GEOLOGY AND MINING HISTORY OF BARTON MINES CORPORATION, GORE MOUNTIAN MINE

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INTRODUCTION

This trip proceeds from Union College to the former Barton Garnet Corporation mine near the summit of Gore Mountain, New York. For 105 years, this was the site of the world's oldest continuously operating garnet mine and the country's second oldest continuously operating mine under one management.

The Barton Mines Corporation open pit mine is located at an elevation of about 800 m (2600 ft) on the north side of Gore Mountain (Fig.1). The community at the mine site is the highest self-sufficient community in New York State. It is 16 km (10 mi) from North Creek and 8 km (5 mi) from NY State Route 28 over a Company-built road that rises 91 m (300 ft) per mile. This road, like others in the vicinity, is surfaced with coarse mine tailings. About eleven families can live on the property. The community has its own water, power, and fire protection systems. On the property are the original mine buildings and the Highwinds Inn, built by Mr. C.R. Barton in 1933 as a family residence. The Inn is now privately leased from the Corporation and operates 10 months per year. It offers a four-bedroom lodge, a four star dining room, cross-country skiing and fantastic views of the Siamese Wilderness Area.

The garnet is used in coated abrasives, glass grinding, metal and glass polishing, and even to remove the red hulls from peanuts. Paint manufacturers add garnet to create non-skid surfaces and television makers use it to prepare the glass on the interior of color picture tubes prior to the application of the phosphors. Barton sells between 10,000 and 12,000 tons of technical-grade garnet abrasive annually. About 40% of the company's shipments are to foreign countries. All current U.S. production of technical-grade garnet is limited to the Barton Mines Corporation. The product is shipped world wide for use in coated abrasives and powder applications (Austin, 1993a,b).

Garnet has been designated as the official New York State gemstone. Barton produces no gem material but collectors are still able to find rough material of gem quality. Stones cut from Gore Mountain rough material generally fall into a one to five carat range. A small number of stones displaying asterism have been found. Garnets from this locality are a dark red color with a slight brownish tint. Special cutting schemes have been devised for this material in order to allow sufficient light into the stone.

HISTORY

The early history of the Barton garnet mine has been compiled by Moran (1956) and is paraphrased below. Mr. Henry Hudson Barton came to Boston from England in 1846 and worked as an apprentice to a Boston jeweler. While working there in the 1850's, Barton learned of a large supply of garnet located in the Adirondack Mountains. Subsequently, he moved to Philadelphia and married the daughter of a sandpaper manufacturer. Combining his knowledge of gem minerals and abrasives, he concluded that garnet would produce better quality sandpaper than that currently available. He was able to locate the source of the Adirondack garnet stones displayed at the Boston jewelry store years before. Barton procured samples of this garnet which he pulverized and graded. He then produced his first garnet-coated abrasive by hand. The sandpaper was tested in several woodworking shops near Philadelphia. It proved to be a superior product and Barton soon sold all he could produce.

In Garver, J.I., and Smith, J.A. (editors), Field Trips for the 67th annual meeting of the New York State Geological Association, Union College, Schenectady NY, 1995, p. 405-412.

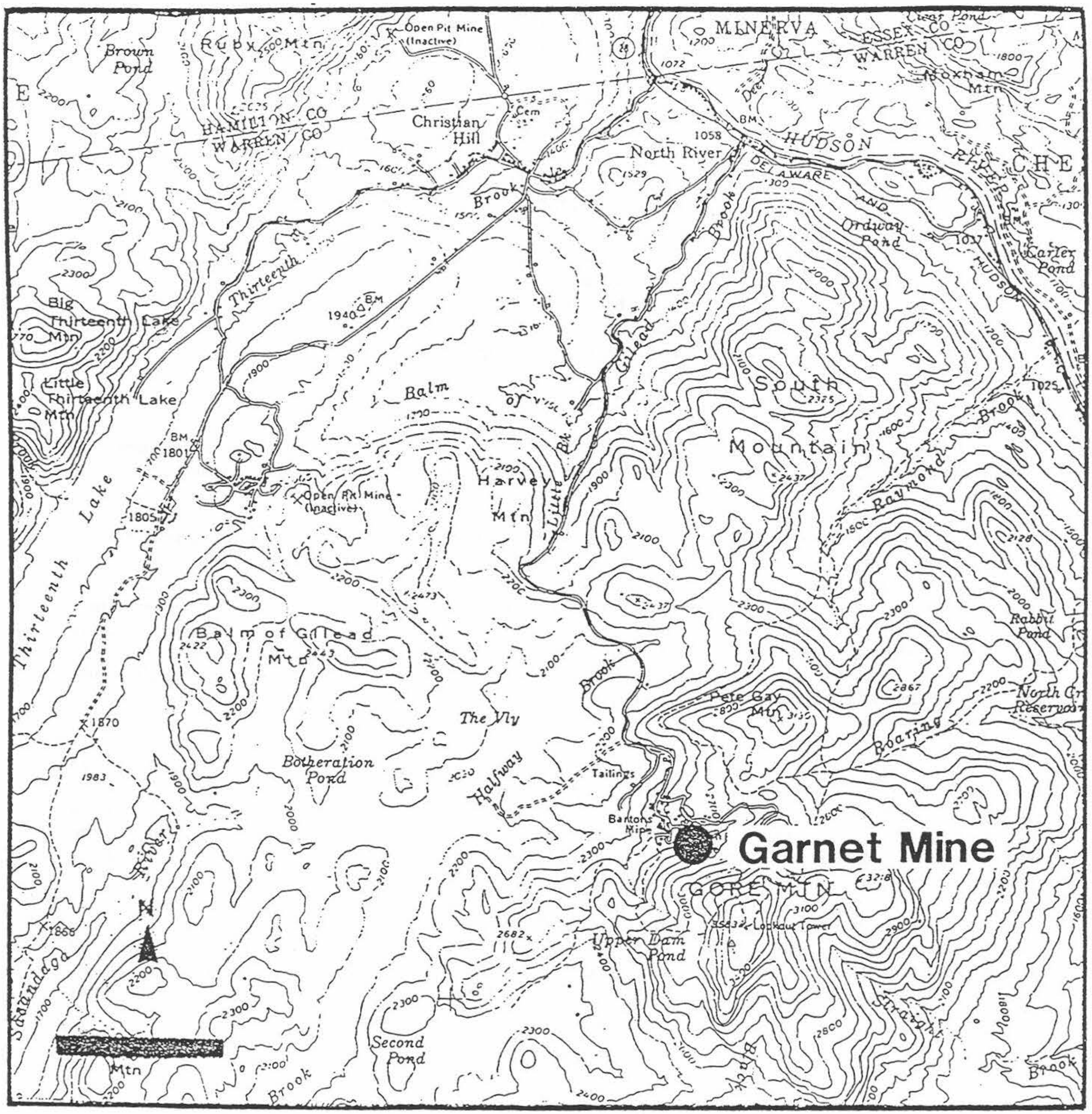

Figure 1. Topographic map (Thirteenth Lake 15' quadrangle) showing the location of the Barton garnet mine. Scale bar = 1.6 km (1 mi).

H.H. Barton began mining at Gore Mountain in 1878 and in 1887, bought the entire mountain from the State of New York. Early mining operations were entirely manual. The garnet was hand cobbed (*i.e.* separated from the waste rock) by small picking hammers and chisels. Due to the obstacles in moving the ore, the garnet was mined during the summer and stored on the mountain until winter. It was then taken by sleds down to the railroad siding at North Creek whence it was shipped to the Barton Sandpaper plant in Philadelphia for processing. The "modern" plant at Gore Mountain was constructed in 1924. Crushing, milling, and coarse grading was done at the mine site. In 1983, the Gore Mountain operation was closed down and mining was relocated to the Ruby Mountain site, approximately 6 km (4 mi) northeast, were it continues at present.

MINING AND MILLING

The mine at Gore Mountain is approximately one mile in length in an ENE-WSW direction. The ore body varies from 15 m (50 ft) to 122 m (400 ft) and is roughly vertical. Mining was conducted in benches of 9 m (30 ft) using standard drilling and blasting techniques. Oversized material was reduced with a two and one-half ton drop ball. The ore was processed through jaw and gyratory crushers to liberate the garnet and then concentrated in the mill on Gore Mountain. Garnet concentrate was further processed in a separate mill in North River at the base of the mountain. Separation of garnet was and is accomplished by a combination of concentrating methods including heavy media, magnetic, flotation, screening, tabling and air and water separation. Processes are interconnected and continuous or semi-continuous until a concentrate of 98% minimum garnet for all grades is achieved (Hight, 1983). Finished product ranges from 0.6 cm to 0.25 micron in size.

CHARACTERISTICS OF GORE MOUNTAIN GARNET

The garnet mined at Gore Mountain is a very high-quality abrasive. The garnets display a well-developed tectonic parting that, in hand specimen, looks like a very good cleavage. This parting is present at the micron scale. Consequently, the garnets fracture with chisel-like edges yielding superior cutting qualities. The garnet crystals are commonly 30 cm in diameter and rarely up to 1 m with an average diameter of 9 cm (Hight, 1983) The composition of the garnet is roughly 43% pyrope, 40% almandine, 14% grossular, 2% andradite, and 1% spessartine (Levin, 1950; Harben and Bates, 1990). Chemical zoning, where present, is very weak and variable (Luther, 1976). Typical chemical analyses of the garnet are presented in Table 1. Hardness of the garnet is between eight and nine and the average density is 3.95 gm/cm^3.

Table 1. Electron Microprobe analyses of Gore Mt. garnet (almandine-pyrope) normalized to 8 cations and 12 anions.

Oxide Weight Percent	#29	#41
SiO_2	39.43	39.58
Al_2O_3	21.40	21.20
TiO_2	0.05	0.10
FeO*	22.80	24.45
Fe_2O_3*	1.44	0.72
MgO	10.65	9.60
MnO	0.48	0.74
CaO	3.85	3.97
Na_2O	0.00	0.00
K_2O	0.00	0.00
Total	100.09	100.36

* Calculated by charge balance (Kelly and Petersen, 1993).

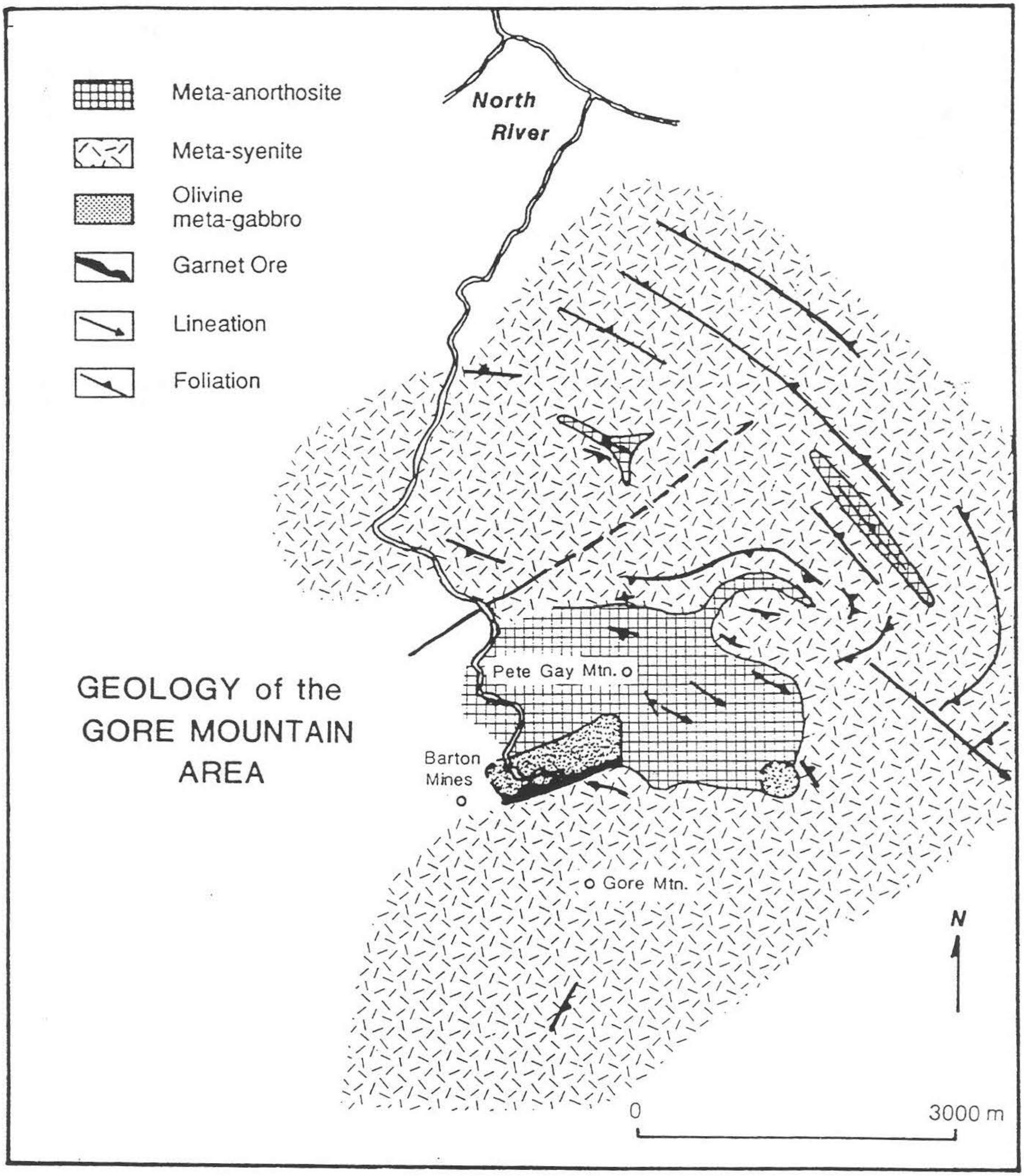

Figure 2. Geologic map of the vicinity of the Barton garnet mine (modified from Bartholomé, 1956).

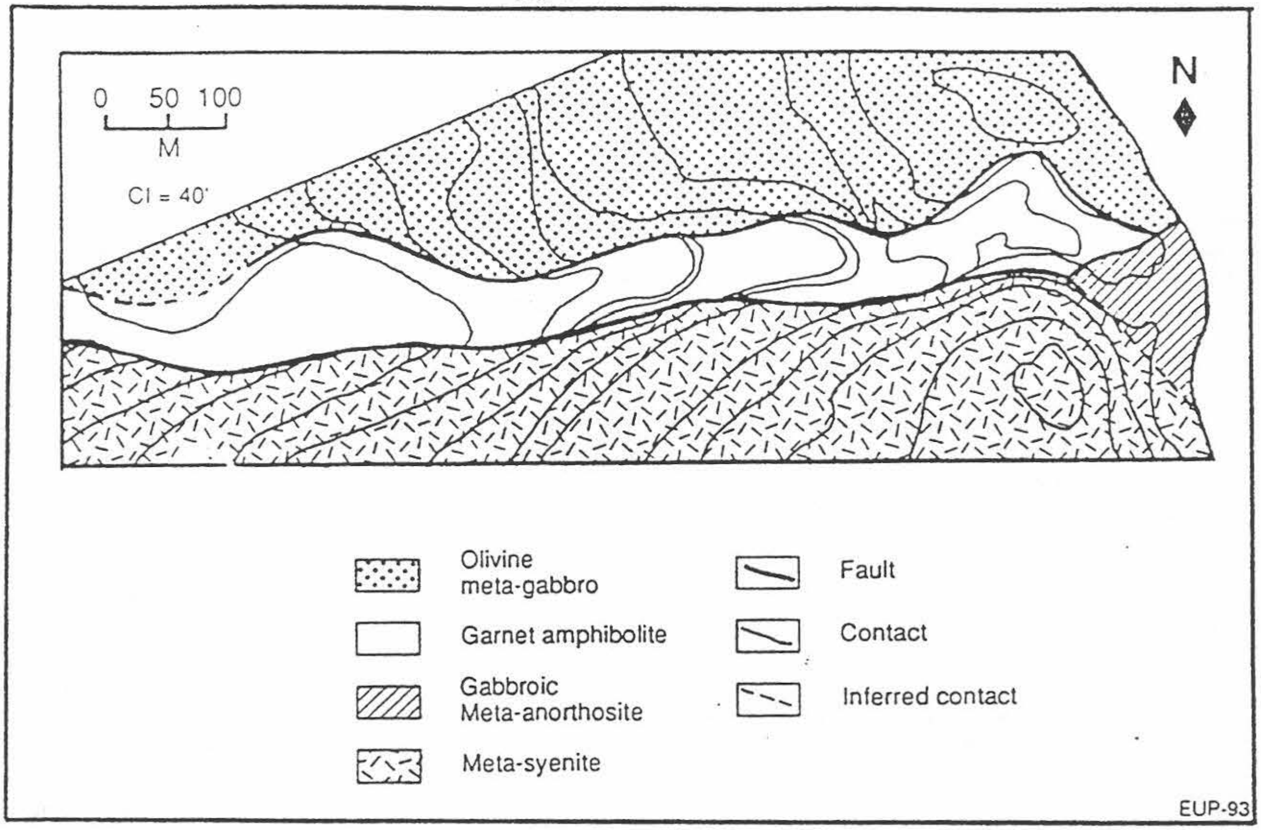

Figure 3. Geologic map of the Gore Mountain mine (modified from Goldblum and Hill, 1992).

GEOLOGY

The garnet mine is entirely hosted by a hornblende-rich garnet amphibolite unit along the southern margin of an olivine meta-gabbro body (Figs. 2,3). The garnet amphibolite grades into garnet-bearing gabbroic meta-anorthosite to the east. To the south the garnet amphibolite is in contact with a meta-syenite; a fault occurs parallel to this contact in places.

The olivine meta-gabbro bordering the ore zone is a granulite facies lithology with a relict subophitic texture. Preserved igneous features, faint igneous layering, and a xenolith of anorthosite have been reported in the meta-gabbro (Luther, 1976). Prior to metamorphism, the rock was composed of plagioclase, olivine, clinopyroxene and ilmenite. During metamorphism, coronas of orthopyroxene, clinopyroxene and garnet formed between the olivine and the plagioclase and coronas of biotite, hornblende and ilmenite formed between plagioclase and ilmenite (Whitney & McLelland, 1973, 1983). The contact between the olivine meta-gabbro and the garnet amphibolite ore zone is gradational through a narrow (1 to 3 m wide) transition zone. Garnet size increases dramatically across the transition zone from less than 1 mm in the olivine meta-gabbro, to 3 mm in the transition zone, to 50 to 350 mm in the amphibolite (Goldblum and Hill, 1992). This increase in garnet size coincides with a ten-fold increase in the size of hornblende and biotite, the disappearance of olivine, a decrease in modal clinopyroxene as it is replaced by hornblende, and a change from green spinel-included plagioclase to white inclusion-free plagioclase (Goldblum and Hill, 1992). Mineralogy in the garnet amphibolite ore zone is mainly hornblende, plagioclase and garnet with minor biotite, orthopyroxene, and various trace minerals. In both the olivine meta-gabbro and the garnet amphibolite, garnet content averages 13 modal percent, with a range of 5 to 20 modal percent (Luther, 1976; Hight, 1983; Goldblum, 1988). The garnet amphibolite unit is thought to be derived by retrograde metamorphism of the southern margin of the granulite facies olivine meta-gabbro. At the west end of the mine, a garnet hornblendite with little or no feldspar is locally present. This rock may represent original ultramafic layers in the gabbro (Whitney et al., 1989). In the more mafic portions of the ore body, the large garnet crystals are rimmed by hornblende up to several inches thick. Elsewhere, in less mafic ore, the rims contain plagioclase and orthopyroxene. Chemical analyses of the olivine meta-gabbro and garnet amphibolite show that the garnet ore was derived by retrograde isochemical metamorphism, except for an increase in the H_2O and fO_2, of the olivine meta-gabbro (Table 2; Luther, 1976).

A strong, consistent lineation and weak planar fabric coincide with the zone of large garnet crystals and are an important feature of the garnet ore zone (Goldblum and Hill, 1992). The lineation is defined by parallel alignment of prismatic hornblende crystals, elongate segragations of felsic and mafic minerals, plagioclase pressure shadows, and rare elongate garnet. The foliation is defined by a slight flattening of the felsic and mafic aggregates.

ORIGIN OF GARNET

Although the garnet crystals in the ore zone at Gore Mountain are atypical in size, the modal amount of garnet is not unusually high for Adirondack garnet amphibolites. Garnet amphibolite that is texturally and mineralogically similar occurs elsewhere in the Adirondacks, usually on the margins of gabbroic rock bodies. The ore at the currently operating Barton Corporation mine at Ruby Mountain, for example, is of the same tenor but the garnets rarely are larger than 2.5 to 5 cm.

Petrologic studies (Buddington, 1939, 1952; Bartholome, 1956, 1960; Luther, 1976; Sharga, 1986; Goldblum, 1988; Goldblum and Hill, 1992) have agreed that the growth of the large garnets is related to a localized influx of water that caused the retrograde metamorphism along the margin of the granulite facies olivine meta-gabbro body. The Gore Mountain garnets are chemically homogeneous suggesting that (a) the garnets grew under conditions in which all chemical components were continuously available and the (b) temperature and pressure conditions were uniform during the period of garnet formation. A zone of high fH_2O along the southern margin of the original gabbro body may have enhanced diffusion and favored growth of very large garnets and thick hornblende rims at the expense of plagioclase and pyroxene. Luther (1976) speculates that physical and chemical conditions were favorable for the <u>growth</u> of garnet but poor for the <u>nucleation</u> of garnet so that the garnet crystals that did nucleate grew to large size. The presence of volatiles, particularly H_2O, promotes the growth of large crystals by aiding transport of components.

Recognition that the garnet ore body, retrograde metamorphism, and L-S deformation fabric all coincide with the southern margin of the olivine meta-gabbro body led Goldblum and Hill (1992) to hypothesize that the high fluid flow required for growth of large garnet crystals was the result of ductility contract at a lithologic contact during high-temperature shear zone deformation. The olivine meta-gabbro is a granulite facies rock with a poorly developed foliation and little evidence for ductile deformation. In the transition zone between the olivine meta-gabbro and the garnet amphibolite, increased ductile deformation resulted in grain-size reduction of plagioclase and pyroxene. Microstructures in plagioclase in the transition zone indicate plastic deformation, and the concurrent modal increase in hornblende indicates an influx of fluid. Fabric development and hydration are most apparent in the garnet amphibolite of the ore zone. According to Goldblum and Hill (1992), the olivine meta-gabbro remained competent and initially deformed by brittle processes along its southern margin while the adjacent feldspar-rich meta-syenite and gabbroic meta-anorthosite deformed plastically during deformation at amphibolite facies conditions. Initial grain-size reduction by cataclasis along the margin of the meta-gabbro allowed hydration and retrograde metamorphism to produce the garnet amphibolite. As the hydrated ore body replaced the olivine meta-gabbro, ductile deformation mechanisms replaced cataclasis. During retrograde metamorphism, the garnet amphibolite was likely a high-strain zone of reaction-enhance ductility. Eventually, metamorphic reactions apparently outpaced the rate of deformation and grain coarsening impeded ductile deformation processes (Goldblum and Hill, 1992).

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ROAD LOG

The Gore Mountain mine of the Barton Mines Corporation is generally open seasonally for visitors. However, it is suggested that visitors call in advance to be sure the mine is open. Arrangements for group tours at any time should be made through Barton Mines Corp., North Creek, NY 12853, (518) 251-2296. DO NOT attempt to visit this mine without permission.

This trip log begins at the intersection of US Route 90 (NYS Thruway) and US Route 87 (Northway) at Thruway Exit 24 (Northway Exit 2).

	Milage	Cumulative milage
Rt. 90/Rt. 87 Interchange	0	0
Travel north on Rt. 87 to Warrensburg, Exit 23	60.2	60.2
Go to end of exit ramp, turn left	0.3	60.5
Go to traffic light at NYS Rt. 9 north, turn right	0.1	60.6
Travel through Warrensburg on Rt. 9		
Traffic light, go straight	0.2	60.8
Traffic light at Rt. 418, go straight	0.6	61.4
Traffic light at fork, fork to right on Rt. 9	0.5	61.9
Travel Rt. 9 north to intersection with NYS Rt. 28, Turn left on Rt. 28 west	2.9	64.8
Blinker at Rt. 8 intersection, go straight	11	75.8
Intersection with Rt. 28N, go straight	6.6	82.4
Turn left on Barton Mine Road	4.6	87
Travel to end of Barton Mine Road	5	92

Note: the intersection of Barton Mine Road and Rt. 28 is marked by a small cluster of buildings. Among these are a Mom 'n' Pop general store with gas pumps and Jasco's mineral shop. On the east side of Rt. 28 facing south there is a sign opposite Barton Mine Road indicating the Barton Mine (Gore Mt.) mineral shop.