GEOCHEMICAL TRAVERSE ACROSS CAMERON'S LINE, BORO HALL PARK, BRONX, NEW YORK

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INTRODUCTION

Boro Hall Park (Fig. 1) as described by Baskerville (1989) includes several good exposures of both the Hartland Formation and the Manhattan Schist, and is one of only a few locations around the greater New York City area where the plate suture (Cameron's Line) separating the two formations is readily accessible. Boro Hall Park, therefore, affords a good opportunity to examine and compare the two very similar biotite schist units that make up much of New York City.

It has been our experience that the overlapping physical appearance, mineralogy, chemical composition, and structural attitude of the Hartland Formation and the Manhattan Schist make them difficult to distinguish. The convoluted trace of the contact between the two adjacent units adds to the problem and makes it all the more important to find a quick and reliable basis of identification. Our analysis of samples collected at Boro Hall Park, therefore, was done as at attempt at further characterizing the two formations, and in particular, at finding a consistent criteria that could be quickly or easily used for future mapping.

GEOLOGIC SETTING

Contrasts in the depositional environment and provenance of the Hartland Formation and the Manhattan Schist, as proposed by Baskerville and Mose (1989), Merguerian (1983) and Merguerian and Sanders (1991), are very significant and should be reflected in the chemical composition of the two units. The Hartland Formation is interpreted by these authors as a eugeosynclinal deep-water shale deposited on oceanic crust. In contrast the Manhattan Schist is interpreted as miogeoclinal shallow-water shale deposited on the continental shelf. The provenance of the Hartland Formation was presumably calc-alkaline, island arc, rocks typical of eugeosynclinal settings while the provenance of the Manhattan Schist was presumably a complex mix of crystalline Proterozoic granitic rock exposed along the Atlantic margin such as that exposed in the New Jersey Highlands. Thrusting along the east-dipping suture (Cameron's Line) has superimposed the Hartland Formation onto member c of the Manhattan Schist (Baskerville, 1989).

METHOD

A series of 9 rock samples, spaced at 20 foot intervals, along an east-west traverse along the southern edge of Boro Hall Park were collected in addition to samples from each of the large outcroppings of rock exposed throughout the park. Seven samples were collected from east of Cameron's line defined as a 30 m wide, grass covered "topographic swale" (Baskerville, 1989), that strikes approximately N-S

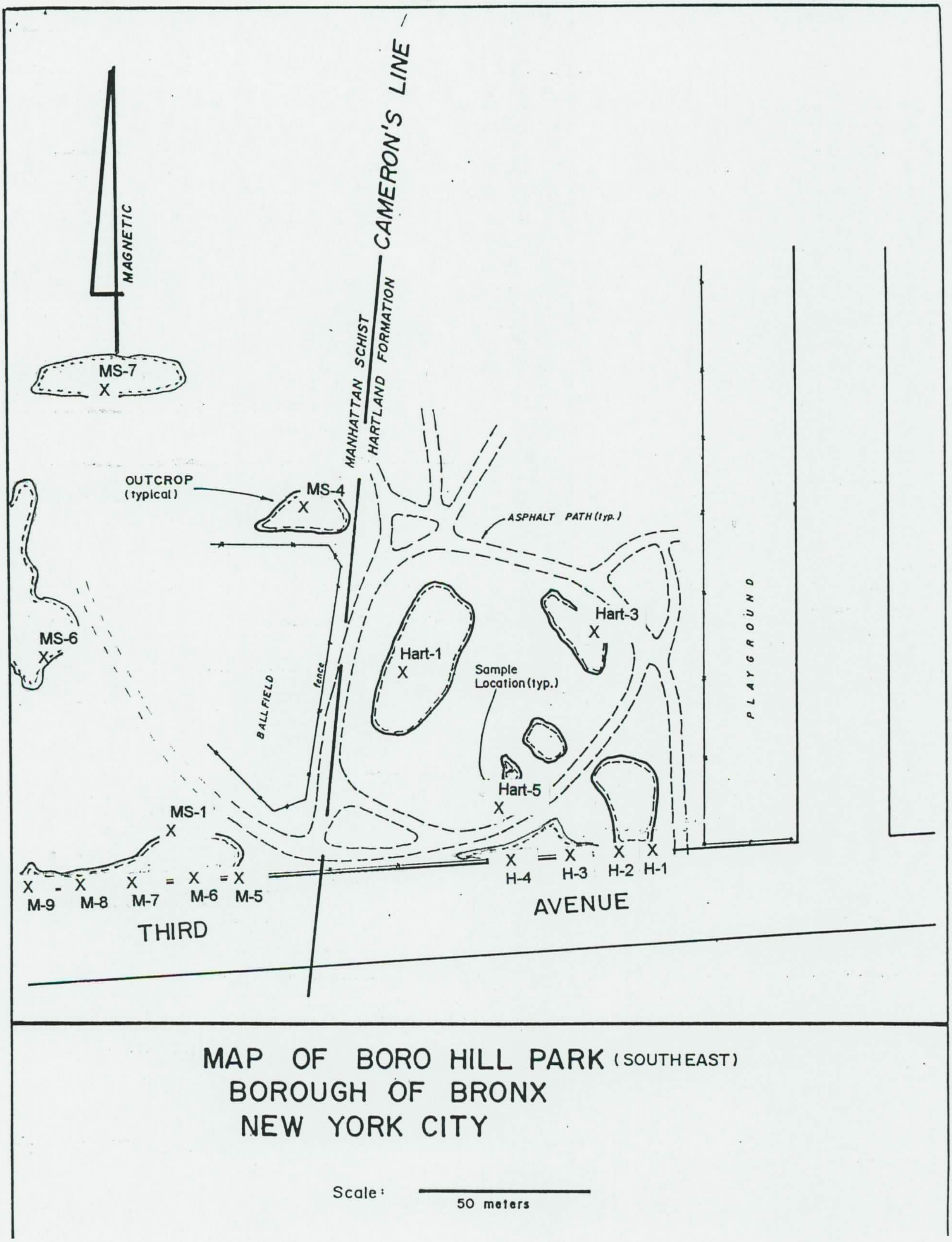

Figure 1. Map of rock outcroppings at Boro Hall Park, New York City with sample locations and the approximate position of Cameron's Line.

through the park, and are therefore Hartland Formation. The remaining ten samples collected west of the swail are Manhattan Schist member C. Thin sections were cut from these samples and were analyzed with petrographic microscopes; ground samples were chemically analyzed (Table 1) with a Rigaku 3030 wave-length dispersive x-ray fluorescence unit at Rutgers University in Newark New Jersey.

RESULTS

Petrographic observations of thin sections cut from samples of Hartland Formation and Manhattan Schist indicate considerable overlap in major mineral composition but consistent differences in some minor minerals. Although biotite, quartz, plagioclase, and garnet are the major minerals of both rocks; kyanite, sillimanite, and pyroxene was found only in samples of Hartland Formation. In addition, one to twelve percent K-spar was found in samples of Manhattan Schist but was absent or found in only trace amounts in samples of Hartland Formation. Concentrations of K-spar seem to increase as pegmatites are approached and may have been introduced into the schist during their emplacement. K-spar rich pegmatites seem to be more common in the Manhattan Schist than in the Hartland Formation.

The chemical composition of samples of Hartland Formation and Manhattan Schist samples from Boro Hall Park overlap with respect to most major elements but clearly contrast in some minor and trace element content (Table 1). The CaO (Fig. 2) and Sr contents, in particular, are much higher in the Manhattan Schist (averaging 4.84 percent and 432 PPM respectively) compared to the Hartland Formation (averaging 1.07 percent and 235 PPM). High concentrations of CaO and Sr correlate with relatively high concentrations of Ca bearing phases in the Manhattan Schist, particularly diopside.

The FeOt and TiO2 contents of the Manhattan Schist (averaging 6.64 and 0.84) percent) also contrast with those of the Hartland Formation (averaging 9.65 and 1.69 percent). High concentrations of FeOt and TiO2 also correlate with high concentrations of opaque iron-titanium oxide in the Hartland Formation.

DISCUSSION

Former attempts at finding a reliable geochemical criteria capable of distinguishing between Hartland and Manhattan schists (Puffer and others, 1994) have been disappointing, but may be due to uncertainties regarding the location of the contact between the two formations. Although Cameron's line crosses through Central Park on some maps it's position is not generally agreed upon. Chemical analyses of 39 biotite schist samples representing each portion of Central Park are not devisable into any discernible pattern and do not reveal any basis for distinguishing Hartland Formation from any Manhattan Schist that might be exposed in the park. It was, therefore, concluded (Puffer and others, 1994) that there is either no geochemical distinction between the two formation, or that Cameron's Line does not cross through Central Park.

Our new geochemical analyses of samples collected at Boro Hall Park, however, reveal a clear geochemical basis for distinguishing between Hartland and Manhattan schists and are consistent with

TABLE 1.

Hartland Formation, Boro Hall Park

	H-1	H-2	H-3	H-4	Hart-1	Hart-3	Hart-5
SiO2	51.45	62.51	40.32	62.06	54.61	58.75	58.95
TiO2	1.62	1.61	2.25	1.63	1.74	1.29	1.93
Al2O3	16.43	13.83	24.04	15.77	19.48	19.82	15.07
FeOt	9.92	8.48	13.4	9.13	10.04	8.67	8.67
MgO	5.52	4.03	5.74	3.65	2.38	2.1	3.07
MnO	0.1	0.14	0.15	0.17	0.16	0.13	0.14
CaO	2.5	1.42	0.75	1.04	0.82	0.79	0.36
Na2O	2.36	1.91	0.91	1.6	0.58	0.46	0.32
K2O	4.53	3.92	6.58	3.49	4.89	3.45	6.19
P2O5	0.31	0.12	0.32	0.25	0.19	0.2	0.22
LOI	5.02	2.64	5.31	2.11	4.52	4.22	4.75
Total	99.76	100.61	99.77	100.9	99.41	99.88	99.67
Ni	73	65	79	73	17	18	20
Rb	92	86	104	81	145	128	176
Sr	328	277	132	192	223	221	175
Zr	146	314	232	358	287	180	219

Manhattan Schist, Boro Hall Park

	MS-7	MS-6	MS-4	MS-1	MS-3	M-5	M-6	M-7	M-8	M-9
SiO2	48.34	61.72	53.86	67.31	61.24	53.05	57.25	60.16	58.84	58.32
TiO2	1.07	1.2	1.09	0.87	0.68	0.87	0.88	0.9	1.09	1.02
Al2O3	19.37	19.25	16.46	12.48	15.68	15.35	15.85	16.4	17.02	17.87
FeOt	7.3	6.26	7.03	5.32	7.01	6.45	6.4	6.25	7	7.02
MgO	3.79	1.72	2.62	1.81	1.73	6.12	4.53	3.72	4.34	4.02
MnO	0.08	0.06	0.07	0.05	0.08	0.15	0.11	0.1	0.04	0.06
CaO	5.14	0.85	5.92	3.02	5.13	9.49	6.45	4.16	3.9	3.95
Na2O	1.31	0.49	1	1.18	0.88	1.34	0.98	0.95	0.6	0.65
K2O	5.45	4.17	4.33	2.33	1.8	2.73	3.48	4.26	3.28	3.32
P2O5	0.21	0.23	0.21	0.2	0.19	0.34	0.25	0.22	0.22	0.23
LOI	5.83	4.85	4.92	5.21	5.11	4.21	3.54	3.42	4.01	4.32
Total	97.89	100.8	97.51	99.78	99.53	100.1	99.72	100.54	100.34	100.78
Ni	24	15	15	16	18	61	65	67	66	65
Rb	192	148	160	133	116	73	83	89	83	78
Sr	929	320	622	630	673	341	465	760	219	358
Zr	297	256	177	257	188	152	201	216	208	202

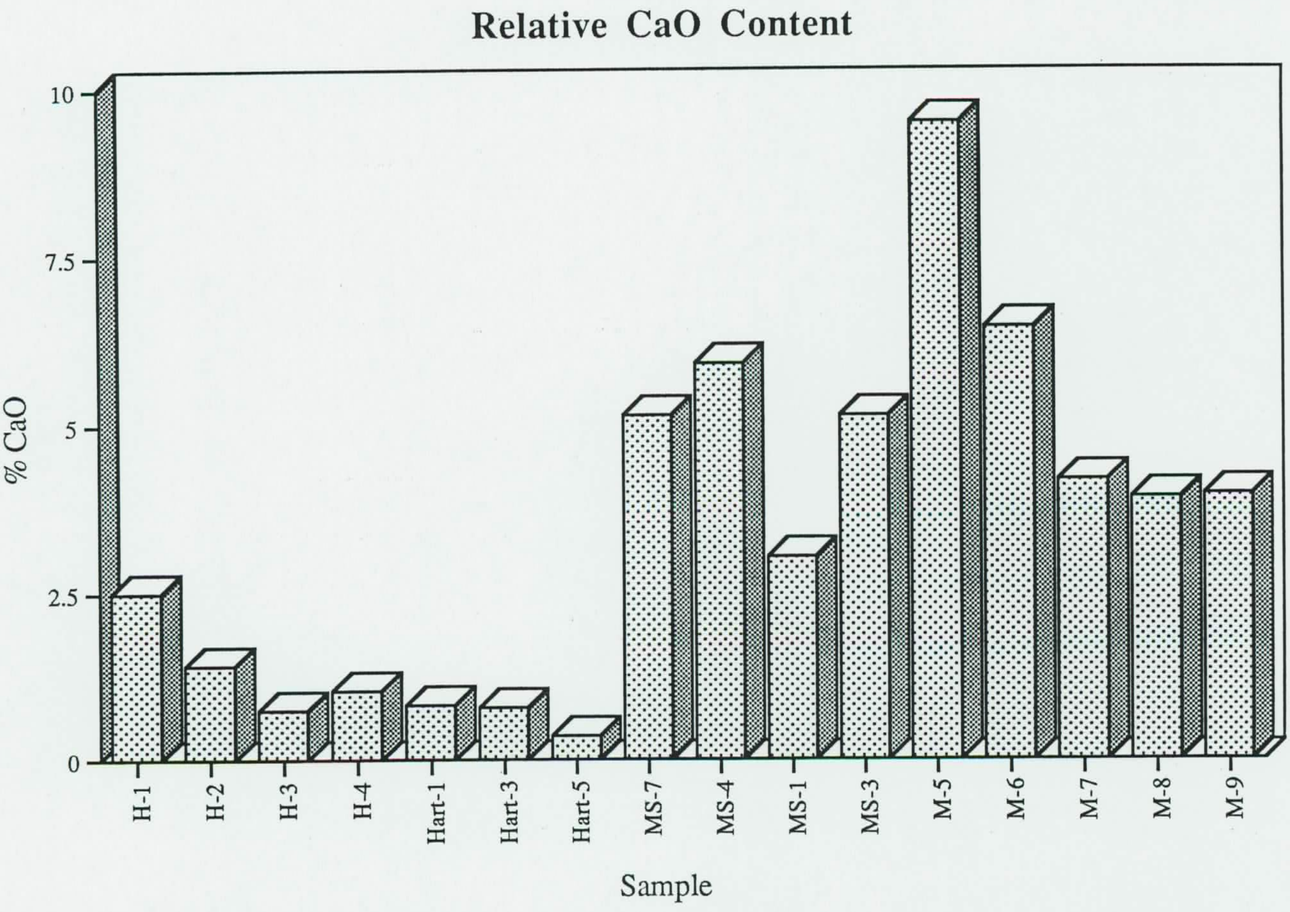

Figure 2. Chart illustrating the contrast in CaO content between samples of Hartland Formation and member C of the Manhattan Schist.

Baskervilles (1989) placement of Cameron's Line through the park. Preliminary results suggest that our data may also be consistent with contrasts in the provenance and depositional environment proposed for the two formations. High concentrations of CaO and Sr may be consistent with increased carbonate deposition in the miogeoclinal (continental shelf) setting proposed for member c of the Manhattan Schist whereas the eugeoclinal shales, graywackes, and volcanoclastics of the Hartland Formation would be expected to contain less carbonate. In addition, high concentrations of FeOt and TiO2 may be consistent with the eugeoclinal (deep marine) deposition proposed for the Hartland Formation (Baskerville, 1989). Further analysis of subtleties regarding chemical compositional controlling factors, however, are still in progress.

We, therefore, propose that contrasting CaO, Sr, TiO2 and FeOt concentrations provide a means for readily distinguishing between the Hartland Formation and member c of the Manhattan Schist at Boro Hall Park, and is useful together with minor and trace mineral content, particularly K-feldspar content, for mapping purposes. We can not extrapolate our conclusion beyond Boro Hall Park without further testing at several locations, but our conclusion is consistent with most of the few published analyses of Hartland Formation and member c of the Manhattan Schist. Although chemical values may locally overlap, abrupt changes in relative concentration should occur across other contacts between the two units as they do at Boro Hall Park.

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