SOME MODES OF QUARTZ-BEARING PLUTONITES FROM DERBY, VERMONT

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INTRODUCTION

Derby township, the southern part of which was formerly known as Salem, is situated in the north central part of the State of Vermont. It is bounded on the west by lake Memphremagog and on the north by the province of Quebec. Rocks of the granitic type have long been known to occur in this district.[1] With very few exceptions, and upon megascopic examination only, they were simply designated as granites. Dale,[2] from a qualitative study, called the rock from the Newport quarry a quartz-monzonite.

No modal analyses of these rocks were found in the literature and since many specimens from the area were available among Dr. Charles H. Richardson's large collection of Vermont rocks, the author thought it might be of value to study them in more detail so that they could be classified on a quantitative basis and a more detailed petrographic description given of them. The modes of the rocks only are given in this paper; it is hoped that the detailed petrographic study will be available for publication in the near future.

The modes of the various rocks were determined by the Rosiwal method and were assigned to the various families, orders and classes in accordance with Johannsen's classification.[3] A few of the assigned names may be changed with further study, especially where the plagioclase-potash feldspar ratio is close to the dividing line between two families, as in No. 2, where an increase of less than one per cent in the microcline content would change the rock from a tonalite to a granodiorite. Likewise, where the biopyribole ratio is near the boundary between two classes, as in No's. 5 and 10, a small increase in the biotite content would indicate a granodiorite rather than a leucogranodiorite. For convenience and comparison the modes of the various rocks are grouped together in table 1.

[1] Hitchcock, C. H., The Geology of Northern New England, (1870–1882), 2–6. Richardson, C. H., Areal and Economic Geology of North Western Vermont, *Rept. Vt. State Geologist* (1905–1906), 106–109; The Geology of Newport, Troy and Coventry, *Rept. Vt. State Geologist* (1907–1908), 280. Dale, T. Nelson, Commercial Granites of New England, *U. S. Geol. Survey Bull.* **738,** (1923), 119–120; The Granites of Vermont, *Rept. Vt. State Geologist* (1909–1910), 113–114.

[2] Dale, T. Nelson, *ibid.*, 119–120.

[3] Johannsen, Albert, A Descriptive Petrography of the Igneous Rocks, **I,** 140 (1931).

TABLE 1. MODES OF QUARTZ-BEARING PLUTONITES

	1	2	3	4	5	6	7	8	9	10
Quartz	23.64	18.26	20.18	21.40	22.68	19.00	22.18	13.01	11.78	41.48
Microcline	3.42	4.49	13.82	17.12	12.89	8.51	13.21	17.50	25.50	13.50
Oligoclase	68.46	69.20	52.10	45.72	55.20	65.98	57.80	57.42	49.21	39.67
Muscovite	x	0.75	1.95	4.94	4.73	0.43	x	1.01	0.51	x
Apatite	x	x	x	x	x	x	x	x	x	x
Biotite	4.06	6.88	11.70	9.88	4.50	6.06	6.13	11.26	13.00	4.96
Zircon	x	x	x	x	x	x	x	x	x	x
Sphene		x	x		x	x		x		
Orthite				x						x
Epidote	x	0.50		0.36	x		x	x		x
Chlorite				x	x			x	x	
Calcite	x					x		x		
Kaolinite	x	x	x	x	x	x	x	x	x	x
Secondary mica	x	x	x	x	x	x	x	x	x	x
Garnet										x
Rutile	?	?	?	?	?	?	?	?	?	?

x The mineral is present.

? May be present but not certain of the identification.

1. Leucotonalite, Johannsen, (128P). La Casse quarry, Derby, Vermont; C. H. Richardson's collection, "Granite."
2. Biotite-tonalite, Johannsen, (228P). South of La Casse quarry, Derby, Vermont; C. H. Richardson's collection, "Granite."
3. Biotite-granodiorite, Johannsen, (227P), Newport quarry, Derby, Vermont; T. Nelson Dale, U. S. Geological Survey, Bull. 738 (1923), pp. 119–120. "Quartz monzonite."
4. Biotite-granodiorite, Johannsen, (227P). Parameter quarry, Derby, Vermont; *Idem:* p. 120. "Granite" or "quartz monzonite."
5. Leucogranodiorite, Johannsen, (127P), Beebe Plains, Derby, Vermont; C. H. Richardson, Building Stones and Clays, 1917, p. 83, "Granite."
6. Biotite-granodiorite, Johannsen, (227P), Derby Line, Derby, Vermont; C. H. Richardson's collection, "Granite."
7. Biotite-granodiorite, Johannsen, (227P), Salem Mountain, Derby, Vermont; C. H. Richardson's collection, "Granite."
8. Biotite-granodiorite, Johannsen, (227P), South side of Salem Mountain, Derby, Vermont; C. H. Richardson's collection, "Granite."
9. Biotite-granodiorite, Johannsen, (227P), Clyde River, Salem, Vermont; C. H. Richardson's collection, "Granite."
10. Leucogranodiorite, Johannsen, (127P), "West side exposures in center of Salem township"; Vermont; C. H. Richardson's collection, "Granite."

General Discussion

The exact geological age of these rocks is in doubt. According to Jacobs[4] the youngest rocks that they intrude in Vermont are Ordovician. Just north in Quebec, however, similar rocks are found intruding Devonian strata, which would make them post-Devonian in age. Jacobs[5] further states that some geologists go so far as to put the time of intrusion as post-Carboniferous. None of the rocks examined in this study showed any evidence of having suffered dynamic metamorphism such as might have been brought about by the Taconic disturbance at the end of the Ordovician. Thus this study only substantiates the conclusion that they are at least post-Ordovician in age.

The most outstanding fact that is brought out by a study of table 1 is the complete absence of orthoclase feldspar. This paucity, however, is not characteristic of this area of Vermont alone, for with the possible exception of the West Dummerston leucogranodiorite, the auther[6] found practically no orthoclase in any of the quartz-bearing plutonites that he studied covering many widely scattered areas throughout the State. Even the small amount of orthoclase listed for this West Dummerston area is undoubtedly too high for a very detailed study (82 sections) by Church[7] lists orthoclase as "little." Probably the few grains listed by both authors are really microcline in which the characteristic twinning does not show, for Johannsen[8] states "in some cases the twinning in microcline becomes of such microscopic dimensions that it is recognizable only in the thinnest sections—in still other cases there appears to be no twinning and microcline can be distinguished from orthoclase only by its extinction angle of 15°–16° on (001)." In thin sections where there are only one or two doubtful grains it would indeed be exceptional if any of them were so orientated as to give a correct determination on extinction alone. Examination of many thin sections of these post-Devonian plutonic rocks from the Appalachian system even as far south as Georgia shows the same remarkable lack of orthoclase.

Table 1 also shows oligoclase to be the most abundant constituent in any of the rocks. A great many refractive index determinations showed

[4] Jacobs, Elbridge C., An Account of Vermont Geology, *Rept. Vt. State Geologist* (1935–1936) 137.

[5] *Ibid.*, 137.

[6] Maynard, J. E., The petrographic re-examination of quartz-bearing plutonites from Vermont: *Jour. Geol.*, **XLII,** 146–162 (1934).

[7] Church, Mary S., A quantitative petrographic study of the Black Mountain leucogranodiorite at West Dummerston, Vermont: *Jour. Geol.*, **XLV,** 763–774 (1937).

[8] Johannsen, Albert, A Descriptive Petrography of the Igneous Rocks: **II,** 145–146 (1932).

its composition to vary between Ab 76 and Ab 84. Mulholland[9] made a chemical analysis of the plagioclase which he separated from the most typical granodiorite of the Derby area. His results yielded oligoclase of the composition Ab 76 An 24.

Another notable fact is the relatively low percentage of potash feldspar as represented by microcline, the average for the ten rocks being 13.0 per cent, in contrast to, the relatively high percentage of oligoclase, the average in this case being 56.0 per cent. These figures and the general petrographic study suggest that the township of Derby at least, and perhaps a considerable part of the Appalachian system, was underlain by granodiorite magma or magmas of which the potash feldspar-plagioclase ratio was such as to yield granodiorite batholiths the composition of which were much nearer tonalites than quartz-monzonites. This expresses itself locally in the actual occurrence of tonalites as differentiates from the main granodiorite magma or magmas. The great mass of this batholith or batholiths has yet to be exposed by erosion, the present exposures being stocks or bosses that represent cupolas of the main masses.

[9] Mulholland, M. M., Zoning as an explanation of optical anomalies of a plagioclase feldspar in quartz-bearing plutonites from Vermont: *Am. Mineral.*, **23**, 534–536 (1938).