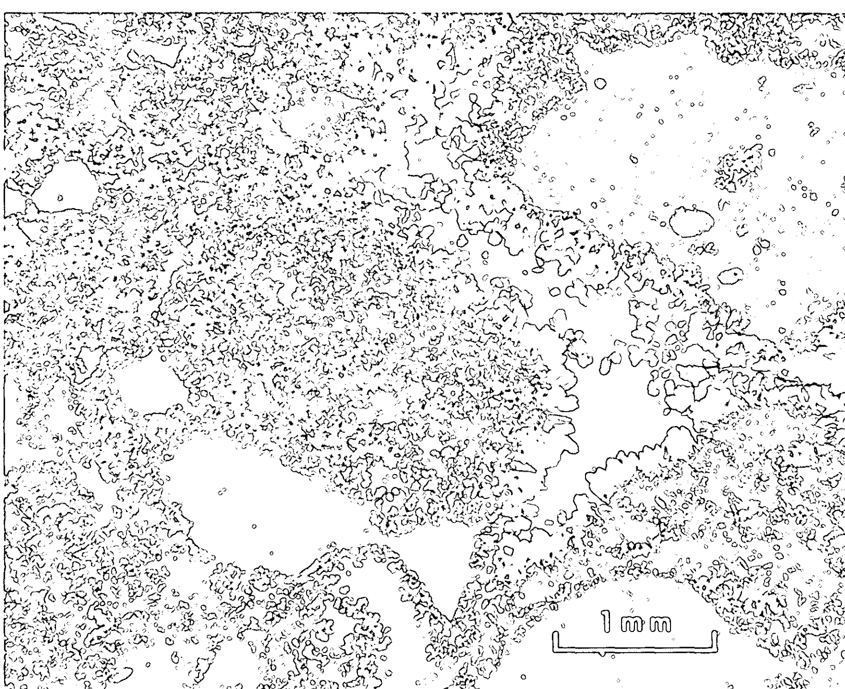

FIGURE. 10.—Breccia containing fragments of jasperoid. Matrix is microcrystalline quartz grading into fine comb-structured quartz. Kezar Falls deposit. Partly crossed polarizers.

OTHER DEPOSITS

Three shallow shafts constituting the Silverdale mine have been sunk on a quartz vein in Pittsfield, Merrimack County, N.H. (43°16′45″ N., 71°20′30″ W.) The vein, which strikes N. 28° E. and can be traced for 1,000 feet, is as much as 15 feet wide and is composed of many parallel and intersecting veinlets of comb-structured quartz. It contains coarse patches of galena and brown sphalerite.

Galena and sphalerite in comb-structured quartz veins were noted by Norman Hatch (written commun., 1967) in two localities in northern Coos County, N.H. These are on Simms Stream (44°50′50″ N., 71°29′30″ W.) and on West Branch of Clear Stream (44°49′20″ N., 71°17′00″ W.).

Other deposits may have been overlooked during this study. However, those described seem to be representative and, in general, are believed to delineate the area in which this type of deposit occurs.

SUMMARY AND CONCLUSIONS

Eleven silver-bearing galena-sphalerite deposits lie in a northeast-trending belt roughly coincident with the belt of plutons of the White Mountain Plutonic Series of Triassic or Jurassic age. The mineralogy and spatial relations suggest that the deposits may be related to intrusion and crystallization of these plutons.

Most of the deposits are quartz veins or quartz-filled breccia veins, but some, such as the Mascot and Shelburne deposits, are veins mainly filled with carbonate minerals. The North Woodstock deposit is not a true quartz vein but is a wide sericite-carbonate alteration envelope containing disseminated sulfides. Probably most of the outcrops of quartz veins and silicified rocks were discovered in this part of New England during clearing of land for agriculture 100 years ago. Many of these have been explored to considerable depth, some with encouraging results.

Other deposits similar to the one at North Woodstock in which sericite and carbonate minerals predominate are less resistant to weathering and glacial erosion. These deposits may have been deeply scoured by glaciers and later covered by drift. Thus, linear valleys or chains of lakes and swamps that might be controlled by post-Acadian fractures become likely ground for geochemical and geophysical prospecting.

REFERENCES CITED

Barton, W. R., and Goldsmith, C. E., 1968, New England beryllium investigations: U.S. Bur. Mines Rept. Inv. 7070, 177 p.

Billings, M. P., 1956, Bedrock geology, pt. 2 *of* Geology of New Hampshire: Concord, N.H., New Hampshire State Plan. and Devel. Comm., 203 p.

Hill, J. M., 1921, Gold, silver, copper, lead, and zinc in the Eastern States, *in* U.S. Geol. Survey, Mineral resources of the United States, 1917: Washington, U.S. Govt. Printing Office., p. 55–62.

Hitchcock, C. H., 1878, Economic geology, pt. 5 [in v. 3] *in* Hitchcock, C. H., Huntington, J. H., Upham, Warren, Hawes, G. W., 1878, Geology of New Hampshire: Concord, N.H., Edward A. Jenks, State Printer, 103 p.

Hodge, J. T., 1853, Report on the mining properties of the Shelburne Lead Mining Co., at Shelburne, New Hampshire: Mining Mag., v. 1, p. 27–34.

Jackson, C. T., 1844, Final report on the geology and mineralogy of the State of New Hampshire: Concord, N.H., 376 p.

McCaskey, H. D., 1908, Gold, silver, copper, lead, and zinc in the Eastern States (mine production), *in* U.S. Geol. Survey, Mineral resources of the United States, 1907; Washington, U.S. Govt. Printing Office, p. 551–570.

Maine Mining Journal, 1880–86, [various numbers]: Portland, Maine (weekly).

Merrill, G. D., 1889, History of Carroll County: Boston, W. A. Ferguson Co., 987 p.

Meyers, T. R., 1941, New Hampshire minerals and mines, a report to the New Hampshire State Planning and Development Commission: Concord, N.H., New Hampshire State Plan. and Develop. Comm., 49 p.

Pearre, N. C., and Calkins, J. A., 1957, Mineral deposits and occurrences in New Hampshire, exclusive of clay, sand and gravel, and peat: U.S. Geol. Survey Mineral Inv. Resource Map MR–6, scale 1:500,000, with text.

Toulmin, Priestley, III, 1961, Geologic significance of lead-alpha and isotopic age determinations of "alkalic" rocks of New England: Geol. Soc. America Bull., v. 72, no. 5, p. 775–780.

Wilson, J. R., 1965, Bedrock geology of the Ossipee Lake area, New Hampshire: Cambridge, Mass., Harvard Univ. unpub. Ph. D. thesis.

U.S. GOVERNMENT PRINTING OFFICE: 1970 O—365–572