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Petrology and Geochemistry of the Pompton Pink Granite, New Jersey Highlands

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ABSTRACT

The Pompton Pink Granite is a small (~1 km^2), post-orogenic granitoid body located in the New Jersey Highlands. It is a mildly peraluminous (ASI or aluminum saturation index, A/CNK = molar Al_2O_3 / ($CaO + Na_2O + K_2O$) > 1.0) pluton composed of microcline, microperthite, quartz, oligoclase, epidote, biotite, and magnetite and is classified as a granite based on its mineral and geochemical composition using standard IUGS classification schemes. The Pompton Pink Granite shows similar major-element geochemistry to other A-type granitoids found in the New Jersey Highlands, but its trace-element geochemistry distinguishes it from these other suites. The Pompton Pink Granite's high SiO_2 (72-74.5 wt%), total alkali ($K_2O + Na_2O$) > 9 wt% , K_2O/Na_2O ratio (2.0-3.1), Ba/Sr (3.3-7.3), FeO_t / ($FeO_t + MgO$) (0.78 to 0.91), low CaO (0.6-1.3 wt%) and low Cr, Ni (< 8 ppm) are consistent with an A-type granite affinity, however the depletion in high-field-strength elements (HFSE) (Y + Nb < 6 ppm), Ga (< 17 ppm), relatively low total abundance of rare-earth-elements (REE) (43 to 464 ppm), and strong positive europium anomalies (Eu/Eu* = 1.5 to 11.8; only one sample, PPG11, has Eu/Eu* = 0.8) are distinctly different from typical A-type granites. The smooth variation and negative correlation between total REE content and positive Eu/Eu* is interpreted to be the result of variable loss of melt from a granitic crystal-liquid mush after emplacement as small, lense-shaped pods by a filter pressing and/or compaction process. One sample (PPG11) is considered to be the closest representative to the parental magma for the rest of the Pompton Pink Granite based on its high total REE content and small negative Eu anomaly. This sample has the strongest A-type geochemical affinity, but still retains a HFSE depleted signature, and thus it can be theorized that rocks similar to the calc-

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alkaline Losee Metamorphic Suite may have partially melted to produce the Pompton

Pink Granite after the end of the main pulse of the Ottawan Orogeny.

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A THESIS

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INTRODUCTION

The Pompton Pink Granite (name first used by Lewis, 1909) represents a historically significant and unique granitoid body found in the New Jersey Highlands. Occupying approximately ~1 km^2, the granitoid can be found just north of the Interstate 287 and Route 23 junction in Riverdale, NJ. Based on its field relationship to the other Mesoproterozoic rocks in the area, it was emplaced after the end of the Ottawan Orogeny suggesting an age of approximately 1 Ga.

In comparison to the major bodies of granite in the NJ Highlands this granite has a distinctive pink color (Figure 1) and thus has been prized as a decorative building stone for over a century. Since the 1800's the granite has been mined from two quarries and has been incorporated in such esteemed buildings as St. Paul's Episcopal Church (Figure 2) in Paterson, NJ and the landing at the entrance of the Smithsonian National Museum (Figure 3) in Washington D.C. (Volkert, 2007). As of today, most of the granite has been mined leaving all but a few trace remains scattered in small bodies. However, there is enough granite still remaining to obtain a representative collection of samples that can be used to help understand its petrogenesis and significance for the geologic history of the New Jersey Highlands.

As compared to the major A-type granite bodies of the NJ Highlands (Byram Granite, Lake Hopatcong Granite, and Mount Eve Granite; Figure 4), little is known about the petrology of this post-orogenic intrusive body. While there has been various mention of the Pompton Pink Granite in several prominent studies on the New Jersey Highlands (e.g., Volkert, 2004; Volkert et al., 2005), to this date no detailed study of the granite's geochemistry has been conducted. Therefore, without detailed knowledge of its

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composition, only educated speculation, formed from the study of similar granite bodies in the Highlands, could be used to theorize its petrogenesis.

It is the goal of this study to present the newly collected geochemical data on the Pompton Pink Granite and use it to determine a granitoid classification. After the granite is classified, the data will then be used to interpret the petrogenesis of the granite body as well as compare it with the other major granite bodies of the New Jersey Highlands.

GEOLOGIC SETTING

The New Jersey Highlands, along with the adjoining Hudson Highlands in southern New York and the Reading Prong in eastern Pennsylvania, makes up one of the many Mesoproterozoic Appalachian orogenic belts' basement massifs found in the northeastern United States (Rankin, 1975) and is a part of the much larger Grenville Province that extends south from eastern Canada (Rankin et al., 1993; Volkert, 2005; Figure 5). Grenvillian in age (~1 to 1.3 Ga), the New Jersey Highlands and contiguous areas are comprised of various metamorphic and igneous rock suites that are interpreted to have been emplaced during the Grenville Orogenic Cycle (Drake, 1984). In New Jersey, the northeast-southwest trending Highlands are bordered to the southeast by the Ramapo fault and the Mesozoic Newark Basin, and to the northwest by the Paleozoic Valley and Ridge Province (Figure 4, inset map). Metamorphic rock assemblages of the area include orthogneiss, paragneiss, and marble of upper amphibolite to hornblende-granulite facies which have been intruded by various granitoids suites (Volkert and Drake, 1990).

The Losee Metamorphic Suite is inferred as the oldest rock unit exposed in the Highlands and possible source rock of granitoid melts (Drake, 1984; Volkert and Drake, 1999). These calc-alkaline metaplutonic and metavolcanic rocks are divisible into leucocratic and charnockitic rocks, with additional minor amphibolites. Based on mineralogical and geochemical similar rocks dated in the Adirondack Highlands, the Losee Suite is thought to be greater than 1.2 Ga (Volkert, 2004).

There are several examples of major granitoid suites found in the New Jersey Highlands. The Byram Intrusive Suite (Drake et al., 1991b) and the Lake Hopatcong Intrusive Suite (Drake and Volkert, 1991) make up the Vernon Supersuite (Volkert and Drake, 1998) and have been concluded to be of A-type origin. Both suites with medium- to coarse-grain rocks are distinguishable by mineralogical (Byram contains quartz, microperthite, oligoclase and varying mafics; Lake Hopatcong contains mesoperthite or microantiperthite, quartz, oligoclase, and clinopyroxene) and geochemical (discussed later) differences. Whole rock Rb-Sr isochron ages of the Byram granite date at 1116 ± 42 Ma and 1110 ± 25 Ma and the Lake Hopatcong granite at 1095 ± 9 and 1097 ± 18 Ma (Volkert et al., 2000). The Mount Eve Granite, 1020 ± 4 Ma, provides an example of localized magmatism in the area (Drake et al., 1991a). This medium- to coarse-grained granitoid consists of quartz, microperthite, and oligoclase with minor hornblende and biotite and chemical composition of A-type affinity granite (Gorring et al., 2004).

The geologic evolution of the New Jersey Highlands is summarized by Volkert (2004) and provides a model of the petrogenesis in the region. The calc-alkaline metaplutonic and metavolcanic rocks of the Losee Metamorphic Suite were formed in a continental-margin magmatic arc > 1200 Ma. Metamorphosed supracrustal rocks then

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formed (> 1176 Ma) in a marginal back-arc basin. After subduction and calc-alkaline magmatism ceased by 1176 Ma, the supracrustal rocks were intruded by thin sheets and dikes of meta-anorthosite and megacrystic amphibolites between 1160 and 1130 Ma. These rocks were then intruded by the Byram (1110 ± 25 Ma) and Lake Hopatcong (1095 ± 9 Ma) A-type intrusive suites. A period of upper amphibolite- to granulite-facies metamorphism then took place during the Ottawan Orogeny from 1090 to 1030 Ma. At the end of the event, the postorogenic Mount Eve Granite (1020 ± 4 Ma) and trondhjemite (1029 ± 1 Ma) was emplaced. Finally, undeformed discordant pegmatites and small granite bodies intruded the area between 1004 and 989 Ma.

METHODOLOGY

Samples of the Pompton Pink Granite were obtained from various road cuts and outcrops within the surface exposure just north of the Route 23 North and Interstate 287 West junction. Approximately five (5) kilograms of each sample was collected with the attempt to obtain a representative sample at each given location. At each site the strike and dip of the surrounding gneiss foliation, GPS coordinates, and elevation were obtained in addition to a general description of the exposure.

For petrographic analysis, thin sections were created from portions of four samples. Each sample was cut into a block approximately 5 cm x 9 cm x 1 cm in size using a water assisted diamond rock saw. Samples were then sent to Spectrum Petrographics, Inc. in Vancouver, WA where standard large format thin sections were created. The resulting thin sections were then analyzed for mineral content using a Zeiss petrographic microscope.

Powders were created from approximately 1-2 kg of each of the samples by first using a hardened steel jaw crusher, a Braun Chipmunk, at Rutgers University, Newark to crush the rock into pieces less than 0.5 cm in diameter. The resulting pieces were then mixed and 50 g of each sample was randomly selected. Using an Al_2O_3-lined shatter box, the samples were pulverized to obtain the powder used for major- and trace-element analysis. Major- and trace-element analysis was performed at the Department of Earth and Environmental Studies, Montclair State University, by inductively coupled plasma optical emission spectrometry (ICP-OES) on a JY Ultima C system. Full trace element analysis was performed by a Perkin Elmer inductively coupled plasma mass spectrometer at Brooklyn College. Samples for the ICP-OES analysis were prepared by the following method. Approximately 100 mg of sample and 400 mg of lithium metaborate flux were mixed and then fused in graphite crucibles at 1050 °C for 20 minutes. The molten samples were then dissolved in 50 ml of 7% HNO_3 (dilution factor of ~500x), and 6.5 ml of this solution was diluted with 50 ml of 2% HNO_3 (~4000x dilution factor). For ICP-MS analysis, 6.5 ml of the ~500x solution was diluted with 125 ml of 2% HNO_3 creating a ~10000x dilution factor. Typical USGS igneous rock standards (BCR-2, AGV-2, QLO-1, DNC-1, GSP-2, G-2, RGM-1 and BVHO-2) were used for instrument calibration. Analytical precision and accuracy for the ICP-OES is based on six complete dissolutions of USGS standard G-2 and was better than 0.7% (2 standard deviations) for all major elements except Mg (1.5%) and P (2.5%) (Gorring et al., 2004). Analytical precision and accuracy for the ICP-MS is based on three complete dissolutions of USGS standard G-2 and was better than 1% for all trace elements except Cr (2.6%), Zr (3.3%), Y (1.6%), Yb (1.9%), and Hf (2.7%).

POMPTON PINK GRANITE

Mineralogy

The areal extent of the Pompton Pink Granite is limited to approximately 1 km^2 area in Riverdale, NJ (Volkert, 2007). Figure 6 shows an excerpt from the Pompton Plains Quadrangle with the Pompton Pink Granite's location noted. It is characterized as a "coarse-grained, poorly foliated granite composed of microcline, microperthite, quartz, oligoclase, and minor amounts of epidote, biotite, and opaque oxides" (Volkert, 2010). The granite is imbedded in and cross-cuts a layer of gneiss, with large gneiss (country rock) xenoliths present in some lenses (Figure 7). Lenses of the granite are exposed as road-cuts and vary in size (see Appendix A), but most average 5 meters in height and 4 meters in width.

Hand samples (Figure 8) of the phaneritic rock are mostly felsic (> 95%) with minor mafics (< 5%). The three distinct felsic minerals include quartz, plagioclase, and K-feldspar. The quartz is identified by its translucent white color, vitreous luster, brittle concoidal fracture, and lack of cleavage. The plagioclase is pale white/green in color, has a milky dull luster, brittle with uneven fracture, and good cleavage. The K-feldspar is salmon pink with good cleavage, has a pearly luster and demonstrates uneven fracture. Two of the distinguishable mafics in the rock are a shiny dark green mineral with good cleavage, and a metallic black mineral with uneven fracture and ferromagnetism. The strong magnetic properties suggest the latter is magnetite.

Four samples of the granite (PPG01, PPG02, PPG05, and PPG07) were selected and large format (75 mm x 50 mm) thin sections were created for petrographic analysis. Mineral assemblages for these four samples are presented in Appendix A and the

petrographic descriptions are summarized as follows. The first major mineral is the feldspar microcline (Figure 9). It is identified by being white, nonopaque, not pleochroic, with good cleavage and low relief in plain polarized light (PP), and first order grey/white, microcline twinning, and biaxial (-) in crossed polarized light (XP). Additionally, veins and patches of plagioclase intergrowth within the microcline suggest an abundance of microperthite. The next most abundant mineral is quartz (Figure 9). It is nonopaque, white, not pleochroic, has low relief and is round with no cleavage in PP. In XP it has low birefringence with first order white to grey, undulatory extinction, anisotropic, and uniaxial (+). The third felsic mineral is oligoclase (Figure 10B). It is nonopaque, pale green, not pleochroic, and has low relief in PP. In XP the mineral has first order birefringence extending into white and pale yellow, polysynthetic and occasional albite twinning, and anisotropic biaxial (+). Oligoclase also shows signs of alteration within the rock causing the breakdown of the mineral (most likely to sericite and/or other clay minerals).

The main mafic mineral, epidote (Figure 9 and 10B), in PP is nonopaque green to white, not elongated, pleochroic red and yellow, has high relief and demonstrates one good cleavage. In XP it is mostly second order birefringence with blue-yellow-purple-orange-green (some examples of 3rd order blue pastel birefringence in what appears to be twins), and has parallel extinction. A minor mafic is biotite (Figure 10A). It is brown with moderate relief, pleochroic and one good cleavage in PP, and second order interference colors and parallel extinction in XP. There is also an abundant opaque, black metallic mineral which is magnetite (Figure 10B).

Granitoid Classification

The Pompton Pink Granite has many characteristics that would suggest the granitoid rock is granite. Physical observations of the rock body depict a mass of rock with approximately equal concentrations of quartz, plagioclase, and K-feldspar with minor mafic accessories. Using normalized mineral grain counts from PPG01-05 and a QAP diagram modified from Streckeisen (1976), the samples plot mostly in the monzogranite region (Figure 11; red circles). However, due to the abundance of microperthite in the rock a misrepresentation of actual mineral content may result from this method and this method does not give a full range from all the samples. Therefore chemical analysis from each individual sample was used to obtain a CIPW normative mineral composition in the samples and is charted on the QAP diagram (Figure 11; blue circles). This shows that the majority of samples chemically are a monzogranite. PPG07 is the only exception as its low plagioclase content results in a syenogranite classification. PPG11 is also of note as it strays away from the majority of the samples, nearing granodiorite composition. Based on normative feldspar content using the chemical data, all samples plot within the granite region on an An-Ab-Or diagram (Figure 12). Once again PPG11 (red circle) distinguishes itself from the rest of the samples due to its much larger albite content.

Whole-Rock Geochemistry

Geochemical data was obtained from eleven (11) samples of the Pompton Pink Granite found within the lenses of various road-cuts and exposures just north of the

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Interstate 287 and Route 23 junction in Riverdale, NJ. Specific sample locations shown in Figure 13 are described in Appendix A and are designated PPG01 through PPG11.

Whole-rock major element analyses for the samples are reported in Table 1 and are summarized as follows. The samples contained relatively high SiO_2 and Al_2O_3 ranging from 72 to 74.5 in weight percentage (wt%) and 13.6 to 14.8 wt%, respectively. Most samples contained high K_2O (6.2-7.7 wt%), low Na_2O (2.6-3.1 wt%), and a high K_2O / Na_2O ratio (2.0-3.1). Each sample has low CaO (0.6-1.3 wt%), low Fe_2O_3 (0.8-2.2 wt%), and low MgO (<0.35 wt%). The Pompton Pink Granite samples are mildly peraluminous with the aluminum saturation index at, or slightly greater than 1 (A/CNK = molar Al_2O_3 / (CaO + Na_2O + K_2O) > 1.0; Fig. 14). The samples have high total alkali content (K_2O + Na_2O) > 9 wt%, molar FeO_t / (FeO_t + MgO) is high (0.78-0.91), and Fe/Mg (as Fe_2O_3 / MgO in wt%) is high (3.9-10.9). PPG11 demonstrates a slight variation from the remainder of the samples with a K_2O/ Na_2O ratio of 0.99 (4.61 wt% K_2O / 4.65 wt% Na_2O) and an Al_2O_3 wt% that is 0.5 percent greater than any other sample.

The whole-rock trace element analyses for the Pompton Pink Granite are reported in Table 1. Most samples contain high Ba (1495-2210 ppm) and modest Sr (275-328 ppm) and Ga (13-16 ppm). PPG11 is the exception with Ba at 980ppm. Cr, Ni, and Y are low with less than 8 ppm in each sample. Cerium shows variable concentration with ranges from 16 to 222 ppm. High-field-strength elements (HFSE) are typically low (e.g. Nb < 2 ppm). Large-ion-lithophile elements (LILE) are elevated with the exception of Cs. Rare-earth-element (REE) patterns (Figure 15) indicate a light REE (LREE) enrichment and mostly positive (i.e., >1) Eu anomalies (Eu/Eu* = 0.8-11.8; where Eu/Eu* is the

chondrite-normalized ratio of measured Eu divided by the hypothetical Eu concentration required to produce REE pattern with no Eu anomaly) between samples, and a depletion in heavy REE (HREE).

The REE data presented in Table 1 and Figure 15 demonstrates characteristics that are of special note when considering samples individually. Overall, while each sample has the same basic granite signature there is an identifiable cascading effect in the data. The plot shows a relationship between REE depletion and the size of the positive Eu anomaly. This is interpreted as the greater the depletion in REE, the larger the positive Eu anomaly is going to be.

PPG11 is significant as it contains higher REE concentrations than any of the other samples, while possessing a small negative Eu anomaly (Eu/Eu* = 0.8). In comparison, PPG02 and PPG09 are the most depleted in REE while possessing very strong positive anomalies (Eu/Eu* = 11.8 and 8.6, respectively). The remaining samples possess a smooth progression between the extremes of PPG11 and PPG02 (or PPG09). Interestingly, each sample contains approximately the sample amount of Eu (12-14 ppm). As Eu^{2+} substitutes for Ca^{2+} in plagioclase feldspars with increased crystal fractionation, the Eu anomalies suggest a definable trend in fractionation patterns from the progression of samples. Additionally, PPG11 displays LREE enrichment and has concentrations of La (374 ppm), Ce (227 ppm), Pr (144 ppm), and Nd (87 ppm) that are more than double than found in the other samples.

Regional Comparisons

Throughout the New Jersey Highlands there are several intrusive suites that can be compared geochemically with the Pompton Pink Granite. The Lake Hopatcong Intrusive Suite (Drake and Volkert, 1991), the Byram Intrusive Suite (Drake et al., 1991b), and the Mount Eve Granite (Drake et al., 1991a; Gorring et al., 2004) each of which have similarities and differences in chemical characteristics that help to determine the magmatic history of the Highlands (Volkert, 1995; 2004; Gorring et al., 2004).

Major and trace element abundance trends in the Bryam Intrusive Suite (BIS) and Lake Hopatcong Intrusive Suite (LHIS) from Volkert (1995), and the Mount Eve Granite (MEG) from Gorring et al. (2004) are compared with the Pompton Pink Granite in Harker diagrams (Figure 16 through Figure 21). Overall SiO_2 content of the PPG lies in the upper margin of the Supersuite and suggests that PPG's remaining oxides by comparison will have lower abundances than the average composition of the BIS and LHIS. This holds true in all the oxides except K_2O which comprises on average a greater proportion than either suite. This can be explained by the large percentage of K-feldspar in the PPG. MEG contains notably less SiO_2 content, as all samples of PPG have higher SiO_2 percentages and average concentration of SiO_2 in PPG is around 5% greater. K_2O in MEG is also elevated, as it is slightly greater in content than BIS and LHIS, but on average PPG contains a higher abundance than all three suites. Al_2O_3 in PPG is similar to BIS and MEG, and contains slightly higher percentages than LHIS. FeO_T and CaO percentages are comparable to those in BIS and LHIS, as PPG averages about the same content at similar SiO_2 percentages. FeO_T in MEG is nearly double the content found in PPG. CaO percentage composition in MEG is similar overall, but shows more variability

at high SiO_2. Na_2O is consistently lower in the PPG than in the other three suites, but it is closer in average percentage composition to MEG. MgO is also lower in PPG than in the other suites, but resembles the lower abundances in LHIS. MgO in MEG is almost double the percentage of PPG. The majority of the Lake Hopatcong and Byram Intrusive suites, and the Mount Eve Granite are metaluminous with an aluminum saturation index <1, while the PPG is mildly peraluminous with an index slightly >1.

Trace element data from the Pompton Pink Granite, Byram, Mount Eve, and Lake Hopatcong granites differ, suggesting different petrogenic processes and/or source characteristics. Enriched Ba (1500-1950 ppm) and low Sr (275-330 ppm) in the PPG are not as abundant in the Supersuite (BIS 360-1400 ppm Ba and 70-170 ppm Sr; LHIS 380-1400 ppm Ba and 20-350 ppm Sr). However, Mount Eve Granite shows similar Ba (450-2400 ppm) enrichment and low Sr (175-680 ppm) as the Pompton Pink Granite. All four granites possess a gently sloping MREE to HREE pattern, in general decreasing in concentration with increasing atomic weight, which is characteristic of granites. However, the Pompton Pink Granite is slightly LREE depleted and strongly HREE depleted in comparison to LHIS, BIS, and MEG (Fig. 7). Eu anomalies in the REE patterns of the BIS, LHIS and MEG are all slight to moderately negative. The PPG Eu anomalies are all positive, except for PPG11.

Geochemical Affinity

Figure 22 shows a modest linear trend of increasing Aluminum Saturation Index (ASI) with the increase in SiO_2 composition. The majority of samples are all mildly peraluminous with the ASI ranging from 1.005 to 1.050. While only one sample is

technically considered metaluminous (PPG10), it is almost in balance between metaluminous and peraluminous at ASI = 0.995. Figure 23 depicts the PPG's $FeO_t /$ $(FeO_t + MgO)$ vs. SiO_2 with a relatively even distribution of samples between tholeiitic and calc-alkaline affinity. There is no definitive trend in the granite, but the data shows that the samples with less than 73% SiO_2 are all tholeiitic. Representative fields for the Vernon Supersuite and Mount Eve Granite are shown for comparison.

In comparison to the A-type standards set forth by Whalen et al. (1987) and Eby (1990), Pompton Pink Granite shares many characteristics of A-type granites, but differs in several key characterizations. The relatively high SiO_2 ($SiO_2 > 72$ wt%), alkali (Na_2O + $K_2O > 9$ wt%), K_2O / Na_2O (2.0-3.1), Ba/Sr (3.26-7.28) and $FeO_t / (FeO_t + MgO)$ (0.78-0.91); and low CaO (CaO < 1.35 wt%) and Cr, Ni (< 8 ppm) are characteristic of A-types granites. However, the positive Eu anomalies (Eu/Eu* = 0.8-11.8), and low concentrations of (Nb, Zr, Hf, and Y) differ from classic models. On a diagram of FeO_t/MgO vs. Zr + Nb + Ce + Y (Figure 24), all samples of PPG with the exception of PPG11 plot in the fractionated granite field. The Vernon Supersuite and Mount Eve Granite fields are shown for comparison.

A Rb vs. Y + Nb tectonic discrimination diagram (Fig. 25) as modeled after Pearce et al. (1984) also shows uncharacteristic traits of A-type in the PPG as no sample is considered a "Within Plate Granite" (WPG). The low concentrations of Y and Nb in PPG rocks cause them to plot well into syn-collisional granite (Syn-COLG) and/or near the volcanic arc granite (VAG) field. On a diagram of Y/Nb vs. SiO_2 the Pompton Pink Granite falls into the VAG and Syn-COLG fields (note that Y/Nb vs. SiO_2 is not plotted here). The $10000*Ga/Al \approx 1$ ratio of the samples suggest a relationship to I- and S-type

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granites even when Zr is not used for comparison (Whalen et al., 1987). With the exception of PPG11 (discussed later), the PPG rocks are not geochemically like A-type granites based on classification schemes of Pearce et al. (1984).

The PPG shows geochemical characteristics that overlay I- and S- type granites, but do not classify the granite as being of either affinity. LILE ratios in the PPG are similar to that of I-type granite, but are contradicted by the high SiO_2 and alkali contents. High alkali and LILE, and low Ca and Sr resemble S-type granites, but the high silica and the relatively low Ni, Cr, and Th are not similar.

The mixed geochemical composition of the Pompton Pink Granite may indicate that other processes were involved to create their diverse geochemistry. The compilation of chemical data suggests that the Pompton Pink Granite was not produced directly by a true melt or actual magmatic source. While the suite displays mineralogical characteristics that classify the rock as granite, the diverse geochemical analysis indicate that the Pompton Pink Granite does not fit within the chemical characteristics of a specific affinity of granite. The large positive Eu anomaly supports this conclusion as most granites regardless of affinity have a negative Eu anomaly. There are exceptions in various localities as petrogenetic process, source rock, fractionation, and assimilation may vary and alter the chemical signature. However, most of these bodies can be traced to original magmatic sources and are the result of a separation from the original melt. PPG most likely represents a combination of these and other petrogenetic processes.

PETROGENESIS

The distribution of PPG within the entire locality is best described as a series of lenses of highly crystallized granite that intrude mostly vertically layered gneiss. Assimilation of the gneiss results in a migmatitic appearance in between large volumes of PPG at various locations. Xenoliths of the gneiss found within larger lenses of PPG (Fig. 7) indicate the relative strength within particular areas of the gneiss, as well as the ability of the melt to infiltrate weak points in the gneiss during emplacement. Several lenses exhibit distinct pinch outs indicating the concentration and swelling of the PPG during emplacement. All of the Pompton Pink Granite lenses exhibit a lack of metamorphic foliation. The lack of stress indicators on PPG and its cross-cutting relationship to the gneiss establishes the timing for emplacement of the granite to late- to post-Ottawan after the thermal peak of the metamorphic event. The resulting transition to regional extension after the metamorphism at the end of the Ottawan orogeny resulted in lingering thermal activity and the introduction of volatile compounds (mostly H_2O; Volkert et al., 2005) which caused the minor crustal melting to produce the PPG.

The petrogenesis of the Pompton Pink Granite (Figure 26) can be attributed to a complex, multi-stage process and was not simply fractionated from a parental magma as many large-volume granites are. Given its major element chemical similarities to the A-type granites of the region, it may have had a similar source rock that partially melted to form a parental PPG magma that was similar to those of other New Jersey Highlands granitoids. Prior to and/or during the emplacement, a parental PPG magma may have undergone a fractional crystallization process in which the parental magma evolved into a granitic crystal-liquid mush, consisting of melt + feldspars and quartz crystals. As

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suggested by Volkert et al. (2005), the parental form of the Pompton Pink Granite shares characteristics with rare earth pegmatites theorized by Černý (1992), which includes LREE enrichment, Th (40 ppm in PPG11), and post-tectonic emplacement. However, the depletion of REE and HFSE, and the enrichment of LILE within the majority of the PPG bodies imply that another process then altered the chemistry of the rock. This can best be theorized by the loss of the remaining evolved liquid (melt), most likely through a filter pressing and/or compaction process. Solar and Brown (2001) explained the petrogenesis of migmatitic leucogranites and smaller granite bodies of the Phillips pluton, Maine by a similar process. Partial melting through muscovite dehydration reactions formed small, peraluminous granite bodies that reflected the cumulate product of fractional crystallization and the variable loss of evolved fractionated liquid.

The REE patterns of PPG (Fig. 15) show a distinct trend. The proportionate progression in depletion of REE that is correlated with the magnitude of the positive Eu anomaly suggests variable loss of melt from the different lenses of Pompton Pink Granite. In terms of melt loss, the samples with the largest positive Eu anomalies and the largest depletion in REE and HFSE represent the most melt loss from the original crystal-liquid mush. The varying REE depletion in the PPG samples can be theorized to represent variable amounts of filter pressing or compaction within the general area during formation and emplacement.

PPG11 is interpreted to represent the most likely candidate for a parental magma for the Pompon Pink Granite. Its slight negative Eu anomaly, lower Ba, roughly equal K_2O and Na_2O, and higher REE levels suggest closer relation to a true parental magma than the remainder of the rocks sampled. Using Feo_t / MgO vs. $Zr + Nb + Ce + Y$ (Fig.

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16) and Ce vs. Zr comparisons modeled after Whalen (1987), PPG11 is the only sample that can be characterized by A-type affinity as displayed in the other granites of the Highlands. However, the HFSE concentrations (Y, Nb, etc) do not allow for "Within Plate Granite" classification suggesting the PPG is not a true A-type granite. In the field, the geometry of PPG11 closely resembles that of a dike and marks the eastern termination of the Pompton Pink Granite. Several one-meter wide by ten-meter high dike-like bodies of PPG have intruded the vertically foliated gneiss in this area. This particular formation of dike-like granite by PPG11 is the only location that the Pompton Pink Granite has this geometry and it physical distance from the other samples of PPG can be seen in Figure 13. The remainder of the granite is found as larger lenses that are emplaced parallel to foliation in the surrounding gneiss. If PPG11 in fact represents parental magma derived from the original source, there are at least two possible theories to explain the unique field relations of this sample.

1) PPG11 dikes may represent the inflow source from a deeper crustal magma chamber and represent feeder dikes for the other bodies of PPG.

2) The dikes represent a branch of the original feeder dikes that strayed away from the main PPG intrusion. Upon initial emplacement, this intruded its way through a weak point in the gneiss, but before large enough quantities could transgress to form a large cavity it became cut off from the main bodies.

Regardless of how these dike-like granite bodies were emplaced (as represented by PPG11), the preservation of the original chemistry in this location as compared to the remainder of the suite was most likely due to the relatively narrow volume of PPG that froze soon after emplacement and thus had minimal fractional crystallization ± melt loss.

Possible crustal source rocks that partially melted to form the Pompton Pink Granite could include previously melted leucocratic arc rocks found in the New Jersey Highlands, such as the Losee Metamorphic Suite. Evidence from laboratory experiments of Litvinovsky et al. (2000) showed the ability of these rock compositions to produce A-type granite. The source for the Byram, Lake Hopatcong, and Mount Eve granites of the NJ Highlands is interpreted to be an Fe-rich upper mantle or juvenile lower crustal mafic or intermediate parent (Drake, 1984; Volkert et al., 2000; Gorring et al., 2004), the Pompton Pink Granite's geochemical similarity to these suites suggests that they most likely share a similar "arc-like" crustal source. However, the combination of A-type affinity and HFSE depletion, along with total REE depletion and large positive Eu anomalies distinguishes PPG from these other granitoids. This implies that the previously mentioned accumulation of feldspar crystal-liquid mush and the variable loss of liquid by filter pressing/compaction during the emplacement were additional petrogenetic processes that affected the Pompton Pink Granite.

CONCLUSION

The Pompton Pink Granite represents a small post-orogenic granitoid body that intruded into gneisses in the New Jersey Highlands after the thermal peak of the Ottawan Orogeny. The mildly peraluminous lenses of PPG are composed of microcline,

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microperthite, quartz, oligoclase, epidote, biotite, and magnetite, and its mineral and chemical composition falls within a classification as granite. While the Pompton Pink Granite shows similar major-element geochemistry as the A-type granites found in the New Jersey Highlands, its trace-element geochemistry distinguishes it from these other suites. The Pompton Pink Granite's high SiO_2, total alkali, K_2O/Na_2O, Ba/Sr, $FeO_t/(FeO_t + MgO)$, low CaO and low Cr, Ni suggest an A-type granite affinity, but its depletion in HFSE (eg., Nb, Y, Hf), relatively low abundance of REE, and positive Eu anomalies are different. The Pompton Pink Granite is interpreted as having formed from a feldspar and quartz crystal-liquid mush that variably lost its liquid component after emplacement due to filter pressing and/or compaction. Based on the relatively distinct progression of REE enrichment in most samples and the distinction of PPG11 among the other samples, PPG11 is considered to be the closest representative to the original source, and is interpreted to have formed from partial melting of a calc-alkaline arc-like source compositionally similar to the Losee Metamorphic Suite.

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APPENDIX A: SAMPLE DESCRIPTIONS AND LOCALITIES

All Pompton Pink Granite (PPG) samples were collected from various road-cuts/exposures just north of the Interstate 287 and Route 23 junction in Riverdale.

PPG01-   Very coarse grained, 2-3 m thick by 3-4 m tall lens parallel to vertically foliated gneiss with minor contact assimilation and mini-faults. Felsic domination (97%). N31-43E 65-72SE. Thin section- microcline, microperthite-microcline, quartz, oligoclase, epidote, and magnetite. N40°59.595' W74°18.775' elevation 106 m. Large outcrop next to Sport's Authority/Wal-Mart complex. 5 S of electric generators, half way between 2nd and 3rd light pole from N entrance gate. Collected from various spots within the lens.

PPG02-   Very coarse grained, 5 m thick by 4 m tall lens emplaced between mostly vertical gneiss and weathered gneiss. Slightly more mafic and assimilation near top. N33-35E 62-68SSE. Thin section- microcline, microperthite-microcline, quartz, oligoclase, epidote, biotite and magnetite. N40°59.583' W74°18.791' elevation 110 m. Large outcrop next to Sport's Authority/Wal-Mart complex. After 3rd light pole from N gate, corner of Sport's Authority. Collected at center of lens.

PPG03-   Very coarse grained, 5x5 m lens emplaced between weathered (rusty) folded gneiss. N28-31E 54-59S-SSE. N40°59.580' W74°18.810' elevation 114 m. Large outcrop next to Sport's Authority/Wal-Mart complex. S end of outcrop, N viewing wall past the end of Sport's authority. Collected at various edges of lens.

PPG04-   Coarse grained middle of PPG03. Smaller crystal growth encased in the larger crystals near the edge of the lens. N40°59.580' W74°18.810' elevation 114 m. Large outcrop next to Sport's Authority/Wal-Mart complex. S end of outcrop, N viewing wall past the end of Sport's authority. Located mid-height at center of wall.

PPG05-   Series of 1x1 m and smaller coarse grain lenses surrounded by rich mafics. Almost a sense of lineation nearing top of outcrop. Multiple fractures and mini-faults. Migmatitic resemblance with minor folding of thinner emplacements surrounded by assimilation. N35-41E 45-61SSE. Thin section- microcline, microperthite, quartz, oligoclase, epidote, and magnetite. N40°59.570' W74°18.830' elevation 124 m. Large outcrop next to Sport's Authority/Wal-Mart complex. Extreme S termination of outcrop. Collected at top of outcrop within a meter of gneiss.

PPG06-   20 m long by 12 m tall very coarse lens with pinch out nearing both ends. Distinct contact zone with no lower assimilation of horizontally oriented gneiss but assimilation nearing top. Large gneiss, well preserved xenolith (1 x 3 m) in center of mass. N35E 37SE. N40°59.446' W74°18.662' elevation 103 m. Rte 23 N onramp to I-287 S. Collected 1 m above contact zone, below center of a large gneiss xenolith.

PPG07-   3 x 4 m slightly weather coarse lens with minor assimilation. N22-28E 49-51SE. Thin section- microcline, microperthite, quartz, oligoclase, epidote, biotite and magnetite. N40°59.607' W74°18.750' elevation 121 m. Large outcrop next to Sport's Authority/Wal-Mart complex. N end of outcrop, slightly north of 1st light pole near power generators. Collected from various spots within the lens.

PPG08-   6 x 4 m exposure representing a 1-2 m thick lens with notably more very coarse k-feldspar concentration. Minor assimilation with vertical gneiss. N28-32E 64-67SE. N40°59.455' W74°18.696' elevation 108 m. I-287 S onramp to Rte 23 S, approximately 25 m from underpass. Collected from various spots within lens.

PPG09-   2 x 4 m exposure representing a 2-3 m thick lens with notably more very coarse k-feldspar concentration, not appearing to be connect to PPG09. Minor assimilation of vertically foliated gneiss. N24-30E 63SE. N40°59.451' W74°18.708' elevation 102 m. I-287 S onramp to Rte 23 S, approximately 15 m from underpass. Collected from various spots within lens.

PPG10-   20 m long by 12 m tall very coarse lens with pinch out nearing both ends. Distinct contact zone with no lower assimilation of horizontally oriented gneiss but assimilation nearing top. Large gneiss, well preserved xenolith (1 x 3 m) in center of mass. N35E 37SE. N40°59.441' W74°18.662' elevation 103 m. Rte 23 N onramp to I-287 S. Same lens as PPG06. Collected at pinch-out just above contact.

PPG11-   Several dike like 1 meter wide very course grained lenses, 4 m in height passing through 8 m of the rock wall. Blood red feldspar appearance within. N31-32E 67-69SSE. N40°59.521' W74°18.607' elevation 98 m. I-287 S off ramp just before 23 fork. Collected from three small (approx. meter size) lens.

APPENDIX B: TABLES AND FIGURES

Table 1. Whole-rock compositions of the Pompton Pink Granite

Sample	PPG01	PPG02	PPG03	PPG04	PPG05	PPG06	PPG07	PPG08	PPG09	PPG10	PPG11
Major elements											
SiO_2	72.54	73.06	72.58	74.04	73.68	74.45	73.78	74.09	73.62	72.01	73.47
TiO_2	0.15	0.05	0.07	0.12	0.09	0.07	0.07	0.05	0.04	0.08	0.04
Al_2O_3	13.94	14.34	13.63	13.67	13.83	14.33	13.89	14.32	14.32	14.26	14.82
$Fe_2O_3^{\dagger}$	2.22	1.33	1.91	1.69	1.48	1.43	1.79	0.80	1.18	1.62	1.25
MnO	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01
MgO	0.32	0.19	0.20	0.32	0.32	0.22	0.20	0.21	0.15	0.15	0.31
CaO	1.18	1.09	0.84	0.80	1.31	1.14	0.64	0.61	0.91	0.87	1.15
Na_2O	2.87	3.14	2.80	2.63	2.59	3.10	2.47	2.94	2.78	2.75	4.65
K_2O	6.18	6.30	6.59	6.68	6.55	6.17	7.71	7.54	7.05	7.57	4.61
P_2O_5	0.04	0.02	0.04	0.04	0.03	0.05	0.05	0.03	0.01	0.05	0.03
Total	99.46	99.52	98.66	100.00	99.88	100.97	100.60	100.60	100.08	99.38	100.35
Mineral (CIPW norm %)											
Quartz	28.8	27.6	28.8	30.5	29.8	29.3	27.4	25.9	27.7	24.5	25.3
Albite	24.8	26.9	24.3	22.5	22.1	26.2	20.9	24.8	23.6	23.5	39.5
Anorthite	5.4	5.0	3.8	3.6	6.0	5.1	2.7	2.6	4.2	3.9	5.3
Orthoclase	38.1	38.6	40.8	40.9	40.0	37.3	46.7	45.4	42.8	46.3	28.1
Mineral (point count %)											
Quartz	30.8	31.7	33.3	31.6	25.8	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Alkali Feldspar	33.3	46.3	33.3	36.8	41.9	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Plagioclase	35.9	22.0	33.3	31.6	32.3	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Trace elements											
V	24.1	16.4	21.8	22.0	20.1	19.5	17.3	13.7	19.8	21.1	13.8
Cr	5.0	3.7	3.9	2.9	5.0	5.5	3.8	2.8	3.9	4.4	4.8
Co	3.2	1.9	2.2	3.0	2.9	2.7	2.4	1.8	2.0	2.4	2.4
Ni	6.1	5.1	3.9	4.2	8.5	7.6	5.5	7.5	5.7	7.9	5.2
Ga	16	15	15	14	15	15	14	13	14	14	15
Rb	167	174	184	181	176	174	204	205	203	201	133
Sr	302	308	287	276	329	297	301	309	309	297	301
Y	4.6	1.7	3.1	2.0	3.5	3.7	3.6	2.4	2.8	3.1	5.0
Zr	108	46	59	43	92	93	107	75	99	93	345
Nb	1.4	0.9	1.1	1.6	1.8	1.2	1.0	0.9	0.7	0.8	1.1
Cs	0.26	0.29	0.28	0.39	0.28	0.36	0.26	0.26	0.25	0.25	0.23
Ba	1679	1804	1842	1959	1642	1495	2210	1885	1680	1799	982
La	59.0	14.7	22.7	24.4	52.2	16.9	39.5	23.4	12.5	17.4	141
Ce	97.0	19.0	34.6	36.9	83.9	25.3	60.1	31.7	16.1	25.5	222
Pr	9.3	1.7	3.3	3.5	8.0	2.5	5.8	3.1	1.6	2.5	21.6
Nd	27.4	3.8	9.4	9.4	23.8	7.4	17.0	8.3	3.9	7.3	62.6
Sm	2.64	0.17	0.84	0.70	2.27	0.80	1.55	0.61	0.23	0.70	5.54
Eu	1.17	1.10	1.19	1.21	1.20	1.05	1.28	1.12	1.06	1.09	1.17
Gd	1.72	0.52	0.87	0.80	1.49	0.99	1.23	0.75	0.64	0.86	2.89
Tb	0.16	0.04	0.08	0.06	0.13	0.11	0.11	0.06	0.06	0.09	0.23
Gd	1.53	0.37	0.74	0.67	1.31	0.87	1.08	0.61	0.52	0.76	2.59
Dy	1.00	0.49	0.68	0.58	0.82	0.83	0.83	0.62	0.61	0.75	1.13
Ho	0.17	0.08	0.11	0.08	0.13	0.14	0.14	0.10	0.10	0.12	0.18
Er	0.42	0.17	0.26	0.17	0.29	0.34	0.33	0.22	0.24	0.28	0.40
Tm	0.07	0.03	0.04	0.03	0.05	0.05	0.05	0.04	0.04	0.05	0.06
Yb	0.44	0.18	0.25	0.16	0.29	0.30	0.32	0.21	0.25	0.27	0.44
Lu	0.07	0.03	0.04	0.02	0.05	0.05	0.05	0.03	0.04	0.04	0.08
Hf	2.83	1.12	1.54	1.04	2.51	2.35	2.62	1.83	2.49	2.30	9.28
Pb	5.32	2.64	3.70	3.32	10.96	2.68	6.73	4.63	2.54	3.83	4.77
Th	9.12	0.74	2.48	2.37	13.78	0.59	6.01	3.74	1.20	0.68	40.64
U	0.47	0.22	0.24	0.13	0.50	0.16	0.30	0.18	0.22	0.14	0.69
$ASI^{\dagger\dagger}$	1.03	1.03	1.03	1.05	1.01	1.03	1.02	1.02	1.03	1.00	1.01
Eu/Eu*###	1.59	11.82	4.45	5.15	1.95	3.80	2.83	5.32	8.60	4.43	0.82
K_2O/Na_2O	2.15	2.01	2.35	2.54	2.53	1.99	3.12	2.56	2.54	2.75	0.99
$FeO_t / (FeO_t + MgO)^{\S}$	0.86	0.86	0.90	0.82	0.80	0.86	0.89	0.78	0.87	0.91	0.78
Ba/Sr	5.56	5.85	6.43	7.10	5.00	5.04	7.35	6.11	5.44	6.05	3.26

N.A.- No data collected

††ASI-- alumina saturation index, A/CNK = molar Al_2O_3 / (CaO + Na_2O + K_2O)

†Total iron expressed as Fe_2O_3

###Eu/Eu*--chondrite-normalized ratio of measured Eu divided by the hypothetical Eu concentration required to produce REE pattern with no Eu anomalies

§FeOt / (FeO_t + MgO)--molar FeO_t / (FeO_t + MgO), where FeO_t is total iron expressed as FeO (Fe_2O_3 x 0.9)

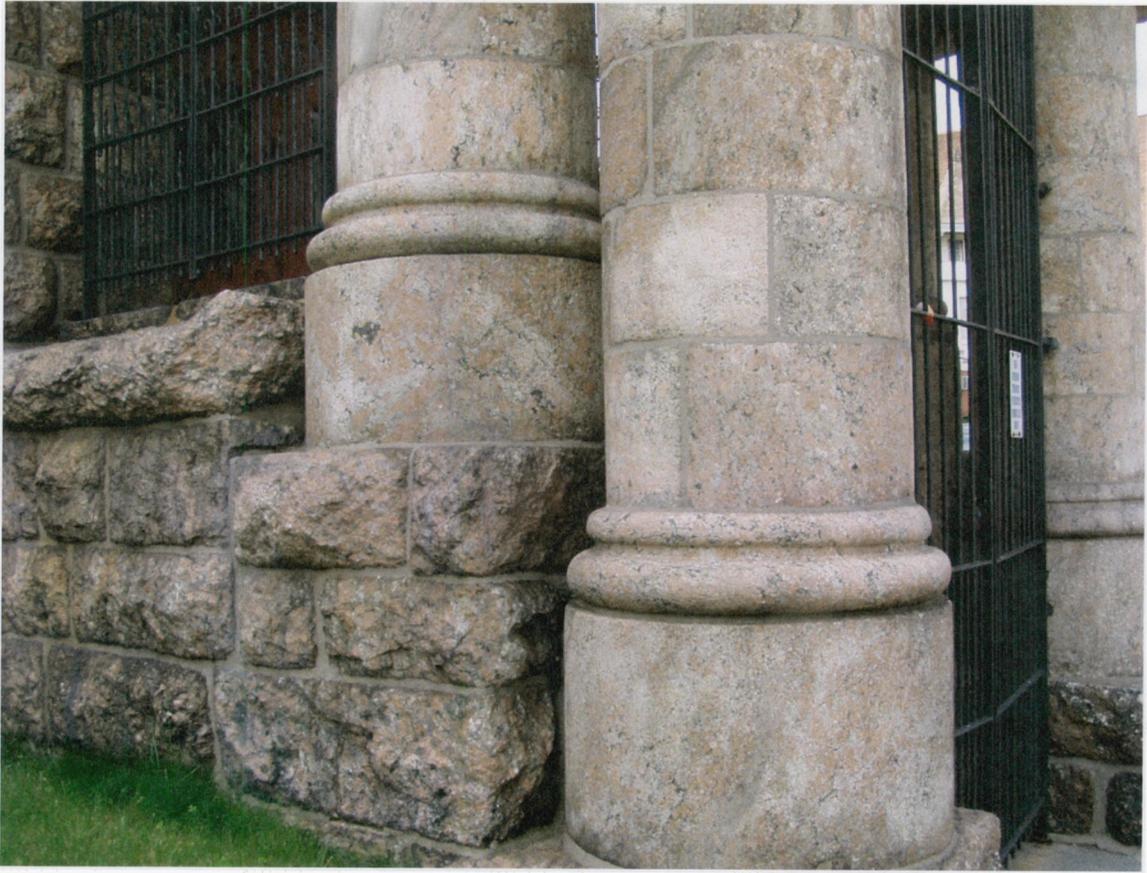**Figure 1. Lense of the Pompton Pink Granite intruding the surrounding gneiss.**

Figure 2. The Pompton Pink Granite as a decorative building stone at St. Paul's Episcopal Church in Patterson, NJ.

Figure 3. Polished Pompton Pink Granite from the landing at the entrance of the Smithsonian National Institute in Washington, D.C.
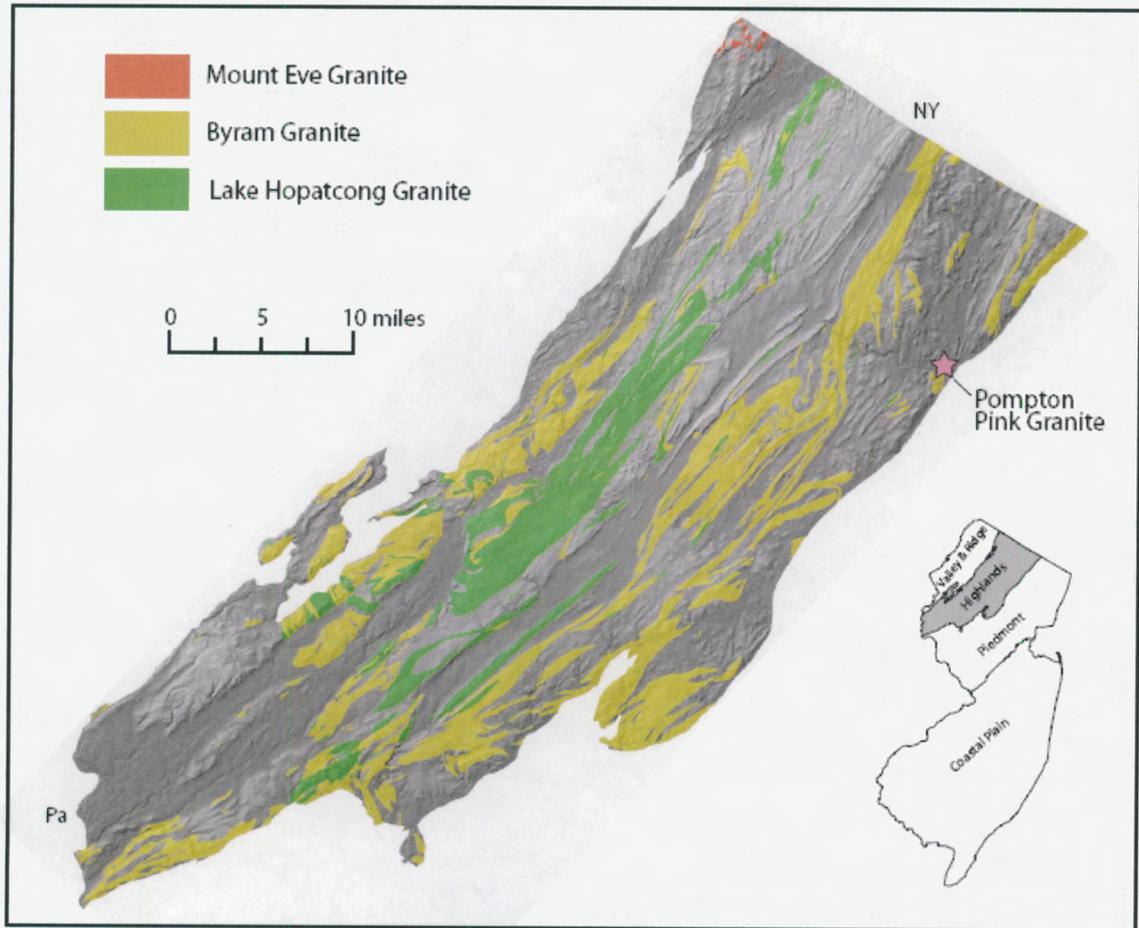
Figure 4. Digital topographic map of the Mesoproterozoic New Jersey Highlands showing the major granite suites (Mount Eve, Byram, and Lake Hopatcong) and the location of the Pompton Pink Granite (pink star). Small inset map shows the geologic provinces of New Jersey. Figure modified from Volkert, (2007).
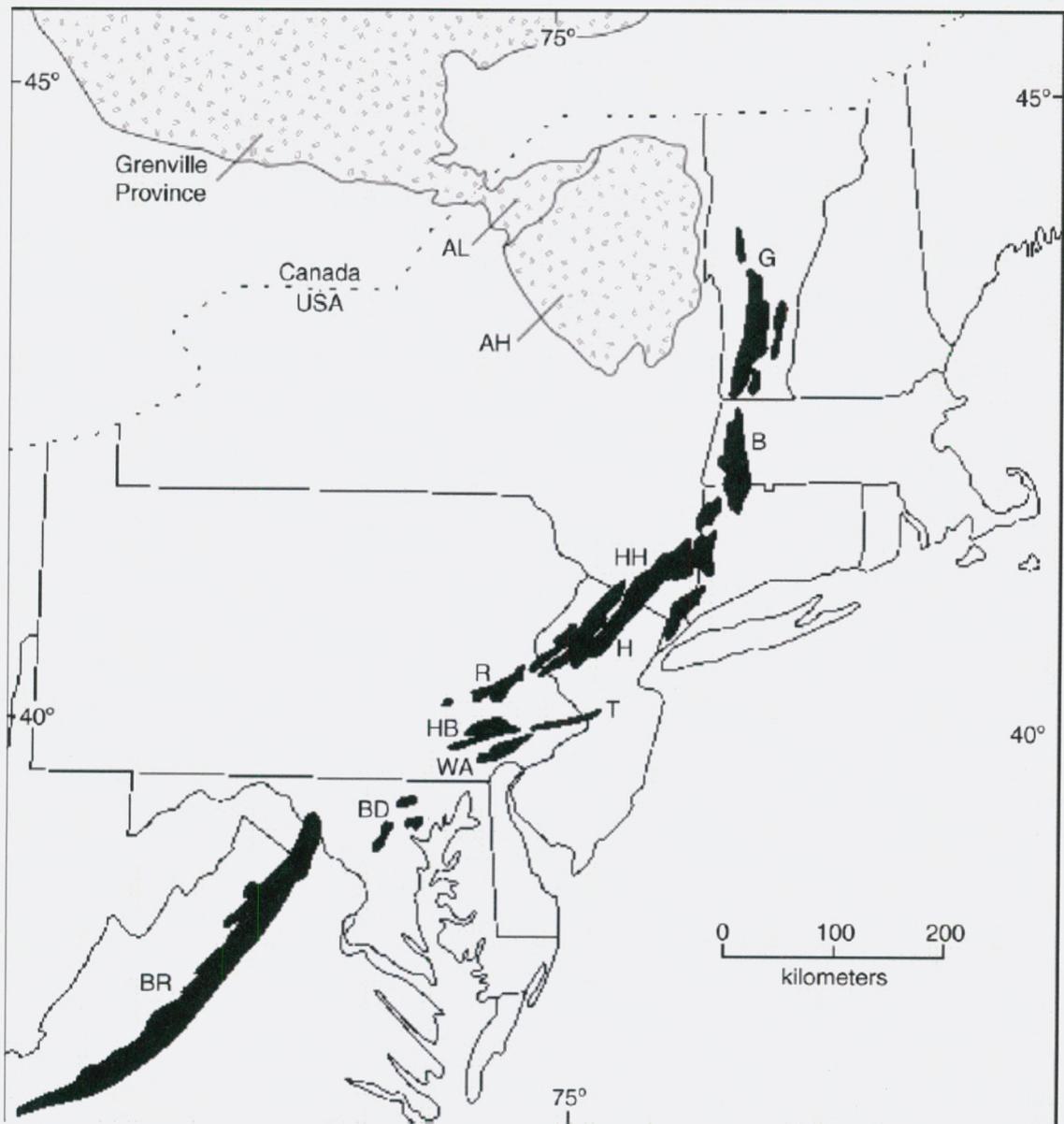
Figure 5. Map showing the distribution of Grenville-age rocks in the central and northern Appalachians (solid black), the Adirondacks Highlands (AH), Lowlands (AL), and the Grenville Province of southeastern Canada (stipple pattern). B- Berkshire Mountains; BD- Baltimore Gneiss domes; BR- Blue Ridge; G-Green Mountains; H- New Jersey Highlands; HB Honey Brook Upland; HH- Hudson Highlands; R-Reading Prong; T- Trenton Prong; WA- West Chester and Avondale Massifs. Modified from Rankin et al., (1993) and Volkert (2005).
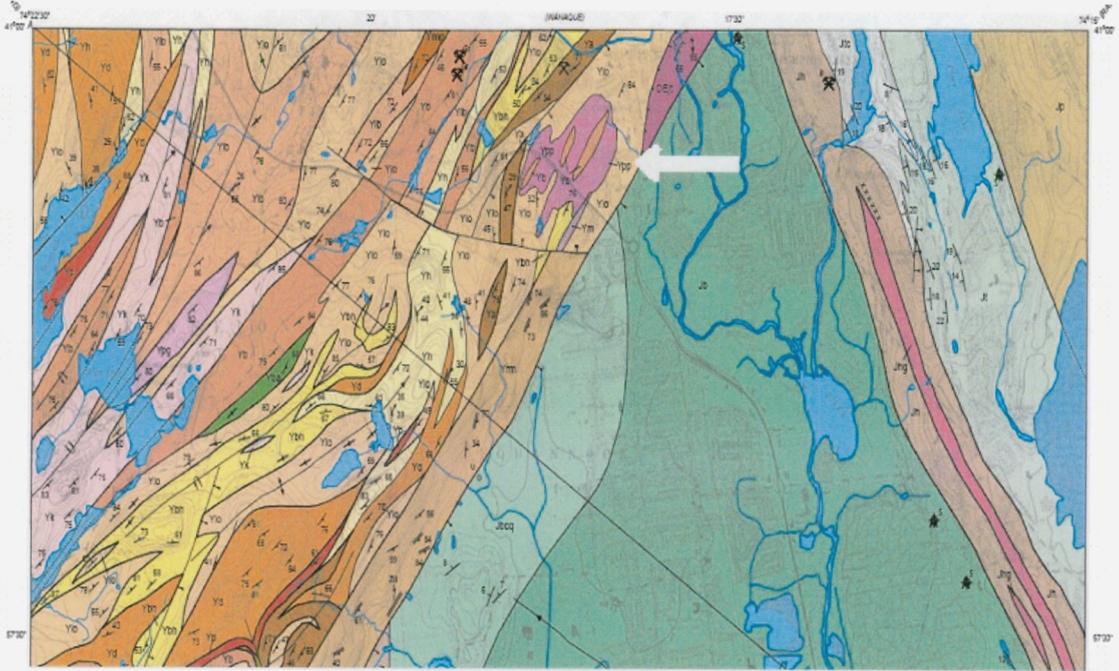
Figure 6. Excerpt of the bedrock map from the Pompton Plains Quadrangle (Volkert, 2010) showing the location (white arrow) of the Pompton Pink Granite (Ypp) near Riverdale, NJ

Figure 7. Gneiss xenolith in the Pompton Pink Granite.

Figure 8. Hand sample of the Pompton Pink Granite.
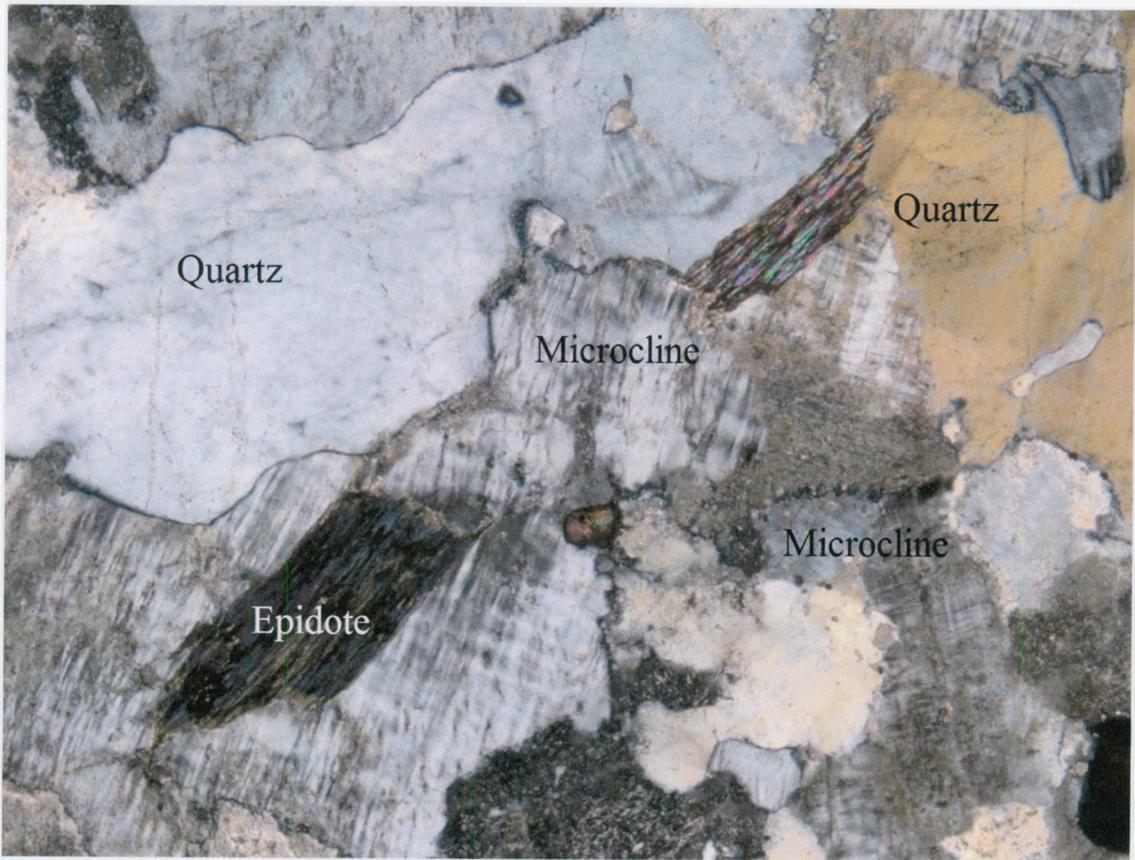
Figure 9. Thin section of PPG showing quartz, microcline, and epidote.
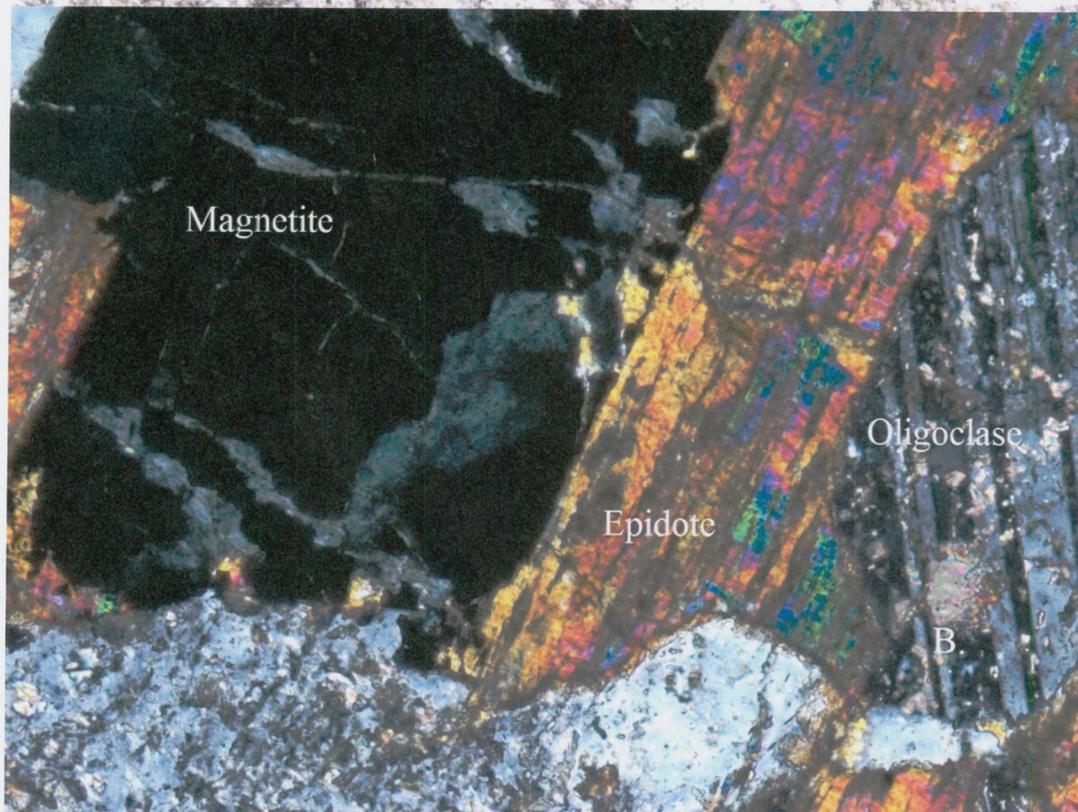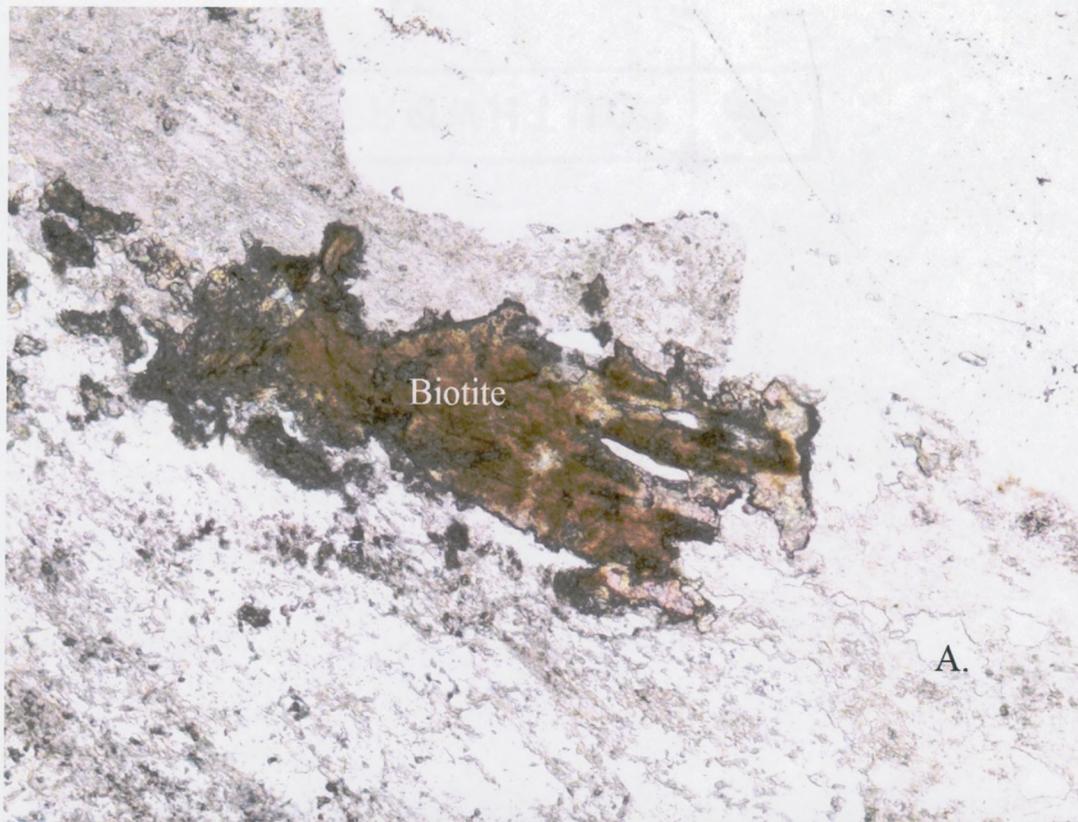
Figure 10. A) Thin section showing biotite. B) Thin section showing magnetite, epidote, and oligoclase.
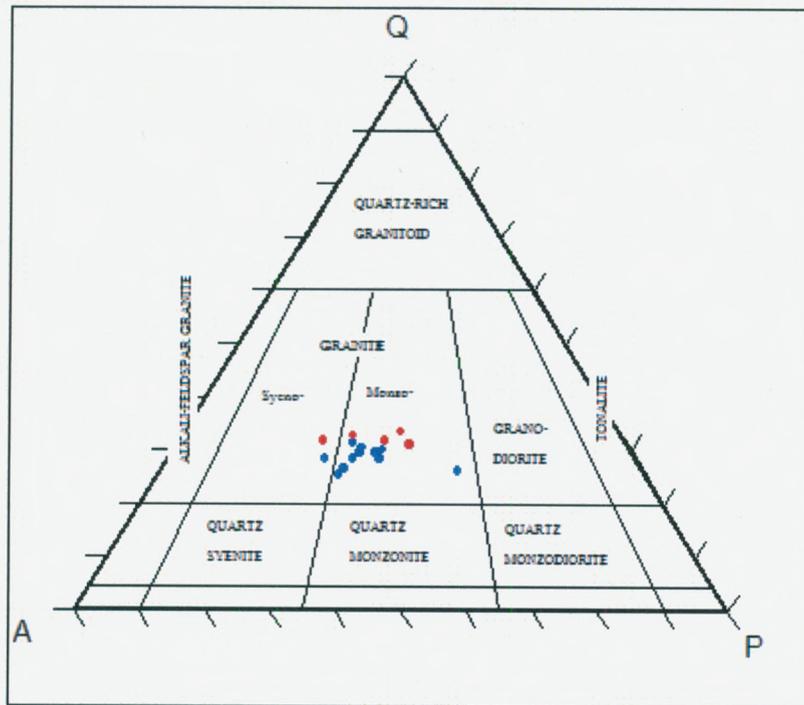
Figure 11. QAP diagram- Normalized PPG01-05 grain counts (red); CIPW normalized PPG01-11 based on whole-rock major element analysis (blue). Diagram after Streckeisen (1976)
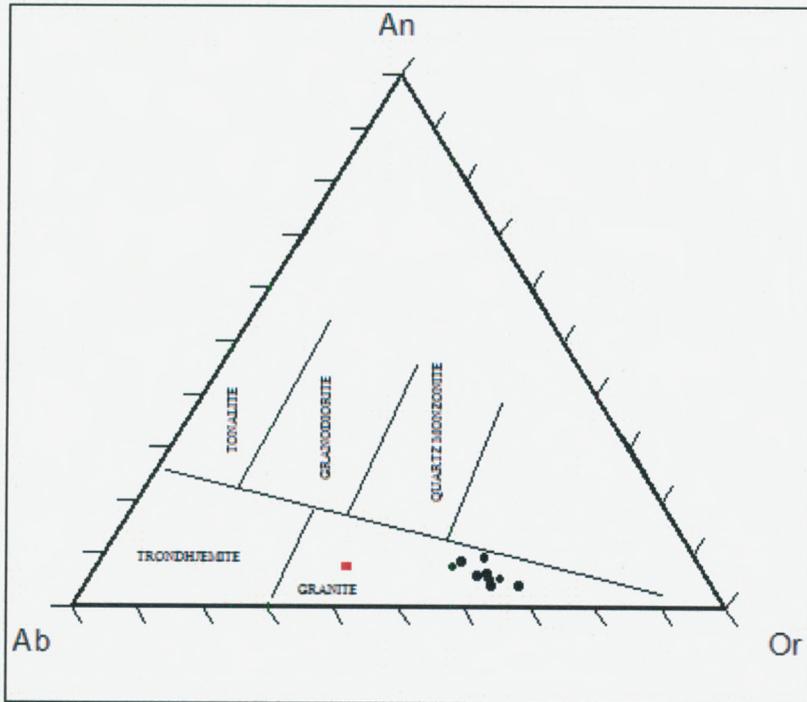
Figure 12. An-Ab-Or diagram- PPG01-10 (black circles) group together in the granite field. PPG11 (red circle) separates itself from the main grouping. Diagram after O'Conner (1965)

Figure 13. Field map showing the sample locations of PPG01 through PPG11.
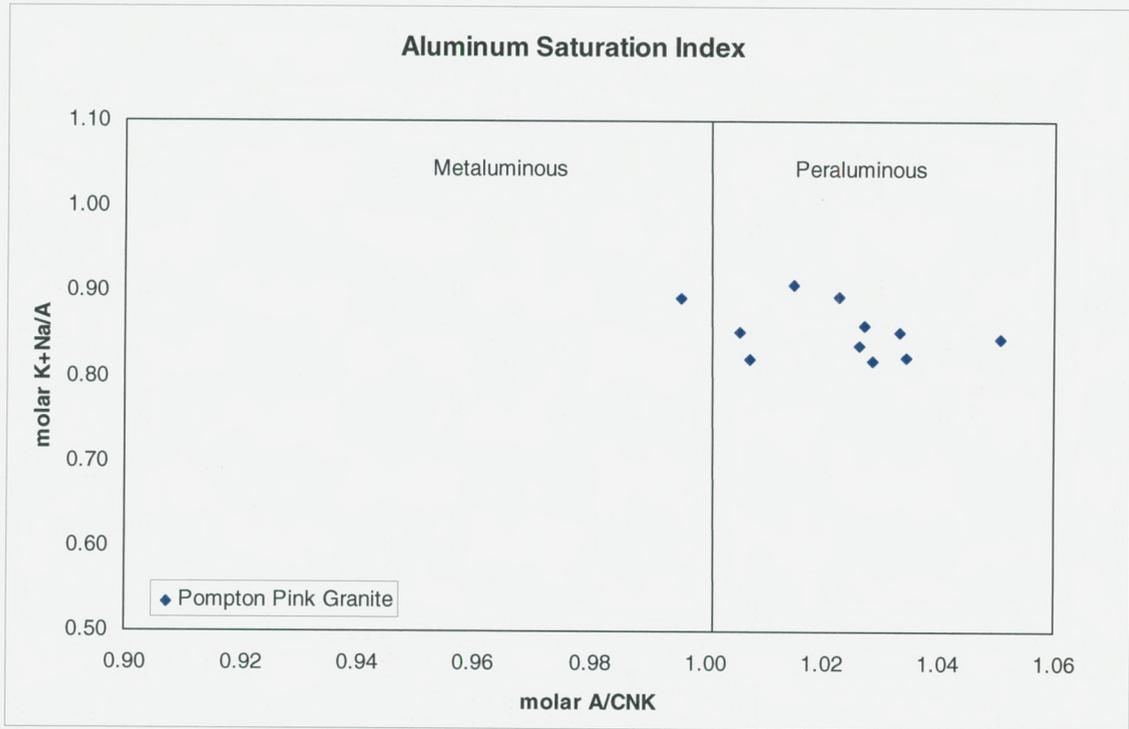
Figure 14. Aluminum Saturation Index (ASI) of the Pompton Pink Granite show mildly peraluminous samples.
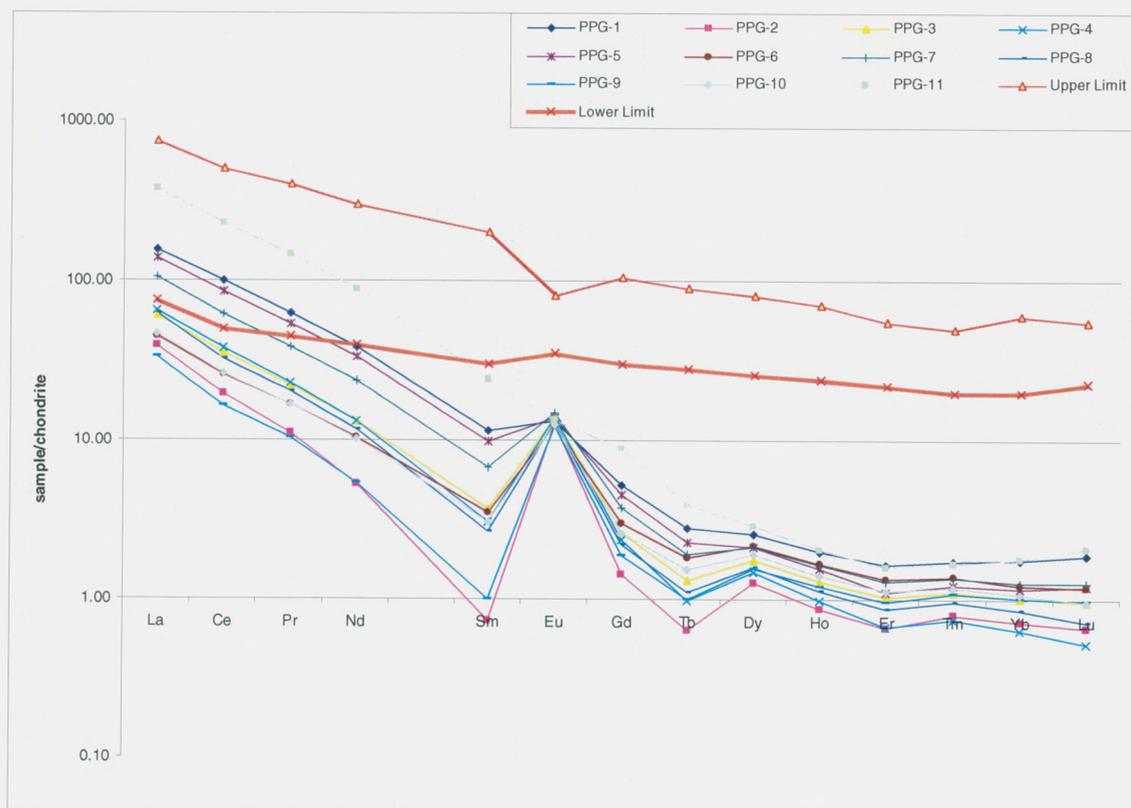
Figure 15. Rare Earth Elements plot of the Pompton Pink Granite with the upper and lower limits of the Byram Intrusive Suite, Lake Hopatcong Intrusive Suite, and Mt. Eve Granite shaded in red for comparison (data from Volkert and Drake, 1998; Gorring et al., 2004). Normalization factors are based on Leedy chodrite (Masuda et al., 1973) and are La (0.378), Ce (0.978), Pr (0.15), Nd (0.716), Sm (0.23), Eu (0.0866), Gd (0.311), Tb (0.0589), Ho (0.087), Er (0.255), Tm (0.039), Yb (0.249), and Lu (0.0387).
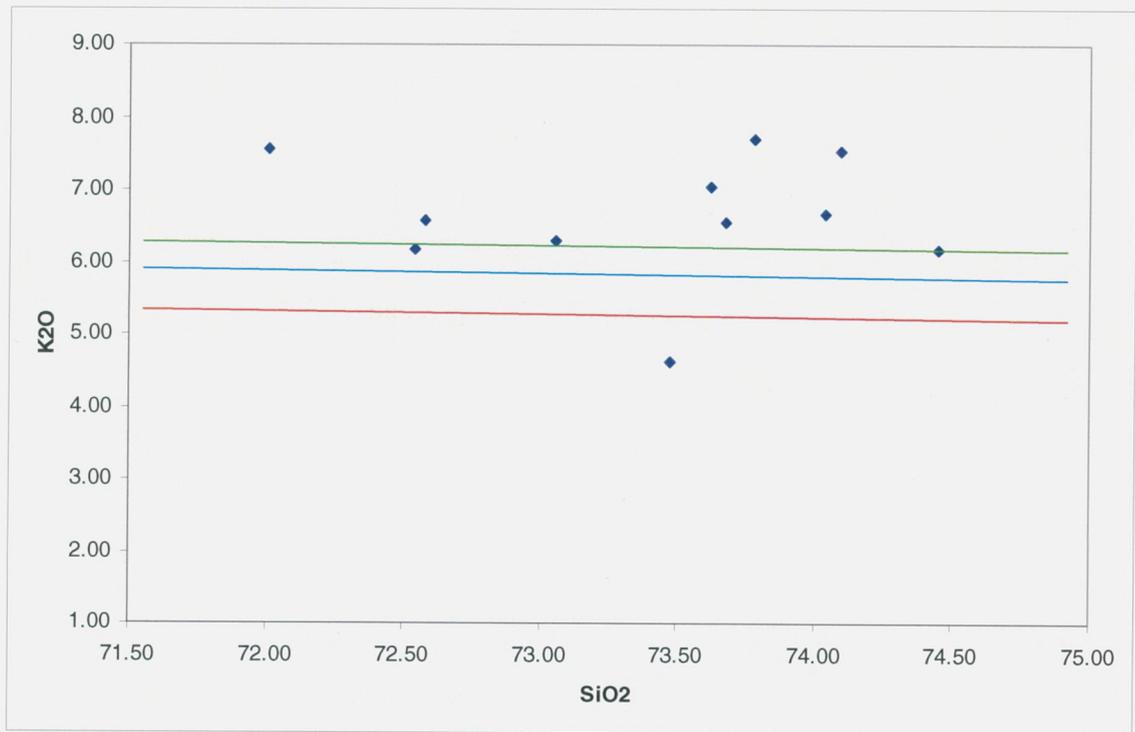
Figure 16. Harker variation diagram of K₂O vs. SiO₂ for the Pompton Pink Granite. Average trend lines of the Mount Eve Granite (green), Byram Intrusive Suite (blue), and Lake Hopatcong Intrusive Suite (red) are shown for relative trend comparison.
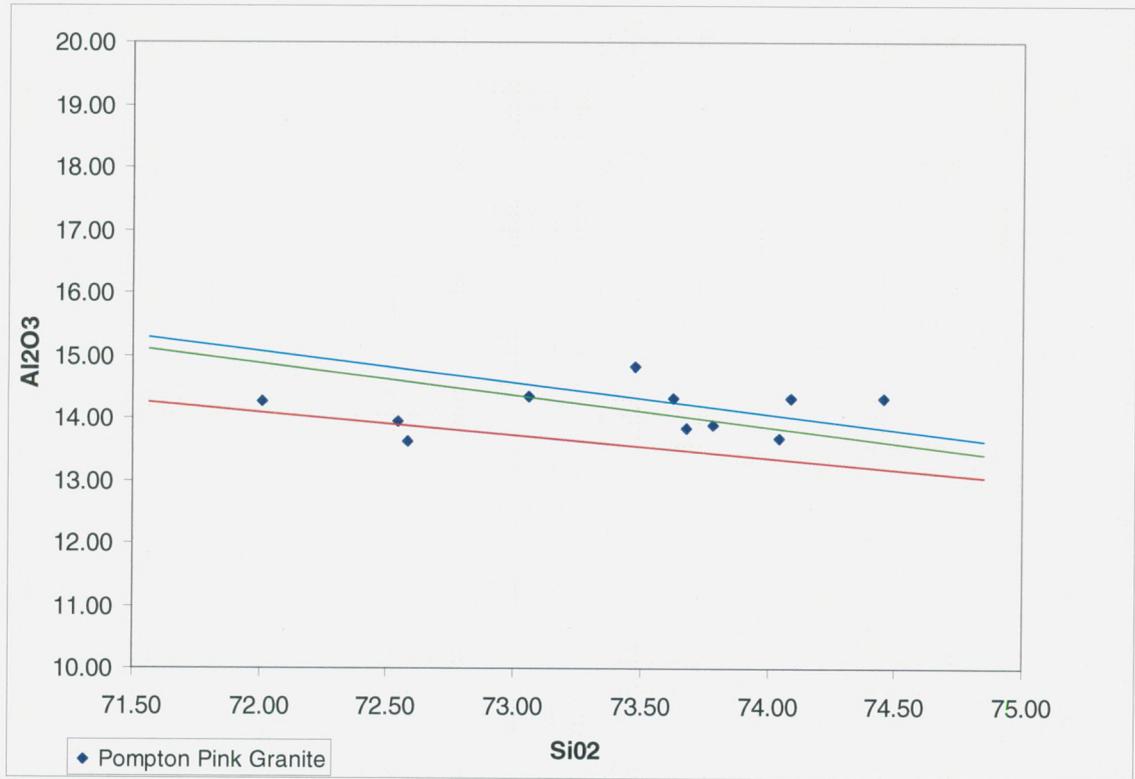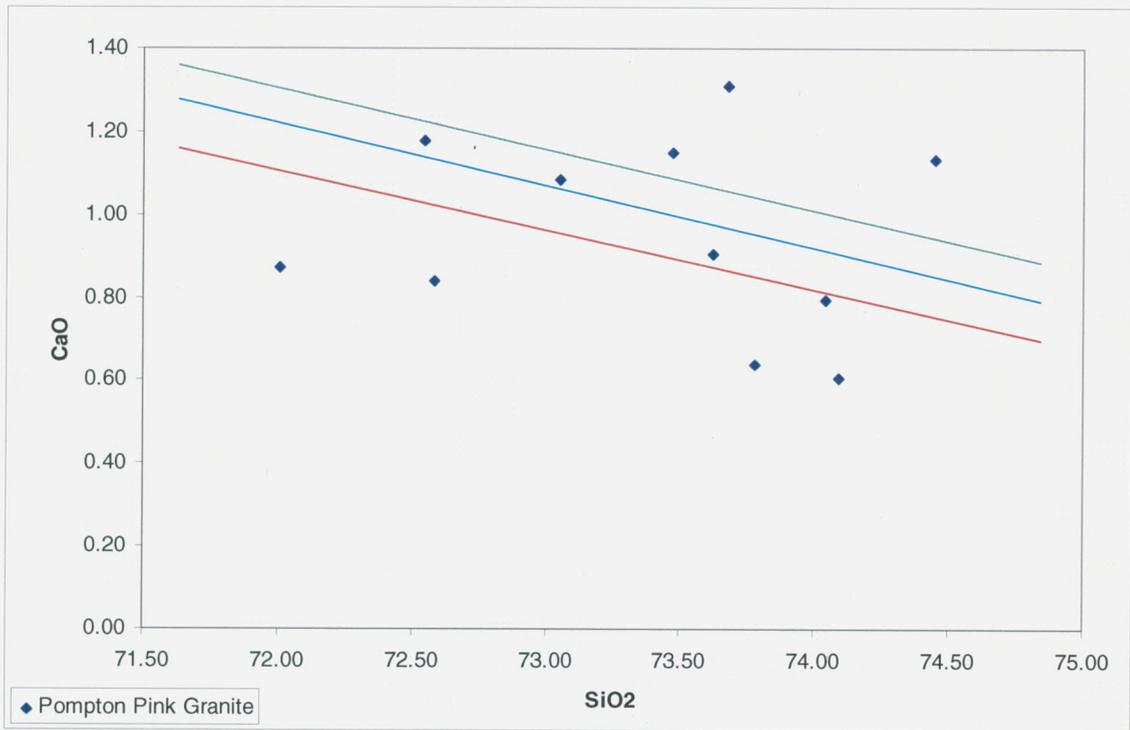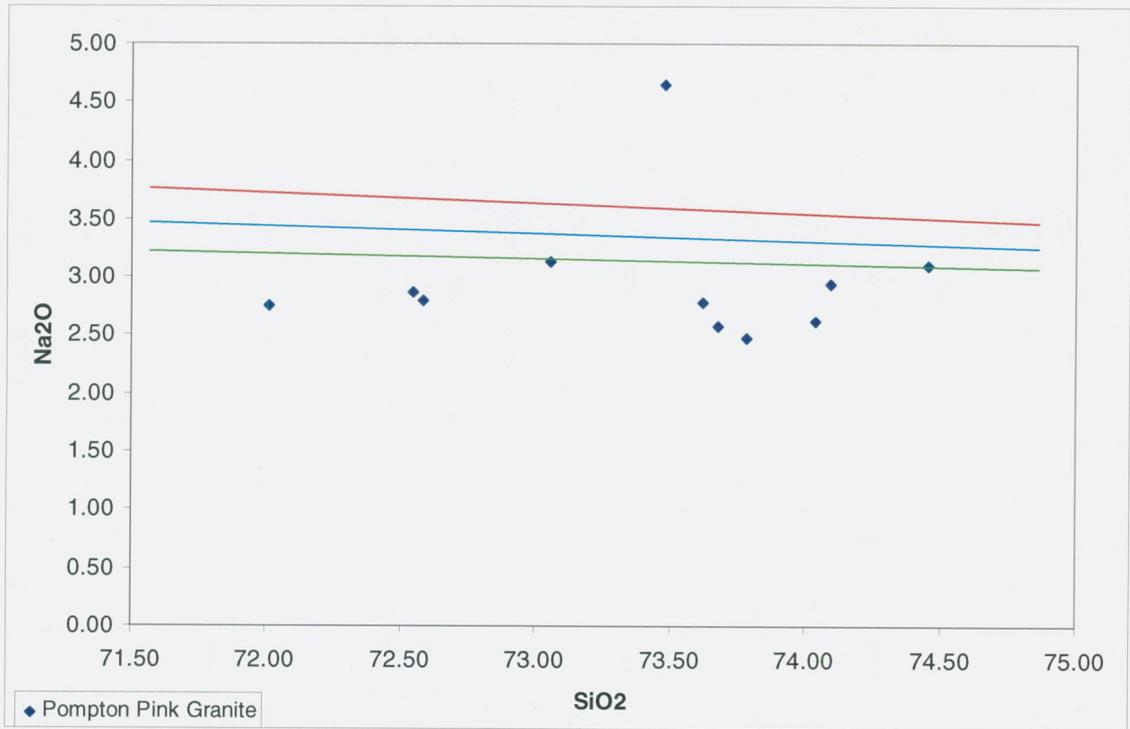
Figure 17. Harker variation diagram of Al$_2$O$_3$ vs. SiO$_2$ for the Pompton Pink Granite. Average trend lines of the Mount Eve Granite (green), Byram Intrusive Suite (blue), and Lake Hopatcong Intrusive Suite (red) are shown for relative trend comparison.
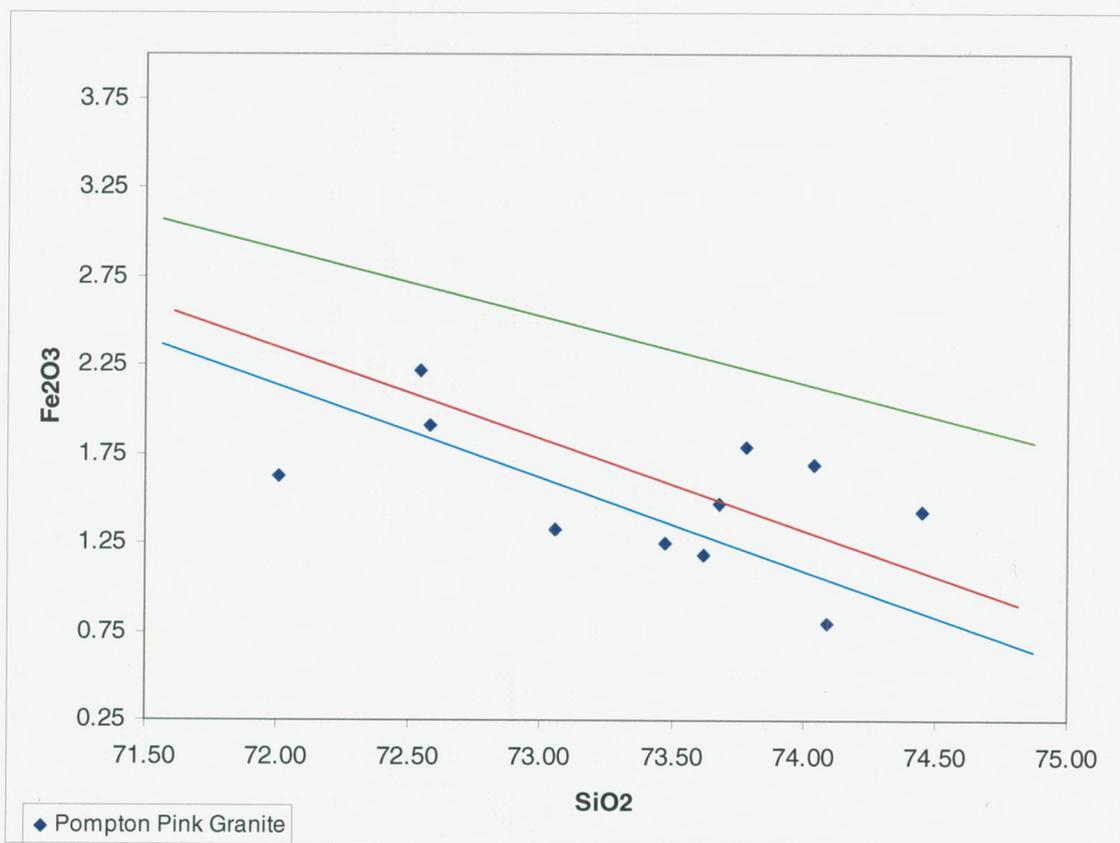
Figure 18. Harker variation diagram of Fe_2O_3 vs. SiO_2 for the Pompton Pink Granite. Average trend lines of the Mount Eve Granite (green), Byram Intrusive Suite (blue), and Lake Hopatcong Intrusive Suite (red) are shown for relative trend comparison.
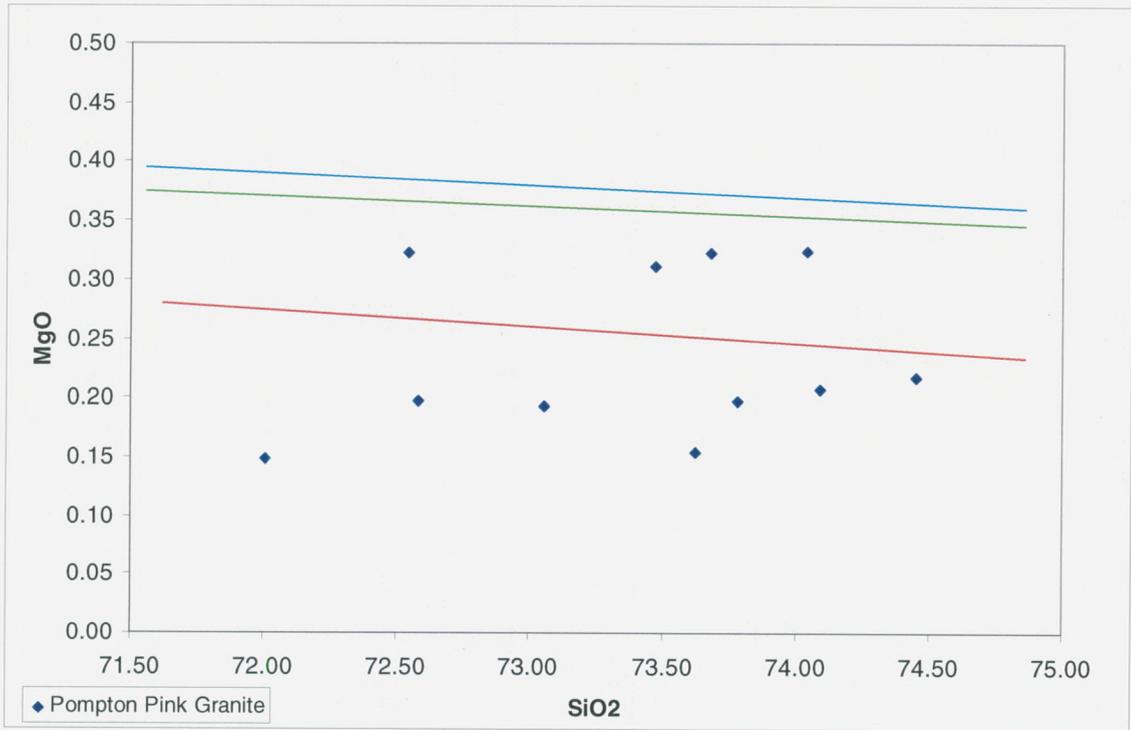
Figure 19. Harker variation diagram of CaO vs. SiO₂ for the Pompton Pink Granite. Average trend lines of the Mount Eve Granite (green), Byram Intrusive Suite (blue), and Lake Hopatcong Intrusive Suite (red) are shown for relative trend comparison.

Figure 20. Harker variation diagram of Na$_2$O vs. SiO$_2$ for the Pompton Pink Granite. Average trend lines of the Mount Eve Granite (green), Byram Intrusive Suite (blue), and Lake Hopatcong Intrusive Suite (red) are shown for relative trend comparison.

Figure 21. Harker variation diagram of MgO vs. SiO$_2$ for the Pompton Pink Granite. Average trend lines of the Mount Eve Granite (green), Byram Intrusive Suite (blue), and Lake Hopatcong Intrusive Suite (red) are shown for relative trend comparison.
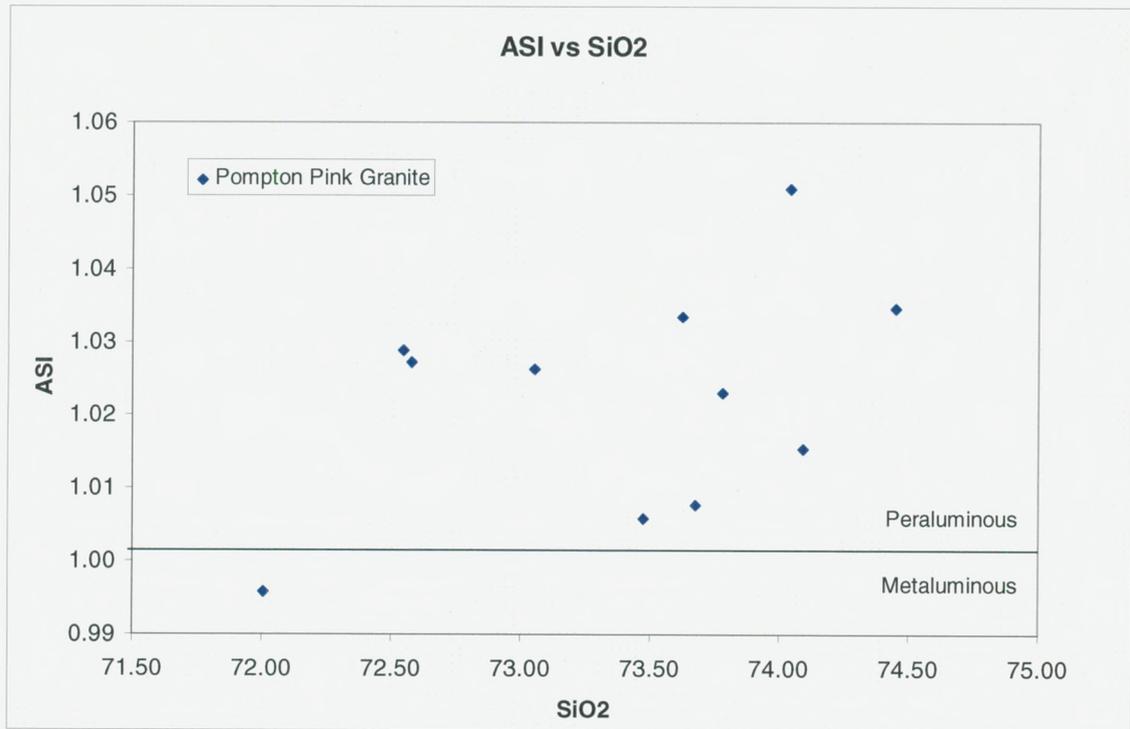
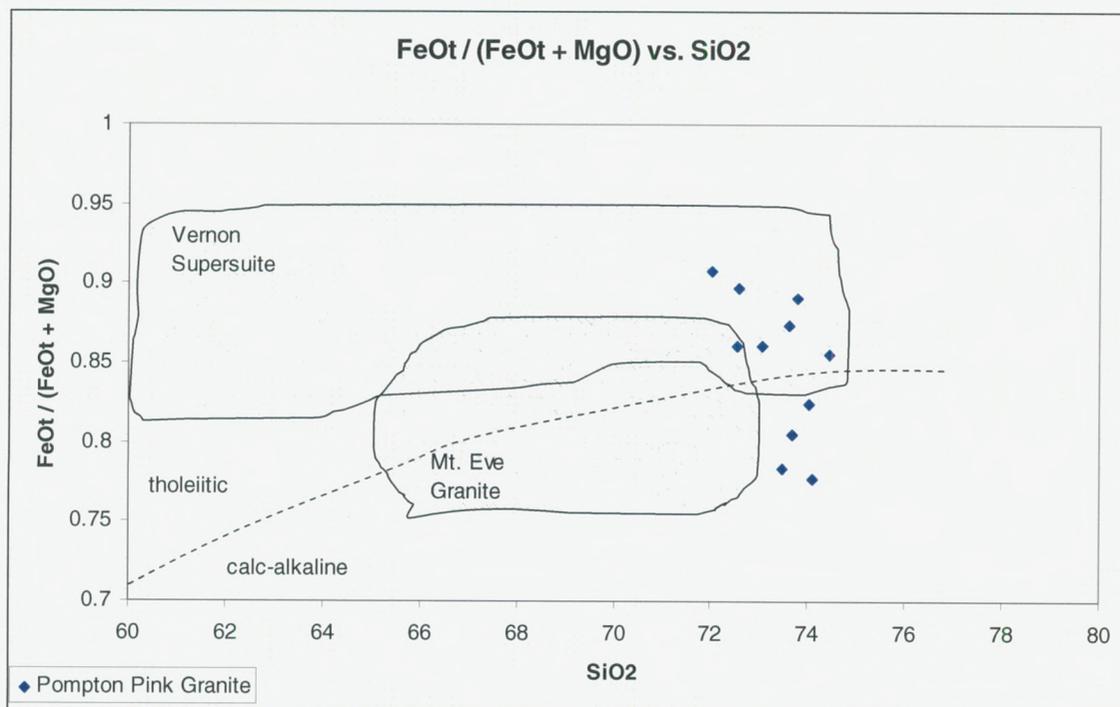**Figure 22. ASI vs. SiO$_2$ showing a moderate increase in ASI with increasing SiO$_2$.**

Figure 23. $FeO_t / (FeO_t + MgO)$ **vs.** SiO_2 **plot of the Pompton Pink Granite with fields for Vernon Supersuite (Volkert et al., 2000) and Mount Eve Granite (Gorring et al., 2004) Plot modified from Anderson (1983) and Frost et al., (2000).**
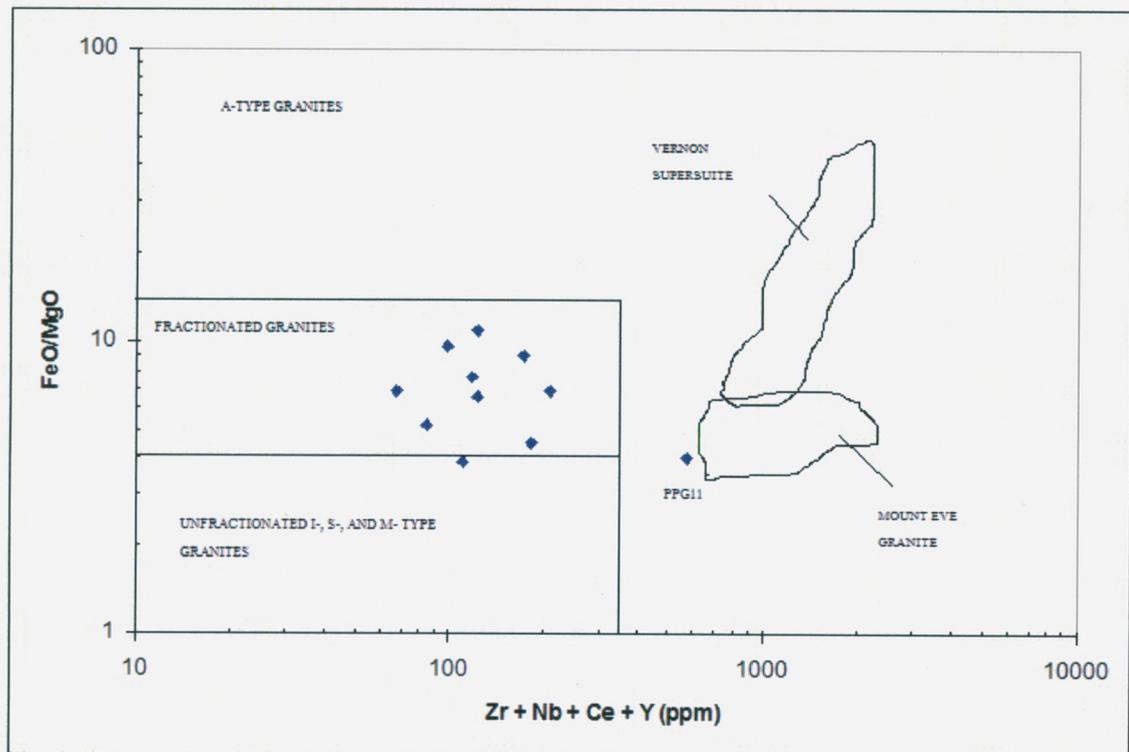
Figure 24. FeO$_t$/MgO vs. Zr + Nb + Ce + Y plot showing the most samples as fractionated granites. PPG11 is the only to classify as A-type granite. The Vernon Supersuite (Volkert et al., 2000) and Mount Eve Granite (Gorring et al., 2004) fields are shown for comparison. Diagram modified after Whalen et al., (1987).
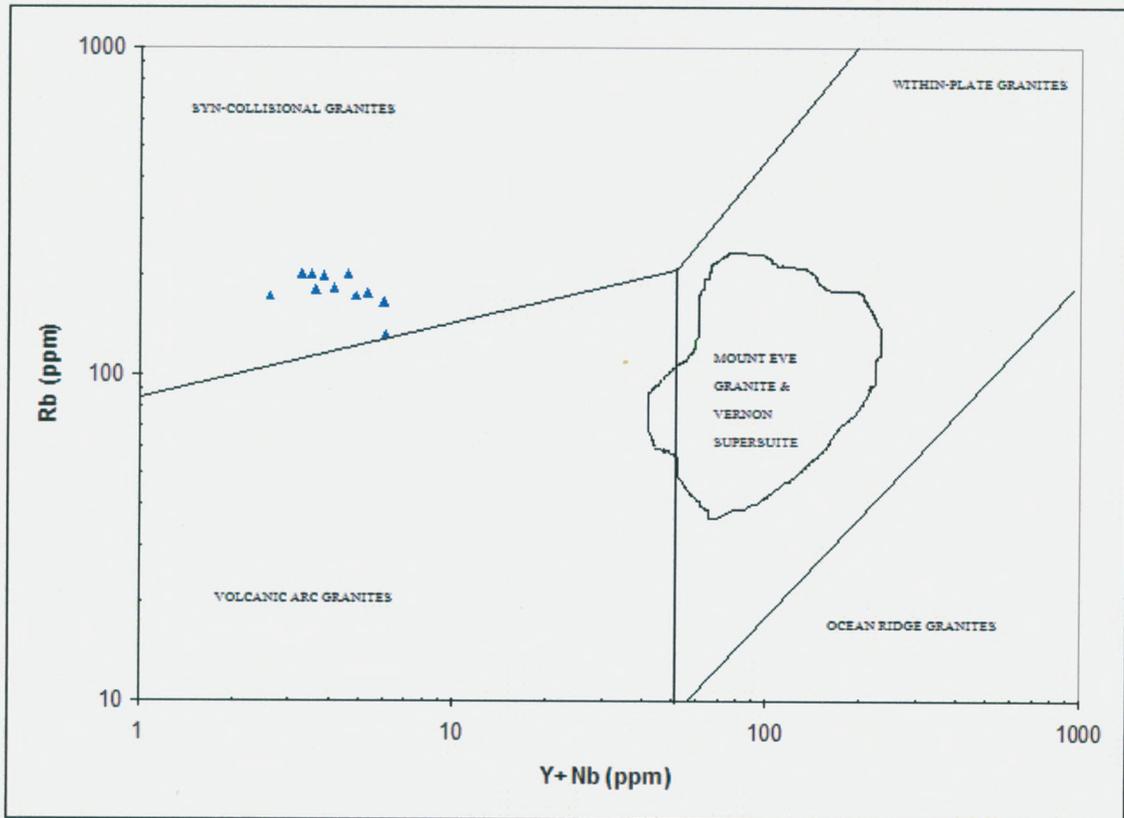
Figure 25. **Rb vs. Y + Nb plot showing syn-collisional granite classification for the Pompton Pink granite. The Vernon Supersuite (Volkert et al., 2000) and Mount Eve Granite (Gorring et al., 2004) fields are shown for comparison. Diagram modified after Pierce et al., (1984).**
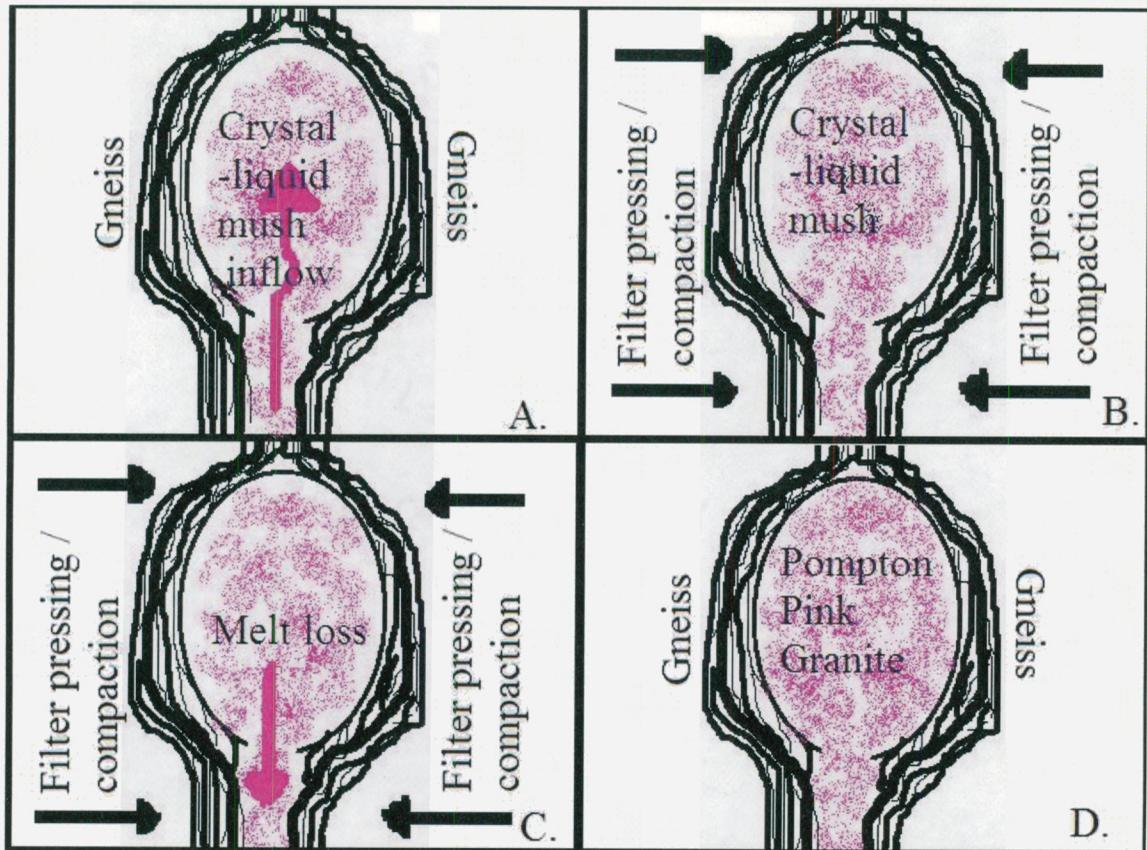
Figure 26. Petrogenesis of the Pompton Pink Granite. A) Inflow of a crystal-liquid mush between layers of gneiss. B) Filter pressing/compaction during and/or after emplacement. C) Melt loss through the filter pressing/compaction process. D) Petrogenesis of the Pompton Pink Granite.