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30. The K-replacement origin for the megacrystal Hermon-type granites in the Grenville Lowlands, northwestern Adirondack Mountains, New York, USA

Lorence G. Collins

email: lorencecollins@gmail.com

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Introduction

Geochemical and field studies identify nine different megacrystal Hermon-type granites in the Grenville Lowlands northwest of the Adirondack Mountains, New York (Carl and deLorraine, 1997); Fig. 1). These include the Gray's School, Sherman Lake, Trout Lake, Hermon Village, Fowler, Fullerville, Ore Bed Road, Mott Creek, and Shiner Pond bodies. Although surface exposures of the Fowler granite do not show K-feldspar megacrysts, drill cores have intersected megacrysts in this body. Because the microcline megacrysts, 2 to 40 cm long, are considered by most investigators to be phenocrysts, the granites have always been assumed to be totally magmatic in origin. The granites range in silica content from 51.5% SiO_2, typical of syenite in the Gray's School granite, to 74.5% SiO_2 in the Shiner Pond and Mott Creek granites, more typical of granite (Fig. 2). Because of the wide distribution of these granites (Fig. 1) and the great variation in MgO and SiO_2-contents, the granites are *not* considered to have a common magmatic source, but rather to have formed separately, supposedly by some magmatic differentiation process. Previous investigators, however, have not studied the transition from the granites to their wall rocks. This article reports the results of field, thin section, and chemical studies of the Fowler, Fullerville, and Gray's School granites and their relationships to the wall rocks and other granites.

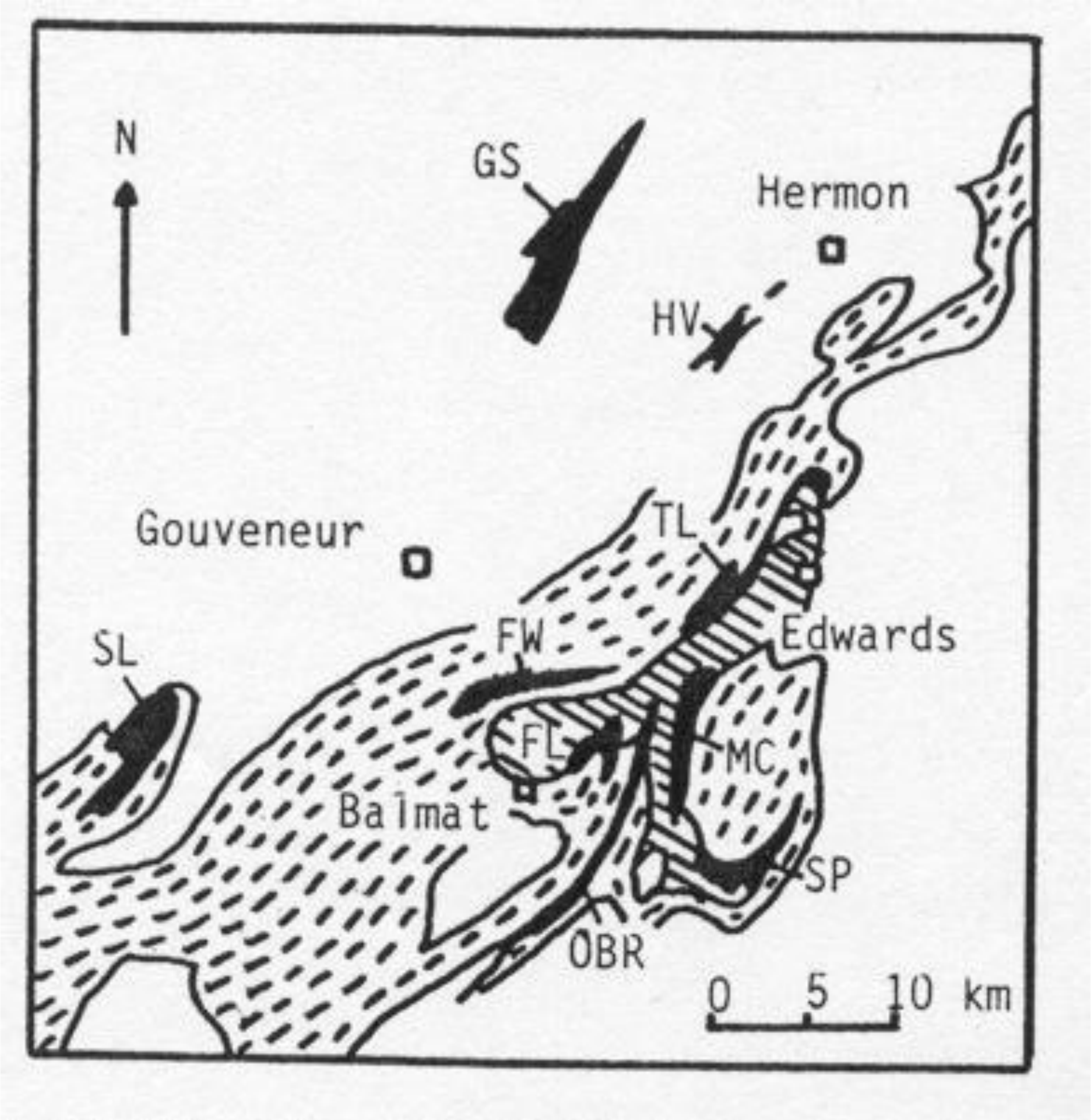

Fig. 1. Location of Hermon-type granites (black), Popple Hill gneisses (dashes), and Upper Marble (lined pattern) in the Grenville Lowlands (modified after Carl and deLorraine, 1997, and omitting many associated rock types). Hermon-type granites include Gray's School (GS), Hermon Village (HV), Trout Lake (TL), Sherman Lake (SL), Ore Bed Road (OBR), Shiner Pond, (SP), Mott Creek (MC), Fullerville (FL), and Fowler (FW) bodies.

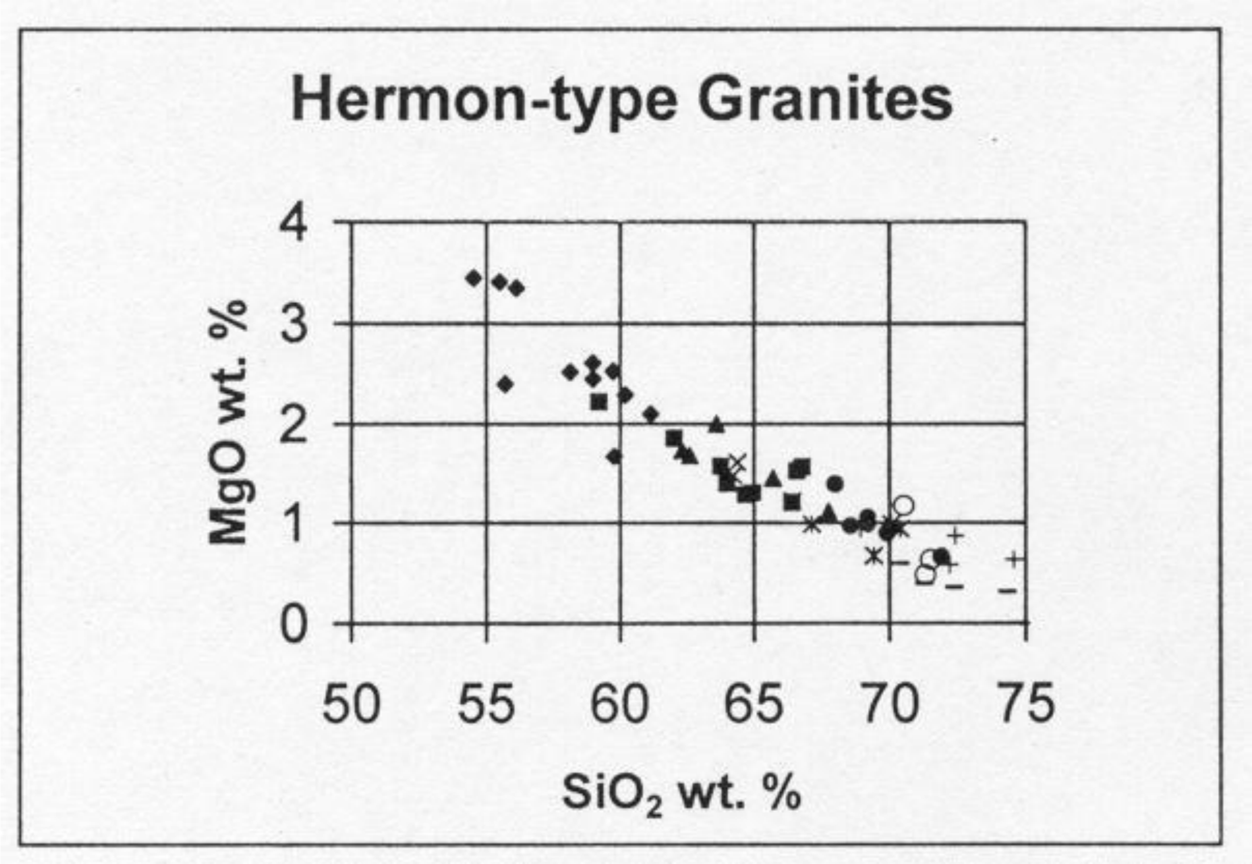

Fig. 2. Harker diagram showing SiO_2 wt. % versus MgO wt. % in Hermon-type granites. Data are from Carl and deLorraine (1997) and Table 1. Solid diamond = Gray's School; solid square = Hermon Village; solid triangle = Trout Lake; X = Sherman Lake; star = Ore Bed Road; open circle = Shiner Pond; plus = Mott Creek; solid circle = Fullerville; dash = Fowler.

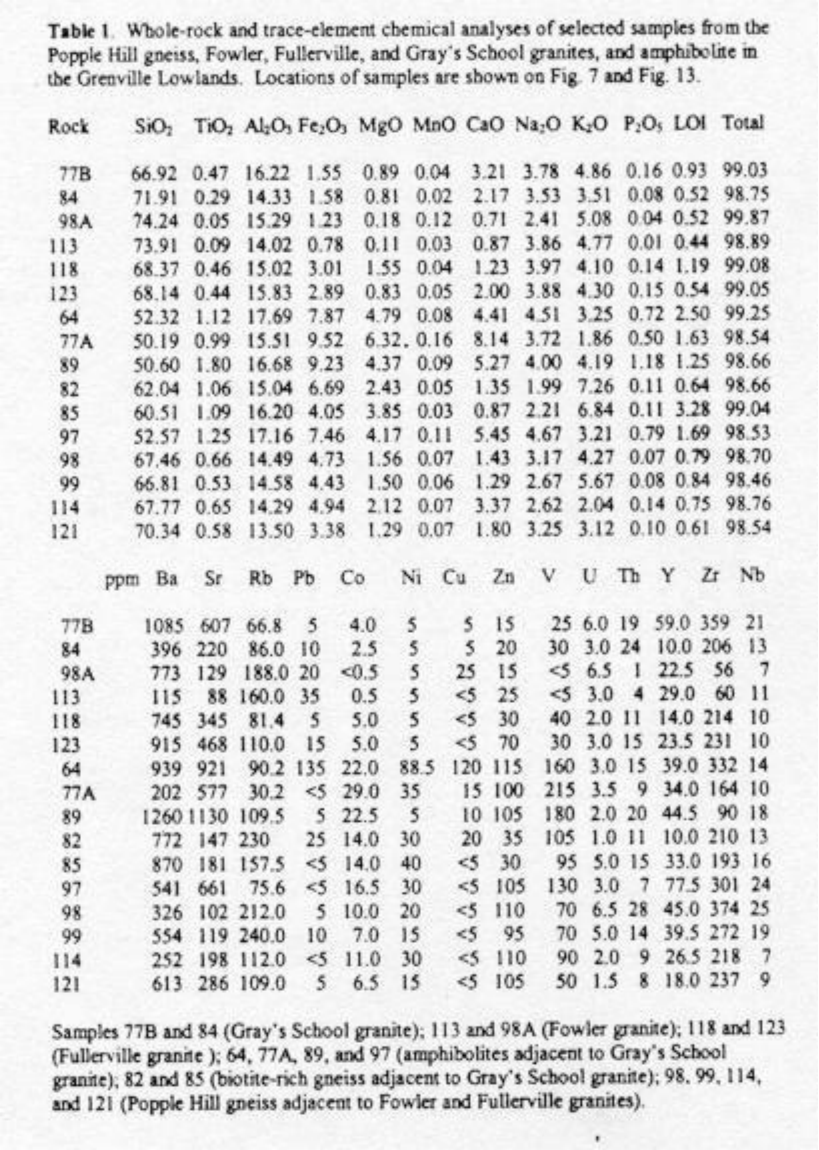

Table 1. Whole-rock and trace-element chemical analyses of selected samples from the Popple Hill gneiss, Fowler, Fullerville, and Gray's School granites, and amphibolite in the Grenville Lowlands. Locations of samples are shown on Fig. 7 and Fig. 13.

Rock	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	MnO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total
77B	66.92	0.47	16.22	1.55	0.89	0.04	3.21	3.78	4.86	0.16	0.93	99.03
84	71.91	0.29	14.33	1.58	0.81	0.02	2.17	3.53	3.51	0.08	0.52	98.75
98A	74.24	0.05	15.29	1.23	0.18	0.12	0.71	2.41	5.08	0.04	0.52	99.87
113	73.91	0.09	14.02	0.78	0.11	0.03	0.87	3.86	4.77	0.01	0.44	98.89
118	68.37	0.46	15.02	3.01	1.55	0.04	1.23	3.97	4.10	0.14	1.19	99.08
123	68.14	0.44	15.83	2.89	0.83	0.05	2.00	3.88	4.30	0.15	0.54	99.05
64	52.32	1.12	17.69	7.87	4.79	0.08	4.41	4.51	3.25	0.72	2.50	99.25
77A	50.19	0.99	15.51	9.52	6.32	0.16	8.14	3.72	1.86	0.50	1.63	98.54
89	50.60	1.80	16.68	9.23	4.37	0.09	5.27	4.00	4.19	1.18	1.25	98.66
82	62.04	1.06	15.04	6.69	2.43	0.05	1.35	1.99	7.26	0.11	0.64	98.66
85	60.51	1.09	16.20	4.05	3.85	0.03	0.87	2.21	6.84	0.11	3.28	99.04
97	52.57	1.25	17.16	7.46	4.17	0.11	5.45	4.67	3.21	0.79	1.69	98.53
98	67.46	0.66	14.49	4.73	1.56	0.07	1.43	3.17	4.27	0.07	0.79	98.70
99	66.81	0.53	14.58	4.43	1.50	0.06	1.29	2.67	5.67	0.08	0.84	98.46
114	67.77	0.65	14.29	4.94	2.12	0.07	3.37	2.62	2.04	0.14	0.75	98.76
121	70.34	0.58	13.50	3.38	1.29	0.07	1.80	3.25	3.12	0.10	0.61	98.54

ppm	Ba	Sr	Rb	Pb	Co	Ni	Cu	Zn	V	U	Th	Y	Zr	Nb
77B	1085	607	66.8	5	4.0	5	5	15	25	6.0	19	59.0	359	21
84	396	220	86.0	10	2.5	5	5	20	30	3.0	24	10.0	206	13
98A	773	129	188.0	20	<0.5	5	25	15	<5	6.5	1	22.5	56	7
113	115	88	160.0	35	0.5	5	<5	25	<5	3.0	4	29.0	60	11
118	745	345	81.4	5	5.0	5	<5	30	40	2.0	11	14.0	214	10
123	915	468	110.0	15	5.0	5	<5	70	30	3.0	15	23.5	231	10
64	939	921	90.2	135	22.0	88.5	120	115	160	3.0	15	39.0	332	14
77A	202	577	30.2	<5	29.0	35	15	100	215	3.5	9	34.0	164	10
89	1260	1130	109.5	5	22.5	5	10	105	180	2.0	20	44.5	90	18
82	772	147	230	25	14.0	30	20	35	105	1.0	11	10.0	210	13
85	870	181	157.5	<5	14.0	40	<5	30	95	5.0	15	33.0	193	16
97	541	661	75.6	<5	16.5	30	<5	105	130	3.0	7	77.5	301	24
98	326	102	212.0	5	10.0	20	<5	110	70	6.5	28	45.0	374	25
99	554	119	240.0	10	7.0	15	<5	95	70	5.0	14	39.5	272	19
114	252	198	112.0	<5	11.0	30	<5	110	90	2.0	9	26.5	218	7
121	613	286	109.0	5	6.5	15	<5	105	50	1.5	8	18.0	237	9

Samples 77B and 84 (Gray's School granite); 113 and 98A (Fowler granite); 118 and 123 (Fullerville granite); 64, 77A, 89, and 97 (amphibolites adjacent to Gray's School granite); 82 and 85 (biotite-rich gneiss adjacent to Gray's School granite); 98, 99, 114, and 121 (Popple Hill gneiss adjacent to Fowler and Fullerville granites).

Table 1. Whole-rock and trace-element chemical analyses of selected samples from the Popple Hill gneiss, Fowler, Fullerville, and Gray's School granites, and amphibolite in the Grenville Lowlands. Locations of samples are shown on Fig. 6 and Fig. 12. Analyst: Chemex Labs Inc.

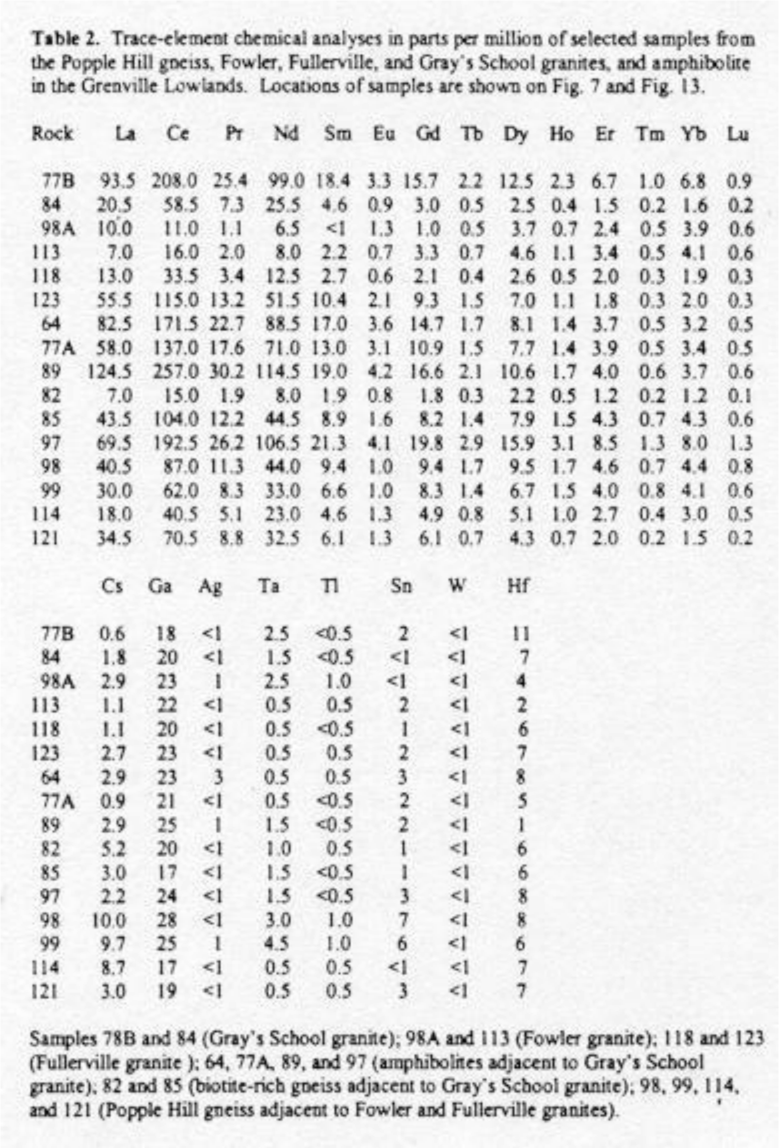

Table 2. Trace-element chemical analyses in parts per million of selected samples from the Popple Hill gneiss, Fowler, Fullerville, and Gray's School granites, and amphibolite in the Grenville Lowlands. Locations of samples are shown on Fig. 7 and Fig. 13.

Rock	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
77B	93.5	208.0	25.4	99.0	18.4	3.3	15.7	2.2	12.5	2.3	6.7	1.0	6.8	0.9
84	20.5	58.5	7.3	25.5	4.6	0.9	3.0	0.5	2.5	0.4	1.5	0.2	1.6	0.2
98A	10.0	11.0	1.1	6.5	<1	1.3	1.0	0.5	3.7	0.7	2.4	0.5	3.9	0.6
113	7.0	16.0	2.0	8.0	2.2	0.7	3.3	0.7	4.6	1.1	3.4	0.5	4.1	0.6
118	13.0	33.5	3.4	12.5	2.7	0.6	2.1	0.4	2.6	0.5	2.0	0.3	1.9	0.3
123	55.5	115.0	13.2	51.5	10.4	2.1	9.3	1.5	7.0	1.1	1.8	0.3	2.0	0.3
64	82.5	171.5	22.7	88.5	17.0	3.6	14.7	1.7	8.1	1.4	3.7	0.5	3.2	0.5
77A	58.0	137.0	17.6	71.0	13.0	3.1	10.9	1.5	7.7	1.4	3.9	0.5	3.4	0.5
89	124.5	257.0	30.2	114.5	19.0	4.2	16.6	2.1	10.6	1.7	4.0	0.6	3.7	0.6
82	7.0	15.0	1.9	8.0	1.9	0.8	1.8	0.3	2.2	0.5	1.2	0.2	1.2	0.1
85	43.5	104.0	12.2	44.5	8.9	1.6	8.2	1.4	7.9	1.5	4.3	0.7	4.3	0.6
97	69.5	192.5	26.2	106.5	21.3	4.1	19.8	2.9	15.9	3.1	8.5	1.3	8.0	1.3
98	40.5	87.0	11.3	44.0	9.4	1.0	9.4	1.7	9.5	1.7	4.6	0.7	4.4	0.8
99	30.0	62.0	8.3	33.0	6.6	1.0	8.3	1.4	6.7	1.5	4.0	0.8	4.1	0.6
114	18.0	40.5	5.1	23.0	4.6	1.3	4.9	0.8	5.1	1.0	2.7	0.4	3.0	0.5
121	34.5	70.5	8.8	32.5	6.1	1.3	6.1	0.7	4.3	0.7	2.0	0.2	1.5	0.2

	Cs	Ga	Ag	Ta	Tl	Sn	W	Hf
77B	0.6	18	<1	2.5	<0.5	2	<1	11
84	1.8	20	<1	1.5	<0.5	<1	<1	7
98A	2.9	23	1	2.5	1.0	<1	<1	4
113	1.1	22	<1	0.5	0.5	2	<1	2
118	1.1	20	<1	0.5	<0.5	1	<1	6
123	2.7	23	<1	0.5	0.5	2	<1	7
64	2.9	23	3	0.5	0.5	3	<1	8
77A	0.9	21	<1	0.5	<0.5	2	<1	5
89	2.9	25	1	1.5	<0.5	2	<1	1
82	5.2	20	<1	1.0	0.5	1	<1	6
85	3.0	17	<1	1.5	<0.5	1	<1	6
97	2.2	24	<1	1.5	<0.5	3	<1	8
98	10.0	28	<1	3.0	1.0	7	<1	8
99	9.7	25	1	4.5	1.0	6	<1	6
114	8.7	17	<1	0.5	0.5	<1	<1	7
121	3.0	19	<1	0.5	0.5	3	<1	7

Samples 78B and 84 (Gray's School granite); 98A and 113 (Fowler granite); 118 and 123 (Fullerville granite); 64, 77A, 89, and 97 (amphibolites adjacent to Gray's School granite); 82 and 85 (biotite-rich gneiss adjacent to Gray's School granite); 98, 99, 114, and 121 (Popple Hill gneiss adjacent to Fowler and Fullerville granites).

Table 2. Trace-element chemical analyses in parts per million of selected samples from the Popple Hill gneiss, Fowler, Fullerville, and Gray's School granites, and amphibolite in the Grenville Lowlands. Locations of samples are shown on Fig. 6 and Fig. 12. Analyst: Chemex Labs Inc.

Field studies of the megacrystal Hermon-type granites

Field studies of the megacrystal Hermon-type granites show that they have gradational contacts with the more mafic wall rocks. The Fowler and Fullerville granites, which have relatively-low MgO- and high SiO_2-contents (Fig. 2), is gradational to biotite-rich gneisses or amphibolites. (See, also, http://www.csun.edu/~vcgeo005/Nr28Popple.pdf for a discussion of the Popple Hill gneiss). Gradational contacts of the Trout Lake megacrystal granite also occur with the Popple Hill gneiss in dynamited road outcrops along Trout Lake Road (northwest of Edwards, adjacent to the southeast end of Trout Lake), and gradational contacts of the Ore Bed Road granite body also occur at its northwest end with Popple Hill gneiss along the road from Balmat to Edwards. Therefore, although possible gradational transitions from granites to wall rocks have not been sought for the other four megacrystal granites, such transitions are presumed to exist.

Thin section studies of the megacrystal Hermon-type granites

All Hermon-type granites, plotted on Fig. 2, are myrmekite-bearing. Myrmekite also occurs in deformed portions of the adjacent wall rocks. Maximum sizes of the quartz vermicules in the myrmekite range from relatively coarse in the Gray's School granite (Fig. 3) to relatively fine in the Fullerville and Fowler granites (Fig. 4). These maximum sizes correlate with what is expected for oligoclase-andesine in the amphibolite wall rocks of the Gray's School granite and for albite-oligoclase in the Popple Hill gneiss wall rocks of the Fowler and Fullerville granites (Collins, 1988).

Fig. 3. Myrmekite with relatively coarse quartz vermicules in microcline (light gray, black; grid-twinning). Sample is from the southeast end of the Gray's School megacrystal granite body.

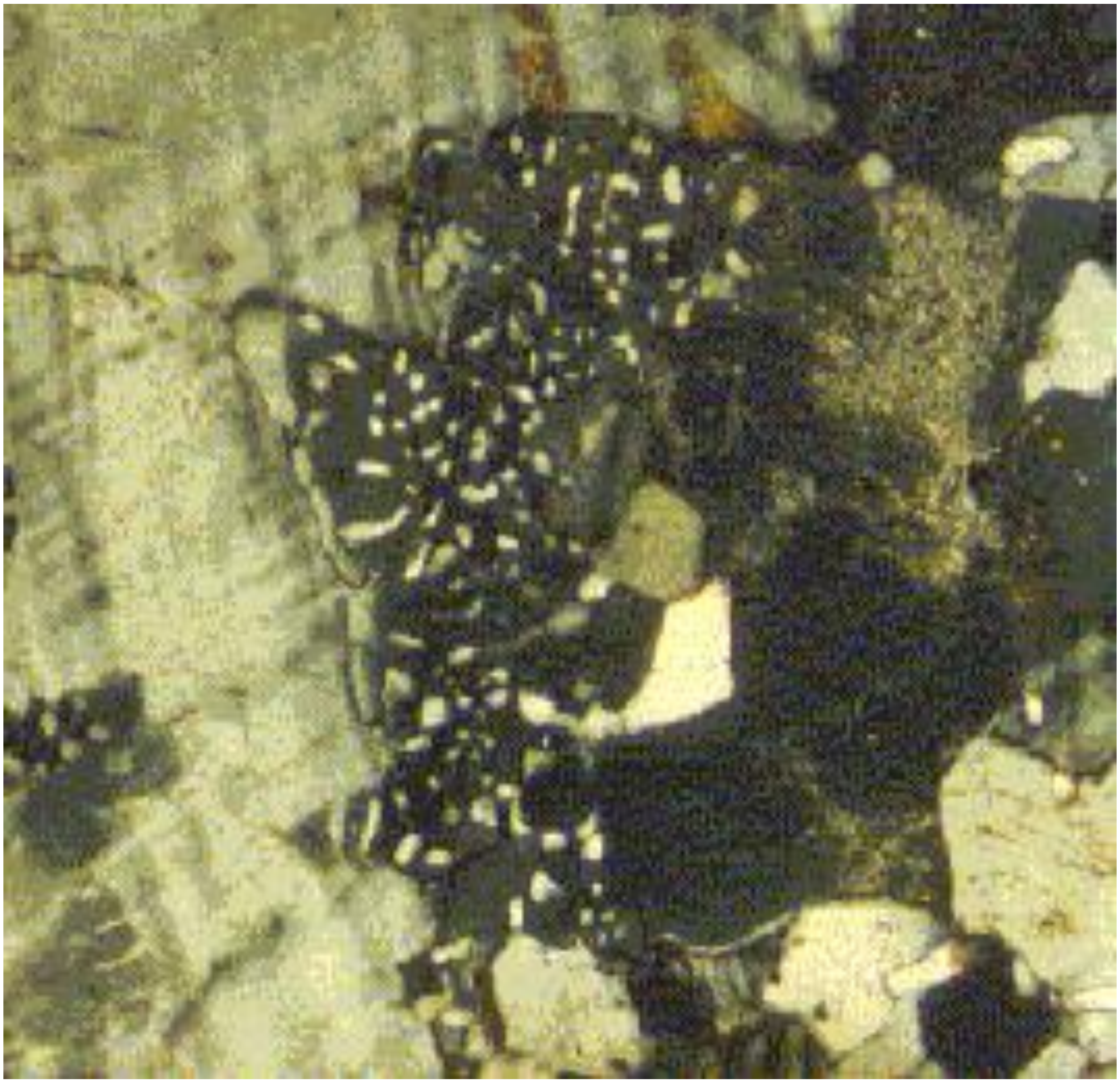

Fig. 4. Myrmekite with relatively tiny quartz vermicules in the northern part of the Fowler granite. Microcline (light gray, grid-twinning); quartz (white, black); plagioclase (speckled tan).

Type of granite also correlates with the type of wall rock. Where the megacrystal granite is hornblende-bearing, the adjacent wall rock is an amphibolite or hornblende diorite. Where the megacrystal granite is rich in sphene, the adjacent wall rock is also rich in sphene. And, where the megacrystal granite contains no hornblende and only biotite, the adjacent wall rock is richer in biotite and lacks hornblende.

Field relationships for the Gray's School Hermon-type granite and its wall rocks

Gradational contacts of the Gray's School granite with its wall rocks can be observed in many places. West of Dekalb, New York, dynamited outcrops of megacrystal granite (Fig. 5) occur along Maple Ridge Road (intersecting Route 17; Fig. 6). This granite becomes increasingly richer in ferromagnesian silicates westward where only stringers of myrmekite-bearing granite remain in a deformed amphibolite (Fig. 7). Eventually the granite disappears in outcrops still farther west. At the north end of the granite body only remnants of amphibolite occur, but here the rock is strongly mylonitized and altered. Exposures in this area are so poor that gradational relationships between amphibolite and granite are obscure. On the east side of the granite body along the Old River Road are many excellent outcrops of the megacrystal granite (Fig. 8) that contain remnants (enclaves) of amphibolite (Fig. 9). The amphibolite that forms the east wall rock of the granite can be found along a "truck road" that intersects the Old River Road, 1.4 miles (2 km) south of Maple Ridge Road. Here a dynamited outcrop of amphibolite (sample 64; Fig. 6) contains stringers and masses of myrmekite-bearing granite.

Fig. 5. Megacrystal Gray's School granite along Maple Ridge Road. Remnants of amphibolite occur in the granite. Black grains are hornblende and biotite. White and gray megacrysts are microcline. U. S. dime (1 cm wide) provides a scale.

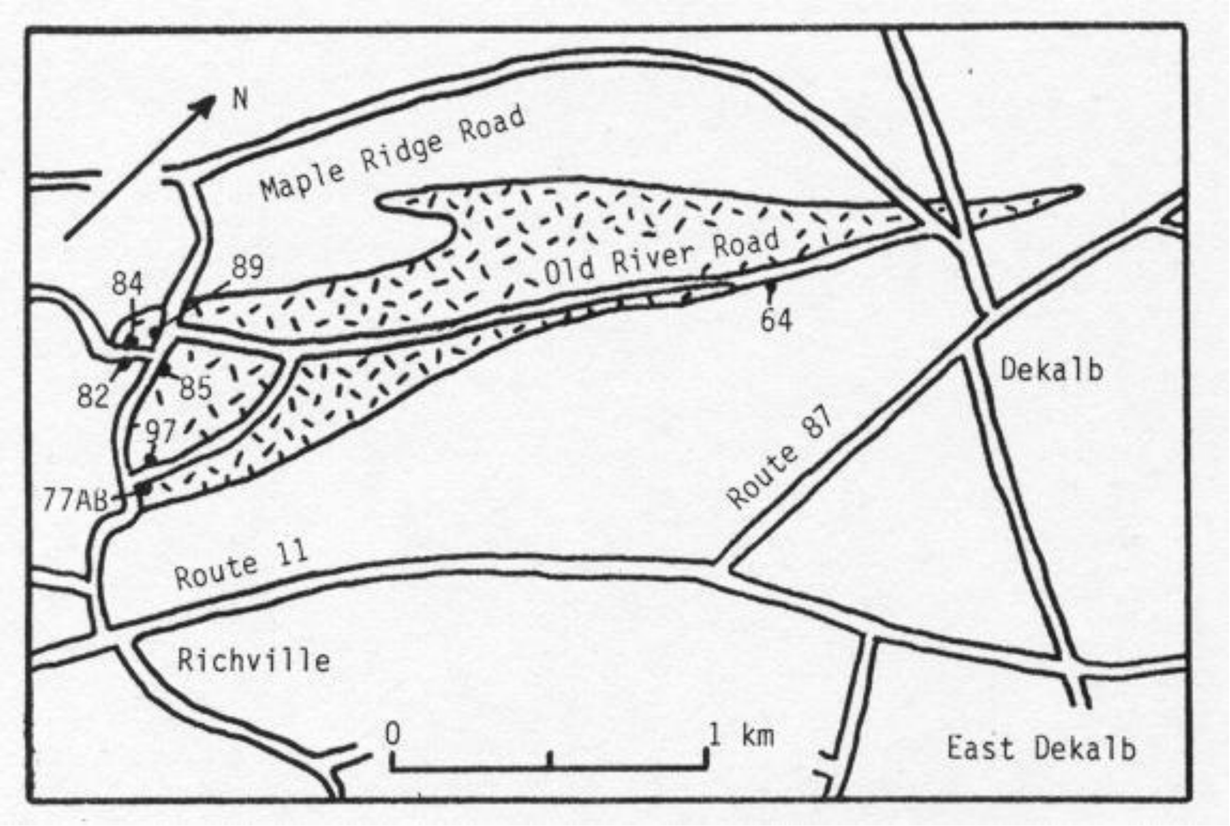

Fig. 6. Geologic map of the Gray's School Hermon-type granite (patterned symbols); modified after Carl and deLorraine (1997) and omitting many other rock types. Locations of samples on Table 1 and Table 2 are indicated by number.

Fig. 7. Stringers of granite in deformed amphibolite along Maple Ridge Road. Locally, microcline megacrysts occur in the granite stringers and amphibolite but are not as large as that in Fig. 5

Fig. 8. Megacrystal Gray's School granite along Old River Road. Largest microcline megacrysts (light pink) are about 1.5 cm long. Hornblende and biotite are the black minerals; plagioclase (white); quartz (gray).

Fig. 9. Megacrystal Gray's School granite with remnant enclaves of amphibolite. Photo taken in dynamited outcrop along Old River Road. Some microcline megacrysts have replaced plagioclase crystals in portions of the amphibolite enclaves. Largest megacrysts are about 1.5 cm long.

In other places gradational contacts are absent and instead the wall rocks are interlayered with the granite. For example, at the southwest end of the Gray's School granite body and extending northward along the western third of the body, the granite is interlayered with biotite-rich gneiss, amphibolite, and coarse diorite. Dynamited outcrops of amphibolite (sample 89) with veins of granite can be observed along the dirt road in the southwestern part of the granite (Fig. 6). Biotite-rich gneisses (samples 85 and 82) and granite (sample 84) occur in outcrops along the road that extends south from the dirt road trending east-west along the south end of the pluton. Likewise, at the southeast end of the Gray's School granite body, both biotite- and quartz-rich Popple Hill gneiss and biotite-hornblende amphibolite (samples 77A and 97) are interlayered with the Gray's School Hermon-type granite (sample 77B, Fig. 6).

Thin section studies of the Gray's School Hermon-type granite and its wall rocks

Thin section studies of the amphibolites and biotite-rich gneiss that are the wall rocks for the Gray's School granite show cataclasis of normal zoned plagioclase crystals, but coexisting microcline megacrysts are unbroken. This relationship gives evidence that the microcline is *later than the cataclasis*. Plagioclase in the amphibolite (or diorite) has remnant normal zoning with relatively calcic cores. In some places, however, microcline penetrates the plagioclase in veins and partially replaces interiors of deformed plagioclase crystals (Fig. 10). In the microcline, island of unreplaced plagioclase are in parallel optical continuity with the larger plagioclase crystal outside the microcline (Fig. 10).

Fig. 10. Veins of microcline (black, dark gray; grid-twinning) replacing interiors of plagioclase (light cream-gray). Remnant islands of unreplaced plagioclase (light gray) occur in the microcline. Sample obtained from southeastern part of Gray's School granite body.

In other places biotite has quartz sieve textures where quartz has replaced the biotite. Hornblende also locally shows replacement by quartz blebs in the interiors of some crystals. The same textural and mineralogical replacement patterns are also found in granite along the Old River Road outcrops where enclaves of both biotite-plagioclase and biotite-hornblende-plagioclase layers can be found. Microcline megacrysts locally replace plagioclase crystals in these enclaves (Fig. 9).

Although many contacts between amphibolite and the Gray's School granite appear to be sharp in the field, thin sections across the contacts commonly show early stages of K-feldspar replacement of interiors of plagioclase crystals and the formation of myrmekite in the amphibolite adjacent to the contact.

Carl and deLorraine (1997) also reported the presence of zoned K-feldspar in one locality with inclusions of biotite and plagioclase aligned parallel to possible crystal faces of a growing K-feldspar crystal. This suggests that a facies of the original primary diorite contained zoned orthoclase. The lack of such zoning in all other K-feldspar megacrysts in other parts of the Gray's School granite lends support to the hypothesis that most of the K-feldspar has formed by replacement processes.

Chemical analyses of Gray's School granite, amphibolite, and biotite gneiss

Chemical analyses of the Gray's School granite, amphibolite, and biotite gneiss (Table 1 and Table 2) give support to the K- and Si-replacement model. Relative to related amphibolite and biotite gneiss samples, the granite is enriched in SiO_2, K_2O, and Pb and depleted in Fe_2O_3, MgO, MnO, CaO, Sr, Co, Ni, Cu, Zn, and V. Other oxides and trace elements give mixed results. Fig. 11 shows the trend of data for MgO wt. % versus SiO_2 wt. % for the parent biotite-rich gneisses (samples 82 and 85) relative to their associated granite (sample 84) and for the parent amphibolites (samples 64, 77A, 89, and 97) relative to their associated granites (sample 77B and samples analyzed by Carl and deLorraine, 1997). Losses of MgO are relatively large where the parent rocks are replaced by granite.

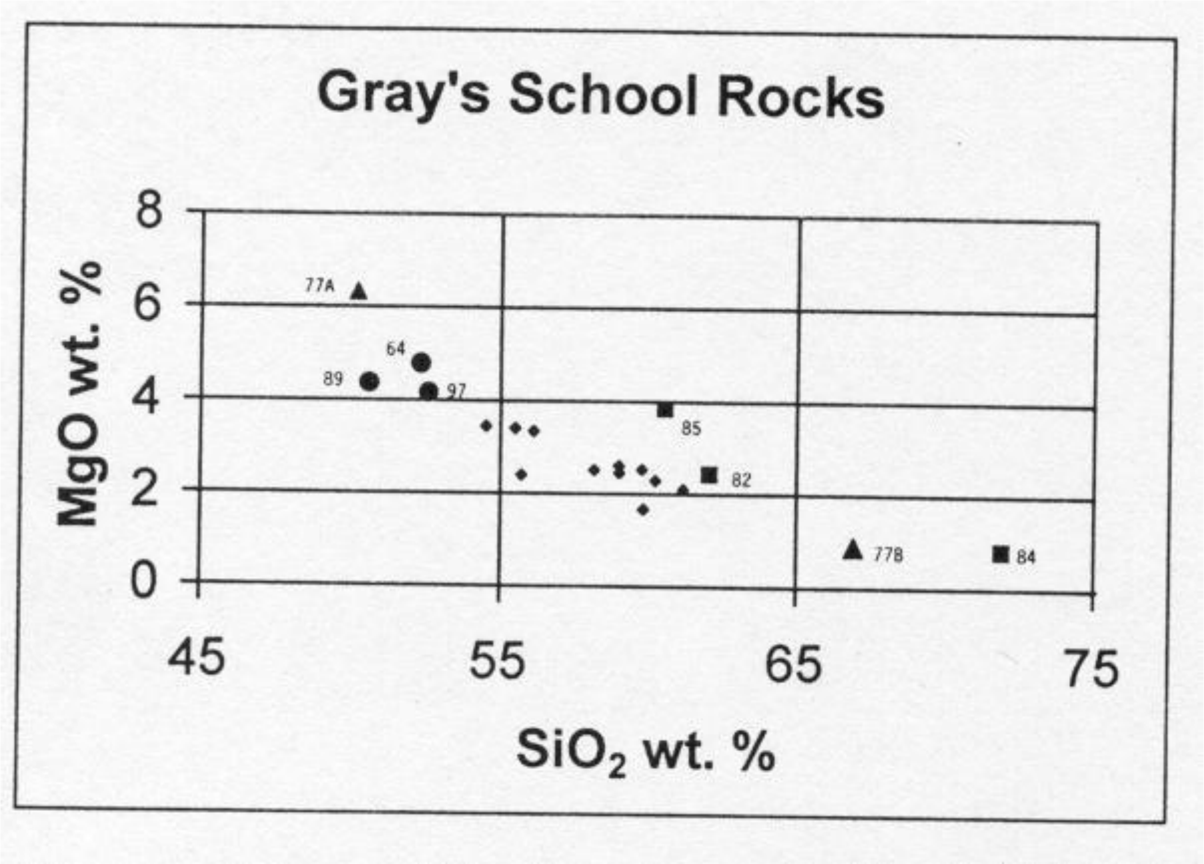

Fig. 11. Harker diagram showing trend of data for MgO wt. % versus SiO_2 wt. % in the Gray's School granite and related amphibolite and biotite-rich gneisses. Data are from Carl and deLorraine (1997) and Table 1. Small solid diamond = granite samples analyzed by Carl and deLorraine; solid triangle = paired samples of biotite-hornblende amphibolite (77A) and granite (77B); solid circle = biotite-hornblende amphibolite (64 & 89); solid square = biotite gneiss (82 & 85) paired with granite (84).

Field relations of the Fowler and Fullerville Hermon-type granites and associated rocks

The Fowler granite is a lenticular body enclosed in Popple Hill gneiss in the western limb of a tight isoclinal fold whose core is the Upper Marble unit that contains zinc sulfide concentrations (Fig. 12). The Ore Bed Road granite is probably a continuation of the Fullerville granite. Both the Fowler and Fullerville granites are similar to the Gray's School granite in physical appearance but differ in kinds of wall rocks. Around the Gray's School granite the plagioclase in the wall rock gneisses and amphibolites tends to be more calcic (oligoclase or andesine) and coexisting with hornblende whereas around the Fowler and Fullerville granites the plagioclase in the Popple Hill gneiss is more sodic (albite or oligoclase) and does not coexist with hornblende. Unlike wall rocks of the Gray's School granite, however, the Popple Hill gneiss along highway 58 west of the city of Fowler near Popple Hill and west of the Fowler granite body contain granite dikes that cut the foliation with sharp contacts.

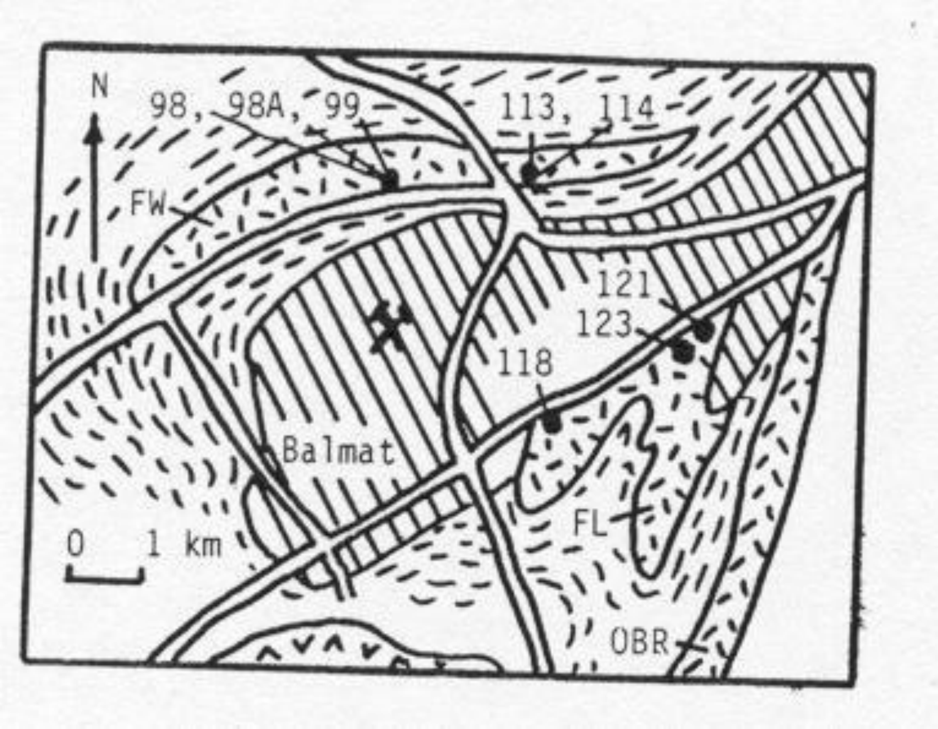

Fig. 12. Geologic map of the Balmat area in the Grenville Lowlands of New York, showing locations of the Hermon-type Fowler (FW), Fullerville (FL), and Ore Bed Road (OBR) granites (patterned symbols). The lenticular granites are in the Popple Hill gneiss (dashes) in the limbs of an isoclinal fold, the core of which consists of the Upper Marble unit (lined pattern). A portion of the California granite (v-pattern) occurs at the bottom of the map. Modified after deLorraine *et al.* (1982) and omitting some other associated rock types. Location of analyzed samples on Table 1 are shown on map by number.

The Popple Hill gneiss is variable in composition but commonly is relatively felsic, consisting mostly of quartz, plagioclase, and small amounts of biotite (Carl, 1998; Engel and Engel, 1958). In some places, however, bands rich in biotite (30 vol. % or more) occur. Disoriented enclaves of this biotite-rich gneiss occur in the contorted Fullerville granite in the western limb of the drag fold as seen along the road towards Edwards, 0.5-2 km north of the Four Corners in Balmat (Fig. 12). Here, the granite is fine-grained, lacking megacrysts, and contains little to no plagioclase, the feldspar being mostly microcline. Farther northeast along the drag fold in the nose of the fold and its eastern limb, where the rock is less deformed (southeast and east of the pond on the Earl Murphy property), the biotite-plagioclase-quartz Popple Hill gneiss interfingers with layers of Fullerville granite containing microcline megacrysts. Mineral compositions and groundmass textures of gneiss and granite are quite similar except that less biotite and plagioclase and more microcline occur in the granite.

Thin section studies of the Fowler and Fullerville Hermon-type granites and their wall rocks

Quartz vermicules in myrmekite in the Popple Hill gneiss (Fig. 13) are the same size as quartz vermicules in myrmekite on borders of megacrysts in the adjacent Fullerville granite (Fig. 14). This relationship is consistent with the hypothesis that the granite is derived from the gneiss simply by replacing some of the plagioclase by microcline megacrysts.

Fig. 13. Myrmekite in Popple Hill gneiss. Quartz (white, gray, black); biotite (brown); speckled grain is altered (sericitized) plagioclase.

Fig. 14. Myrmekite in Fullerville megacrystal granite adjacent to myrmekite-bearing Popple Hill gneiss (Fig. 13). Microcline (black); quartz vermicules (white, gray); plagioclase of myrmekite (light gray, sericitized).

As in the Gray's School granite, in both the Fowler and Fullerville granites, microcline veins replace interiors of plagioclase crystals, and islands of unreplaced plagioclase, remaining in the microcline, occur in optical parallel continuity with the larger unreplaced plagioclase grain outside the microcline (Fig. 15).

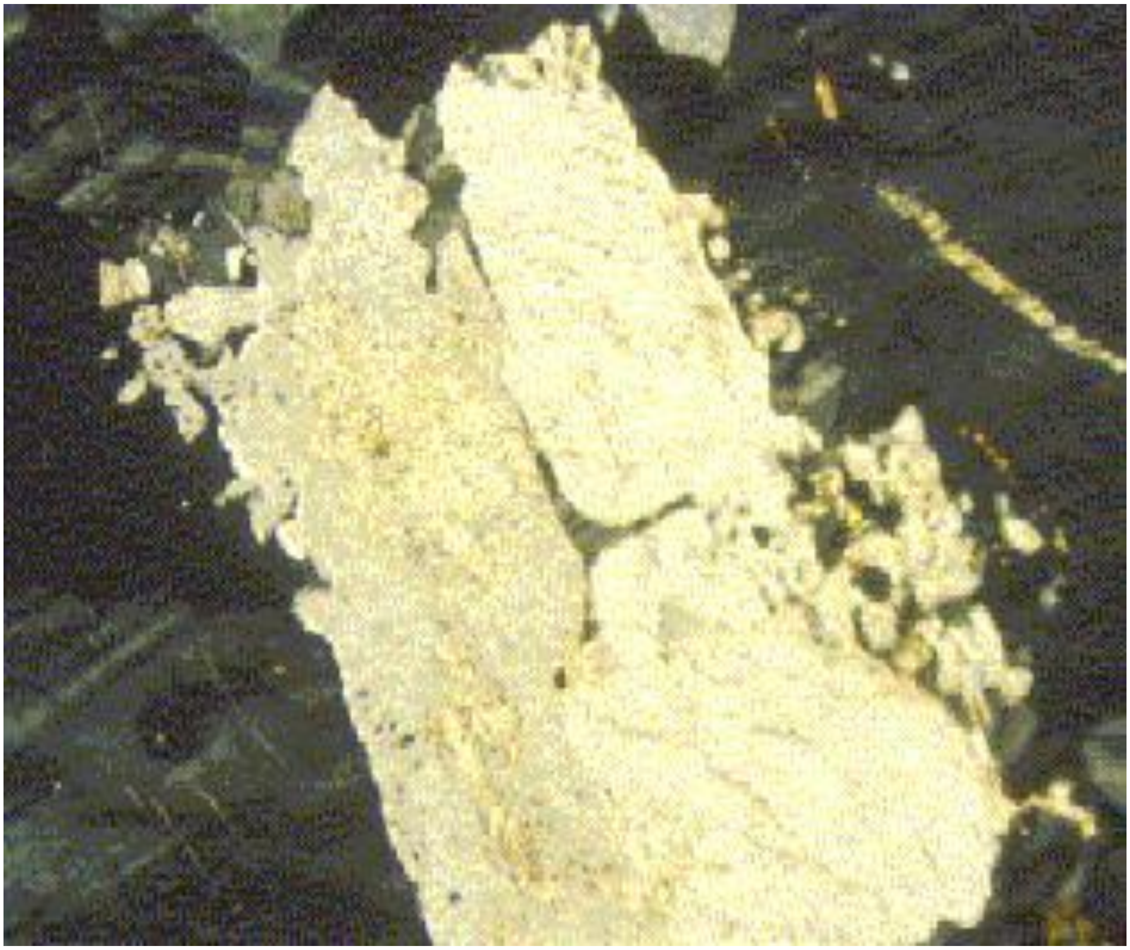

Fig. 15. Interior replacement of plagioclase (white) by veins of microcline (dark gray, black) and islands of unreplaced plagioclase in adjacent microcline. The islands have optically parallel continuity with the larger unreplaced plagioclase grain. Sample obtained from center of the middle part of the Fowler granite body.

In some places the microcline megacrysts in the Fullerville granite are poorly zoned, containing remnant, oriented plagioclase grains with albite-twinning that is aligned parallel to possible faces of the growing K-feldspar crystal (Fig. 16). This zonation might result where random plagioclase grains in the groundmass happen to have lattices that are oriented parallel to the K-feldspar lattice and, thereby, are more stable and less prone to replacement than those whose deformed lattices are inclined to the K-feldspar lattice. The lack of well-developed faces on these plagioclase inclusions, the embayments of K-feldspar into the plagioclase, and the equality in size of the plagioclase inclusions with the groundmass plagioclase grains lend support to this incomplete replacement hypothesis.

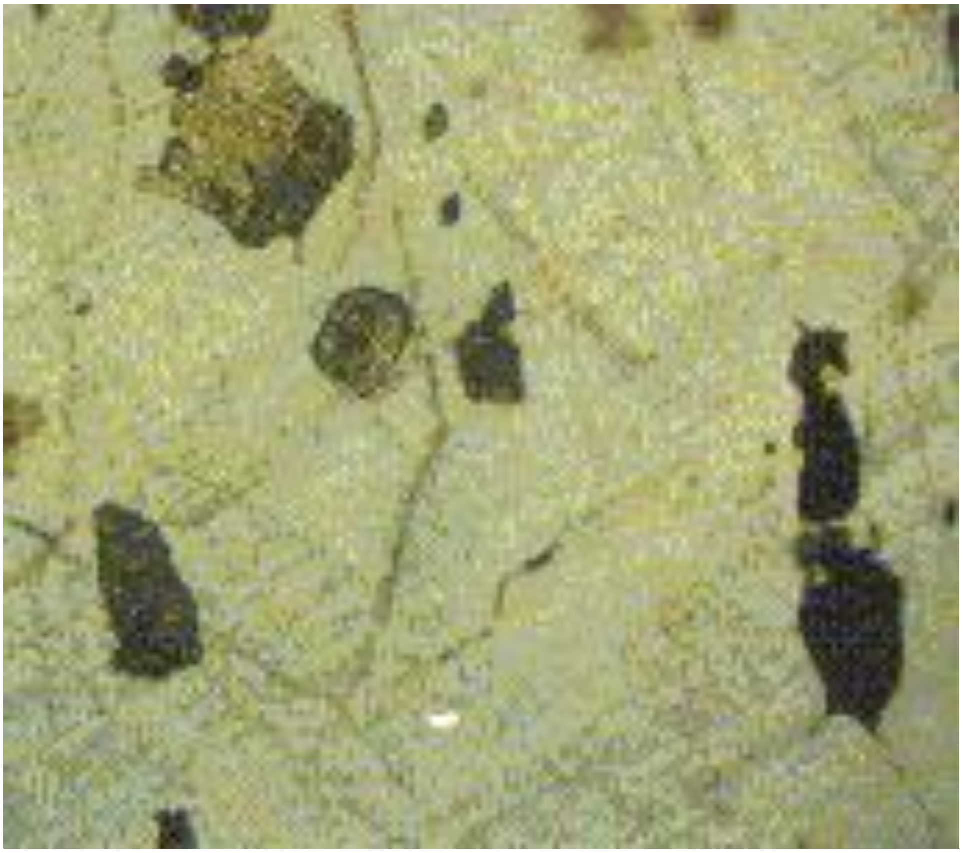

Fig. 16. Microcline (light gray) with plagioclase inclusions (tan) in a poorly developed zonal arrangement. Plagioclase grains are rounded and embayed, and some have albite-twinning that is not oriented parallel to the zonal pattern.

Thin sections of the leucocratic dikes that cut the Popple Hill gneiss near Popple Hill along route 58 west of Fowler show that these dikes consist dominantly of microcline and quartz with occasional myrmekite adjacent to remnant plagioclase. In a few places thin sections of the Popple gneiss adjacent to these dikes show microcline (1 cm long) replacing plagioclase, and some of the microcline is bordered by myrmekite which looks like the myrmekite in the dikes. Therefore, although the dikes give the physical appearance of intrusions of magma from the nearby Fowler granite, they likely represent strong replacements of crushed rocks along fractures cutting the foliation in which most of the biotite is replaced by quartz and most of the plagioclase is replaced by microcline.

Chemical analyses of Fowler and Fullerville granites and the Popple Hill gneiss

Chemical analyses of the Fowler and Fullerville granites and the Popple Hill gneiss (Table 1 and Table 2) also give support to the K- and Si-replacement model.

Relative to the gneiss samples, the granites are enriched in K_2O, Rb, and Pb and depleted in Fe_2O_3, MgO, MnO, CaO, Sr, Co, Ni, Cu, Zn, and V. The SiO_2 content is about the same because the gneisses are quartz rich. Some granite samples have less SiO_2 than the gneiss. The megacrystal granite sample 123 shows a slight increase in CaO over the gneiss sample 121, and this may be because of the occurrence of epidote in the granite. Other oxides and trace elements give mixed results. Fig. 17 shows the trend of MgO wt. % versus SiO_2 wt. % for the parent Popple Hill gneisses (samples 98, 99, 114, and 121) relative to their associated granites (samples 98A, 113, 118, and 123, and samples analyzed by Carl and deLorraine, 1997). Losses of MgO are relatively large where the parent rocks are replaced by granite.

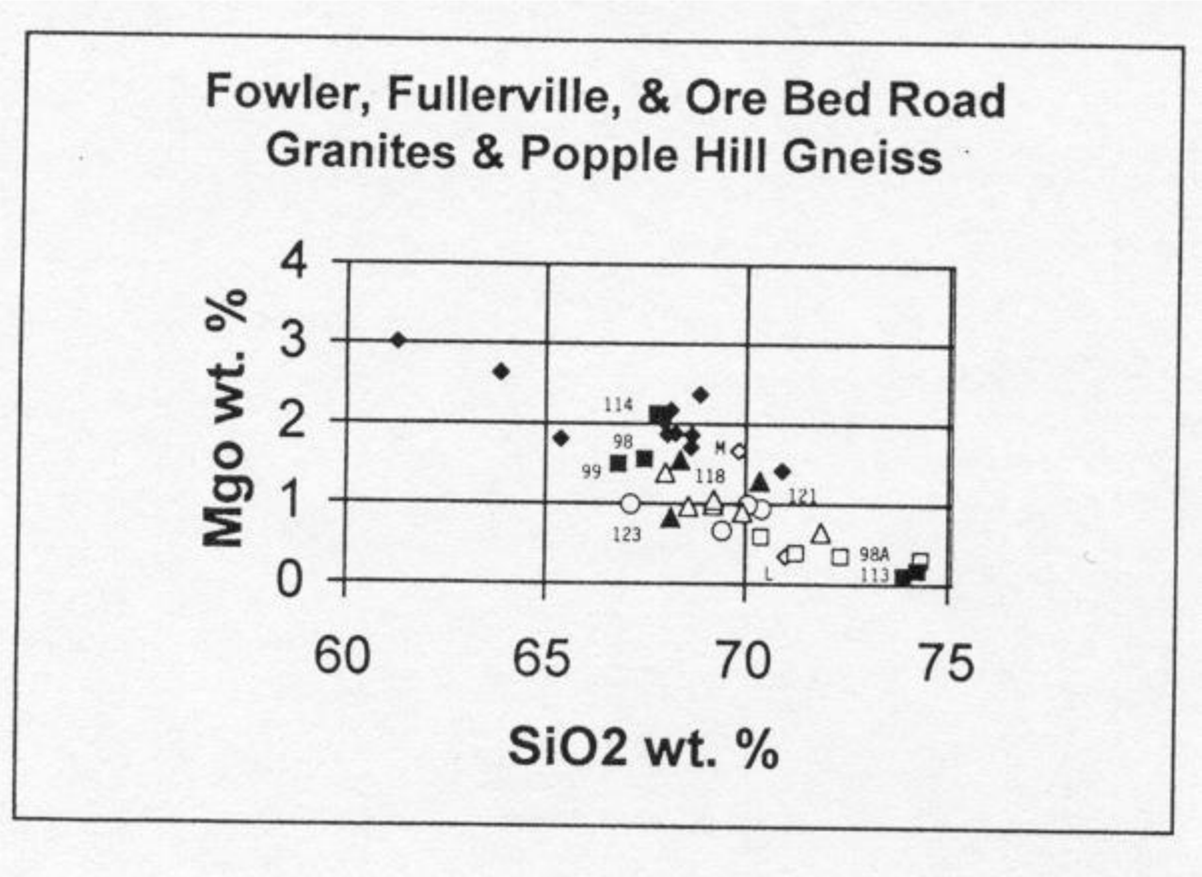

Fig. 17. Harker diagram showing trend of data for MgO wt. % versus SiO_2 wt. % in the Ore Bed Road, Fowler, and Fullerville granites and related Popple Hill gneisses. Data are from Carl (1988), Carl and deLorraine (1997), and Table 1. Solid diamond = Popple Hill gneiss (98 and 99) coexisting with Fowler granite (98A, solid square) and paired Popple Hill biotite gneiss (114, solid diamond) and Fowler granite (113; solid square); open square = Fowler granite from Carl and deLorraine (1997); solid triangle = Fullerville fine-grained granite (118) and

megacrystal granite (123) in association with Popple Hill gneiss (121, solid diamond); open triangle = Fullerville granite and open circle = Ore Bed Road granite from Carl and deLorraine (1997); other solid diamonds = least altered Popple Hill gneiss (Engel and Engel, 1958); and open diamond (M) = average of 7 Popple Hill mesosome gneiss samples (+/- 1.81 wt. % SiO_2; +/- 0.74 wt. % MgO) and open diamond (L) = average of 4 Popple Hill leucosome gneiss samples (+/- 4.03 wt. % SiO_2; =/- 0.16 wt. % MgO).

Discussion

The gradational changes in mineralogy between wall rocks and adjacent granites and the direct correlation between these mineral changes and the degree of deformation of the parent rocks have not been suspected by other investigators and, therefore, such relationships have not been looked for. In the drag fold on the eastern limb of the isoclinal fold north of the Four Corners in Balmat (Fig. 12), the great abundance of microcline and nearly complete absence of plagioclase results from the nearly complete replacement of the former plagioclase by microcline in the strongly deformed Popple Hill gneiss once occupying this space. The progressive and continuous deformation, as the drag fold was formed, would have caused mineral grains in the limbs of the drag fold to be sheared repeatedly, thereby keeping the grain size small (no megacrysts formed) and enabling most of the broken plagioclase grains to be replaced by the microcline. Recrystallization would eliminate most of the former cataclastic texture.

The above relationships between deformation and feldspar compositions are characteristic throughout the megacrystal Hermon-type granites in the Grenville Lowlands. In those places that were affected by the strongest deformation, the granite has the highest percentage of microcline and the least plagioclase, although much of the evidence for this deformation may be eliminated by the replacement and recrystallization. For example, structurally, there is a correlation between deformation and creation of the Fowler and Fullerville granites. These granites are not connected around the nose of the isoclinal fold (Fig. 12). The reason for this is because the nose of this fold is structurally the tightest and the place where the least deformation would occur. Granite was not created here by replacement processes because few (if any) openings where produced through which fluids could move. In contrast, in the limbs of the fold the most sliding of adjacent layers past each other would occur as the rock layers adjusted to the creation of the isoclinal folding. Therefore, rock layers in the limbs underwent the greatest degrees of cataclasis, and these places would have been the most open for throughgoing K-replacement fluids to form the fine-grained and/or megacrystal K-feldspar in the granite.

Similarly, the Gray's School granite (Fig. 6) occupies a space which was affected by strong deformation. As the marble unit (south of the now-granite body) was thrust (rolled) against the biotite-rich gneiss and diorite (amphibolite) layers, these layers slid differentially past each other (like a sliding deck of cards) to make space for the movement of the marble. In that process, the plagioclase crystals would have been deformed and granulated so that K released from replaced biotite could convert the plagioclase into microcline, thereby changing these rocks into megacrystal granite. Supporting this hypothesis are the facts that (1) the greatest conversion of the biotite-rich gneiss and diorite to granite occurs along strike opposite the blunt end of the southern part of the the granite body against the marble where deformation was the strongest, and (2) the degree of replacement dies out westward where the marble unit has not shoved as far northward and where the gneiss and diorite layers have not been as strongly deformed. Replacements also die out northward where the body tapers to a point. Evidence for the strong deformation in the southern part of the pluton has been largely eliminated by the recrystallization that occurred during the K-metasomatism.

Conclusions

The formation of megacrystal Hermon-type granite gneisses by K-replacement of older Popple Hill gneiss, biotite-rich gneisses, and amphibolites (diorites) in the Grenville Lowlands on the northwest side of the Adirondack massif in New York is similar to that found in the megacrystal granite on the eastern side of the Waldoboro complex (web site article number 6), in the megacrystal quartz monzonite at Twentynine Palms, California (web site article number 9), in the megacrystal parts of the outer Ardara granite in Ireland (web site article number 10), in the augen Ponaganset gneiss in Rhode Island (web site article number 22), and in the megacrystal portions of the Kavala pluton in northern Greece (web site article number 29). All of these megacrystal granites have common K-replacement characteristics in that they are in terranes exhibiting strong deformation resulting from tectonism in fault zones or thrust belts or from upward movements of solidified diapiric plutons adjacent to their walls.

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