CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH
JOHN MCLEISH, DIRECTOR

ABRASIVES

PRODUCTS OF CANADA
TECHNOLOGY AND APPLICATION

Part III

Garnet

BY

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INTRODUCTORY

In recognition of the importance of the abrasive industry, and the many inquiries concerning the uses, sources of supply, preparation and markets of the numerous minerals and materials included under the heading of Abrasives, the writer has made an investigation resulting in a series of bulletins embracing the subject in all its phases.

The following publications dealing with abrasives are issued as separate bulletins:—

Part I. Siliceous Abrasives: Sandstones, Quartz, Tripoli, Pumice and Volcanic Dust.

Part II. Corundum and Diamond.

Part III. Garnet.

Part IV. Artificial Abrasives and Manufactured Abrasive Products and their Uses.

In the bulletin on Siliceous Abrasives will be found a general introductory and a table giving the varieties of natural abrasives, forms in which they are used and their principal uses, also a table showing the production of the various natural abrasives by countries between 1913 and 1923.

Up to the present there has been very little collected information on Canadian sources of supply of garnet. Brief references to, and descriptions of, isolated deposits appear in the numerous Government reports and other periodicals. The writer has, therefore, endeavoured to collect and sort out this information and bring it up to date by local inquiries and field investigations. A brief description of the principal deposits, production, and methods of treatment of the foreign materials has been included.

PART III

GARNET

The name "garnet" is given to a certain group of minerals possessing similar physical properties and crystal forms. The group consists of seven different species, all of which are silicates of either aluminium, calcium, magnesium, iron, manganese, or chromium, the different silicates being replaceable, one with another. These varieties are as follows: *Grossularite* (3 CaO, Al_2O_3, 3 SiO_2); *pyrope* (3 MgO, Al_2O_3, 3 SiO_2); *almandite* (3 FeO, Al_2O_3, 3 SiO_2); *spessartite* (3 MnO, Al_2O_3, 3 SiO_2); *andradite* (3 CaO, Fe_2O_3, 3 SiO_2); *uvarovite* (3 CaO, Cr_2O_3, 3 SiO_2) and *rhodolite* which is a mixture of two molecules of pyrope to one of almandite.

GENERAL DESCRIPTION

Garnet crystallizes in the cubic system, commonly as rhombic dodecahedrons, tetragonal trisoctahedrons, or in combinations of the two.[1] It also occurs in an irregular form, either massive or laminated, or as granular aggregates made up of minute crystals usually interspersed with impurities. In many cases impurities such as quartz, mica, hornblende, pyroxene, graphite, etc., are found enclosed within the crystal.

Garnets vary in colour from almost black, through dark red, pink, brown, green, yellow to white. Almandite which is the commonest variety and to some extent andradite are red or brown in colour. The coloured varieties of andradite are melanite (black), demantoid (green), topazolite (yellow-green). The other light-coloured garnets are grossularite (white to yellow) and uvarovite (emerald green). Their occurrence is characterized in the rocks by numerous lumps or nodules, usually of pea size. In some occurrences, depending on the nature of the garnets, the mineral has become so iron-stained and altered on the surface that the characteristics are masked. In other instances the original garnet has become completely changed leaving pseudomorphs of hornblende, scapolite, chlorite, and other minerals.

PHYSICAL PROPERTIES

Hardness: 6·5 to 7·5 on Moh's scale, but some varieties of almandite are said to be 8; *specific gravity:* 3·4 to 4·3; *index of refraction:* almandite, 1·778 to 1·830; andradite, 1·865 to 1·895; *melting point:* almandite, 1,315° C; *streak:* white; *lustre:* vitreous to resinous; *transparency:* transparent to opaque.

Cleavage

Occasionally an indistinct dodecahedral cleavage is observed. Some species possess a pronounced laminated structure which forms planes of weakness along which the mineral separates, but this parting has no relation to the crystal form and is not a true cleavage.[2]

[1] For illustrations see—Dana, E. S.: "System of Mineralogy;" 6th ed., p. 438 (1914).
[2] Myers, W. M. and Anderson, C. O.: U.S. Bureau of Mines, Repts. of Investigations, Serial 2691 (June, 1925)

Fracture

Garnets possessing a glassy structure usually have a marked conchoidal fracture and the mineral in many cases tends to break in thin flakes. In other varieties the fracture is sharp and uneven.

Tenacity

Aggregates of crystals, or the laminated varieties, fracture readily into their component parts. The massive varieties and well-formed crystals are very tough.

OCCURRENCE

Garnets occur in a large variety of rocks all over the world, more particularly in gneisses and schists, and in some cases in such large quantities that rocks are designated as garnet schists or gneisses. They also occur as contact metamorphic deposits in crystalline limestones, pegmatites, serpentines, etc. Hornblende and mica are the usual associated minerals, with quartz, feldspar, and pyroxene in lesser proportions. Garnet also occurs in gangue in ore veins such as iron and copper. Garnets and other aluminium silicates are "high temperature" minerals and are usually found around intrusive contacts, or vein deposits of high temperature origin.

On account of being more resistant to weathering, chemical action, and erosion than their associated rocks, the garnets often occur as a detritus of crystals in the immediate vicinity of the original rocks or as rounded grains in river and sea sands.

As all garnet mining is confined to opencast methods, no reliable information is available as to its occurrence at depth, although garnet has sometimes been found in the gangue at moderate depths when mining other ores.

Due mainly to the small demand, only a few deposits have been developed and there has, therefore, been no extensive research into the origin and methods of occurrence of garnet.

USES

Since prehistoric times transparent garnets possessing an attractive colour have been used for ornamental purposes or for semi-precious stones. The various colours and species have, when found pure enough, been used for cheap gems, more particularly as jewels in the bearings of watches, though ruby and sapphire, on account of their superior hardness, are employed in the better-grade movements. The value of the world's gem garnet production in 1922 is stated to have been $68,000.[1] A detailed account of the localities from which gem garnets are produced will be found in Myers and Anderson's report.[2]

During the war a patent[3] was taken out for making ferro-silicon and aluminous abrasive from almandite garnet. Although good results might be obtained it is doubtful whether the process would be profitable under the present conditions when ferro-silicon is cheaply produced and garnet expensive.

[1] Ball, S. H.: "The Geological and Geographical Occurrence of Precious Stones;" Econ. Geol., Vol. 17, pp. 575-601 (Nov. 1922).

[2] Myers, W. M. and Anderson, C. O.: "Garnet, Its Mining, Milling and Utilization;" U.S. Bur. of Mines, Bull. 256, pp. 6-10 (1925).

[3] U.S. Pat. 1192394, July 25, 1916; also Thompson and Davenport: "The Electric Furnace Reduction of Garnet;" Chem. and Met. Eng., Vol. 22, p. 596 (1920).

QUALIFICATIONS OF ABRASIVE GARNET

Many of the species of garnets vary considerably as to colour, hardness, toughness and method of fracture. For the best abrasive purposes the mineral must be the hardest possible, at least 7·5 (quartz is 7·0). When the garnet is crushed the grains should break into sharp angular fragments without curves, flat, or rounded edges. The mineral should be so tough as not to break too easily and so brittle that the individual grains will eventually break and form new cutting edges rather than become rounded under the strain of use. When used as a coated abrasive long, "slivery" or thin grains do not arrange themselves correctly since they tend to lie too flat, thus presenting a smooth surface, or they protrude above the surrounding grains and tend to scratch. Furthermore, the crushed garnet grains should have a high capillary attraction in order that the glue will completely cover and adhere to them when they are being coated on to the paper or cloth. The colour does not seem to have any particular bearing on the abrasive qualities, but the deep red-coloured mineral is always preferred. This may be due to prejudice, since the Spanish garnet is of a pale pink colour and is of inferior quality.

The garnet should allow of being broken into comparatively large (pea size) clean and solid pieces with a minimum amount of fines so that the full ranges of grades necessary for coated papers can be obtained, and, therefore, deposits that contain garnets of very small crystals are of little or no commercial value, no matter how great the garnet content of the rock may be. Granular garnet usually breaks into rounded grains; other deposits containing large crystals which are badly shattered would, with little pressure, crumble almost to a dust. The grains in garnet sands are not only too small but are also rounded by erosion and water action. Among the common types of deposits, those containing clean unfractured individual red crystals, at least the size of a pea, but preferably larger, should be suitable for abrasive purposes and the ore should contain at least 10 per cent garnet in order to be commercially valuable. The solid, hard and compact massive garnet might be used commercially, but comparatively little experimental work has been done on this type. Up to the present the highest grade abrasive material has been obtained from the large laminated crystals or boulders of red garnet such as occur in New York state.

Almandite is by far the commonest of the garnets and is the type most employed for abrasive purposes, although andradite and rhodolite are also used. They are all iron garnets.

Uses of Abrasive Garnet

General

Over 90 per cent of the garnet mined is used for the manufacture of garnet-coated papers and cloths and the remainder as a lower-priced material in the form of loose grain for various purposes such as for surfacing and polishing marble, slate, soapstone and other soft stones; in some sand-blast operations, and for the surfacing of plate glass. A detailed account of these operations, the manufacture of abrasive-coated papers, and the preparation of the grain will be found in the bulletin "Artificial Abrasives."

Garnet-coated Papers and Cloths

On the American continent garnet-coated papers and cloths are used, almost to the exclusion of all other forms of abrasives, in the wood-working industries, particularly for hard woods. In abrading soft woods garnet and quartz papers appear to be nearly equally efficient since both are soon clogged with the wood particles; consequently there is no advantage in the higher priced garnet. The recent introduction of open-coated papers, however, largely overcomes this trouble. In hard woods the superiority of garnet over quartz is most pronounced and the cutting efficiency of the former is said to be from 2 to 6 times that of the latter. These papers are also used for the finishing of hard rubber and celluloid, also for felt and silk hats, and as fine disks in dental work. They are employed quite extensively on leather, particularly in the boot and shoe industry for the scouring of heels and soles. In recent years fine grits of waterproof garnet papers have taken the place of pumice in the rubbing down of varnished and painted surfaces, especially for automobile bodies. Garnet cloths are sometimes used for the softer metals such as brass and copper.

The garnet-coated abrasive is used in the form of belts, covers for drums, disks, and as small sheets in hand work.

The different grades of garnet used on these papers and cloths range from No. 5, the coarsest which is about 15 mesh, to 7/0 which is about 220 mesh. (*see* Table IV).

There are about a dozen manufacturers of abrasive-coated papers in the United States, and two in Canada, namely the Abrasives Limited, Brantford, Ontario, and the Western Abrasives Limited, Victoria, British Columbia, but the latter is now closed down.

Loose Grain

The largest use for garnet in the form of loose grains is for the surfacing of plate glass, and in the United States several plate glass manufacturers are now using crude water-graded garnet in the "fining" process between the sanding and final rouge polishing operations. An account of the method of the preparation of the garnet for this purpose is described under "Concentration."

A small amount of garnet grain is bonded into wheels for use in glass and some metal grinding. The silicate or shellac processes of manufacture are used, since the low fusion point of garnet (1300° C.) and its alteration by heat, renders it impossible to make garnet into wheels by the vitrified process.

Garnet has been used with some success for the surfacing of the softer ornamental stones, also as a substitute for sand in sand-blasting operations; and as the abrasive used with gang saws for cutting stone, but these uses are still in the experimental stage.

European Demand

In Europe, garnet is not employed so extensively as on the American continent, although its use is increasing. This may be attributed to the high price of garnet and to the use of chalk flint, which is cheaper and

occurs in great abundance in England and France. It is superior to the American flint or quartz and almost equal to garnet in its abrasive qualities. The annual consumption of garnet in England probably does not exceed 2,000 tons per year.

MARKETING AND PRICES OF ABRASIVE GARNET

The price of the best American garnet in the form of a high-grade mixed concentrate (over 90 per cent garnet), free of fines, is about $85 to $90 per ton in bags of 100 to 150 pounds, f.o.b. shipping point. The finished and graded grains vary from 3 to 10 cents per pound depending on grade or size of grain. The inferior types of garnet, such as the Spanish and low-grade concentrates, sell for about $50 to $60 per ton.

TARIFF

Crude garnet ore, as well as ungraded garnet concentrates, enters the United States on the free list.

A sample of mixed garnet concentrates was recently (March 1926) submitted to the Director of Customs, Washington, resulting in the following statement:—

"Ungraded garnet like the sample submitted would, in the opinion of the Department, be free of duty as a crude mineral under paragraph 1619 of the tariff act—

Para. 1619 "Minerals crude, or not advanced in value of condition by refining or grinding, or by other process of manufacture not specially provided for".....FREE

Graded grain or specially prepared garnet is dutiable at 1 cent per pound under the provisions of paragraph 1415 as follows:—

"Emery, corundum, and artificial abrasive grains and emery, corundum and artificial abrasives, ground, pulverized refined or manufactured".....1 cent per pound.

Crude garnet for use as precious stones or for decorative purposes is dutiable at 10 per cent ad valorem.

WORLD'S OCCURRENCES AND PRODUCTION OF ABRASIVE GARNET

HISTORICAL

Garnet was first employed as an abrasive in United States and became commercially important about 1880, when it was used as a coated abrasive by Herman Behr and Company of Brooklyn, New York,[1] and its superiority over flint and the Californian red carnelian for sanding hardwood was quickly established. The first mining operations were conducted by Mr. H. H. Barton of Philadelphia, in the Adirondack section of New York state, followed immediately afterwards by the development of a deposit by Herman Behr at Boothwyn, Delaware county, Pennsylvania, and later, of deposits in Connecticut. The first large-scale milling of garnet ores was done by Mr. F. C. Hooper of the North River Garnet Co., North River, New York, in 1893. After the exhaustion of the Pennsylvania and Connecticut deposits, production was confined to New York, New Hampshire, and North Carolina. The New York mines are now the world's leading producers.

[1] Abrasive Industry, p. 128 (April, 1923).

For many years garnet has been produced from Spain, but is of inferior quality to the American and was never a serious competitor, except in the early days of the industry, and the present output of Spanish garnet is almost negligible.

PRODUCTION AND DISTRIBUTION

The world's commercial abrasive garnet deposits appear to be mainly confined to the American continent. Although there are numerous occurrences in other countries, there has been no recorded production outside America, except from Spain and small quantities from India and Madagascar. The statistics for the early Spanish output are not available but at their best did not exceed 2,500 tons per year and are now about one-tenth of this. The American production which is about 8,000 tons annually, is given under the description of the United States deposits. Garnet was first mined in Canada in 1924 when about 1,200 tons was exported.

A description of Canadian garnet occurrences, followed by a brief review of the world's principal deposits, will be found in the following pages.

CANADA

BRITISH COLUMBIA

The known garnet occurrences in British Columbia are comparatively few, and of these, the majority have been found as one of the gangue minerals when mining for various metallic minerals, principally copper ores. To date, none of these garnet occurrences has been seriously considered as suitable for abrasive purposes, and little, if any, information is available concerning their extent or abrasive properties. The locations of various occurrences mentioned from time to time in different Government reports have been collected with the available information in case some of them may prove to be of economic value.

Besides the Stikine River (Alaska) garnets, probably the only occurrences mentioned below that may possibly prove of some commercial value are those at Kootenay lake, Columbia river, Kamloops, and North Thompson river.

Ainsworth Mining Division

Garnetiferous and mica schists occur on the west shore of Kootenay lake, north of Ainsworth. These schists outcrop along the roadside for a distance of several miles and their disintegration causes quantities of small garnets to be strewn all over the road. The garnets are pea size and smaller, of a dark brown colour, and their percentage in the schist is usually low. The band is over 1,000 feet wide, and strikes due north, and dips about 45 degrees west. It has been traced from Ainsworth almost up to the head of Kootenay lake.

It is possible that there are bands or pockets where the garnets are larger and more concentrated than those seen near the lake shore. Garnet schists also occur north of Kootenay lake in the Lardeau valley.

Figure 1. Garnet occurrences in British Columbia. (For reference Nos., See Table I.)

Kamloops Mining Division

Light grey garnetiferous mica schists are exposed along the side of the Shuswap-Okanagan road between Lansdowne and Grande Prairie about half way between the former and the first bridge over the Salmon river near Davidson creek. The garnet crystals are reported to be nearly equal in size to the Stikine garnets and in places to form at least half the rock mass.

Revelstoke Mining Division

A large body of garnet ore is stated to occur between Gold and Downie creeks on the Columbia river about 40 miles north of Revelstoke. Garnet sands are also in evidence in many places along the Columbia river in this region. Samples of the main ore-body submitted by Mr. McBean of Revelstoke showed that the garnet consists of masses of large, intertwined crystals of an opaque brownish red colour. The fracture and abrasive qualities appear to be good, although the colour is not of the best.

Stikine Area

A short distance from the shore, at Rothsay point, which is at the entrance of the Stikine river opposite Wrangell, beautifully formed, large and almost transparent, claret-coloured garnet crystals occur in a fine-grained, dark grey, crystalline, siliceous mica-schist. Perfect crystals of combined dodecahedrons and tetragonal trisoctahedrons over an inch in diameter are found in many places. These crystals are studded throughout the schist at fairly close and regular intervals. They readily fall out when the rock is fractured or they may be picked out with a knife.

These garnet schists are in United States territory within a few miles of the International Boundary. The schists strike northwest-southeast, which is almost parallel to the boundary line, and dip west. Similar occurrences have been reported farther up the Stikine river in British Columbia but no definite information is available. The garnets possess excellent abrasive qualities but the long distance haulage to manufacturing centres is a disadvantage. However, considerable quantities have, in the past, been mined and shipped to various places including Victoria, where the Western Abrasives Limited, makes abrasive papers and cloths.

In concentrating, advantage is taken of the ease in which the garnets are freed from the rocks, for, after a light crushing, the loose garnets can be quickly picked out by hand.[1]

Well-formed garnet crystals are also found associated with the copper ores in the White River district, near the head of Cross creek.

Maritime Provinces

Garnet is not common in the Maritime Provinces and with the exception of a deposit at Chegoggin point, Yarmouth county, Nova Scotia, none of the known occurrences appears large enough or produces garnets suitable for present abrasive requirements.

Brief information concerning these occurrences will be found in the general table.

[1]The Stikine garnet deposit was recently acquired by the Western Garnets Limited, of Victoria, B.C., who contemplate erecting a mill on the property in the near future.

Yarmouth County

Chegoggin Point. A belt of garnetiferous hornblende-schist about 60 feet in width outcrops on the seashore, a quarter of a mile north of Chegoggin point, 4 miles west of Yarmouth. In the central part of the belt there is a band about 30 feet wide which is very thickly studded with well-formed, opaque, red-brown garnets varying in size from a large pea to three-quarters of an inch in diameter.

At low water the rocks are exposed for several hundred feet and the garnet ridge protrudes prominently above the lower-lying, soft, grey schists and slate belts on its westerly contact. (*See* Plate I A and B). The rocks at this point dip about 70 degrees to the east and strike diagonally inland at about 40 degrees to the east. On the east of the garnet ridge there is a sharp contact with a white clean quartzite belt some 350 feet in width; in places this quartzite is banded grey and white. Black hornblende schist, interbanded with quartzites, occurs still farther east. Within these schists there are a few narrow bands of garnets.

Along the line of strike the rocks are hidden beneath the drift, but at a distance of about 3 miles, near the edge of Utley lake, a pit has been dug revealing the garnet ridge (*see* Figure 3). No sign of the ore-body can be seen around the shore of the lake owing to overburden and sand, but about 12 miles to the northeast, directly along the line of strike, red garnet sands occur in the eastern shore of lake George and on both shores of Brazil lake which lies immediately to the east of the former lake. The sands consist of deep pink and clear grains.

About 1892, J. O. Huntingdon investigated the belt as a source of abrasive and sank two pits, one near the shore and one near Utley lake. Some of the material was crushed in a stamp mill erected previously on the shore to crush the quartzite. According to local information about a ton of crushed, semi-concentrated garnet was shipped to the United States for the manufacture of grinding-wheels.

Concentration tests were recently made on garnet from this deposit by Mr. A. E. Flynn, of the Nova Scotia Technical College, Halifax. The tests showed that the garnet is fairly easy to concentrate, but care must be exercised to eliminate the hornblende. The usual gravity methods were employed, crushing to 6 mesh, screening through 20 mesh, jigging, further crushing, tabling, and final magnetic separation. The samples obtained for the above experiments were close to the surface and somewhat weathered, but, below the weathered zone, the garnets should be cleaner and easier to concentrate. Although abrasive tests were not up to the standard of the best American garnet, due allowance should be made for the weathered nature of the samples.

It appears that this deposit continues for a considerable distance and where exposed on the seashore averages at least 40 per cent garnet over a width of more than 30 feet. It can be easily and economically mined, concentrated, and transported either by water or rail. Commercial use might be also made of the white quartzite, which parallels the garnet ridge.

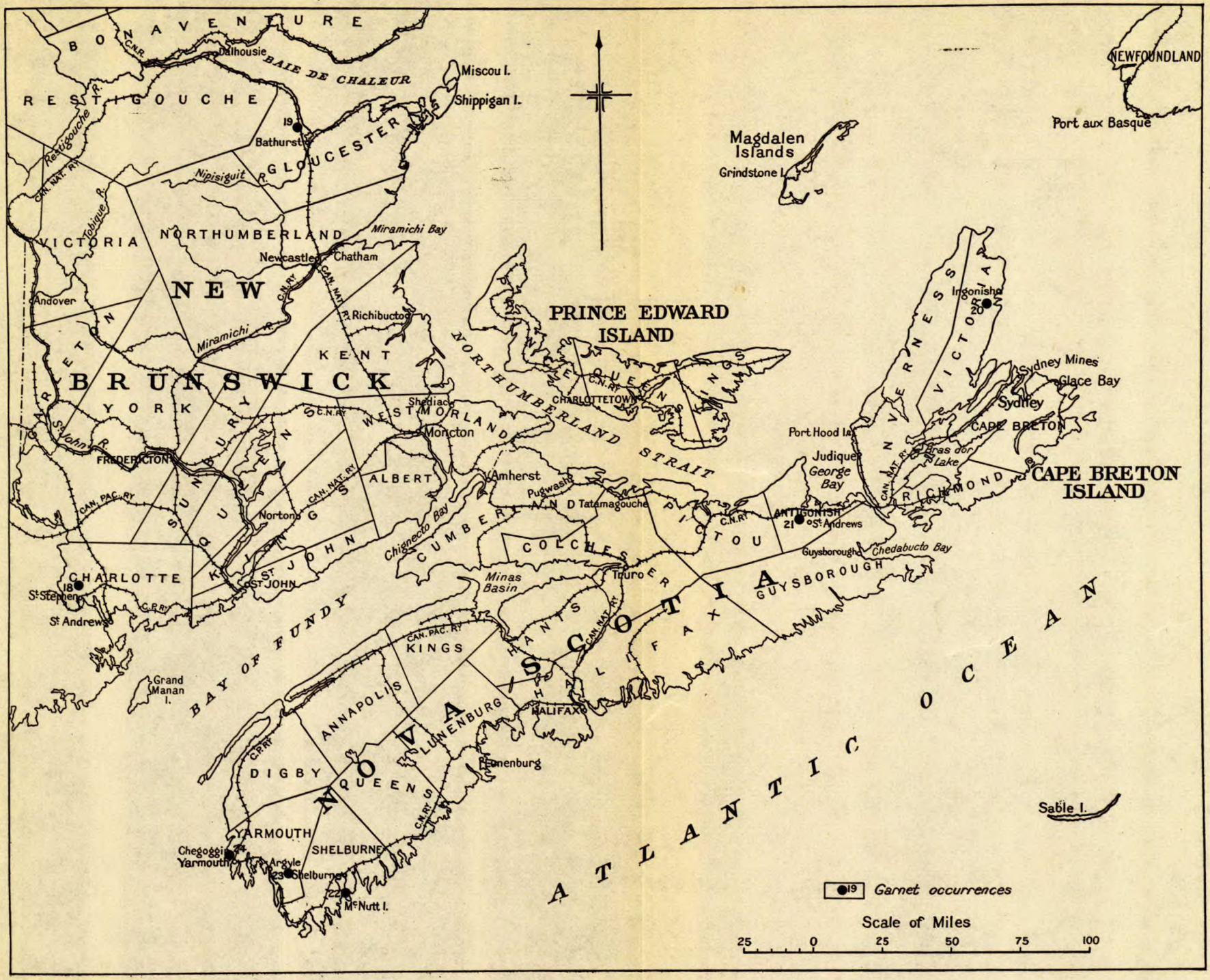
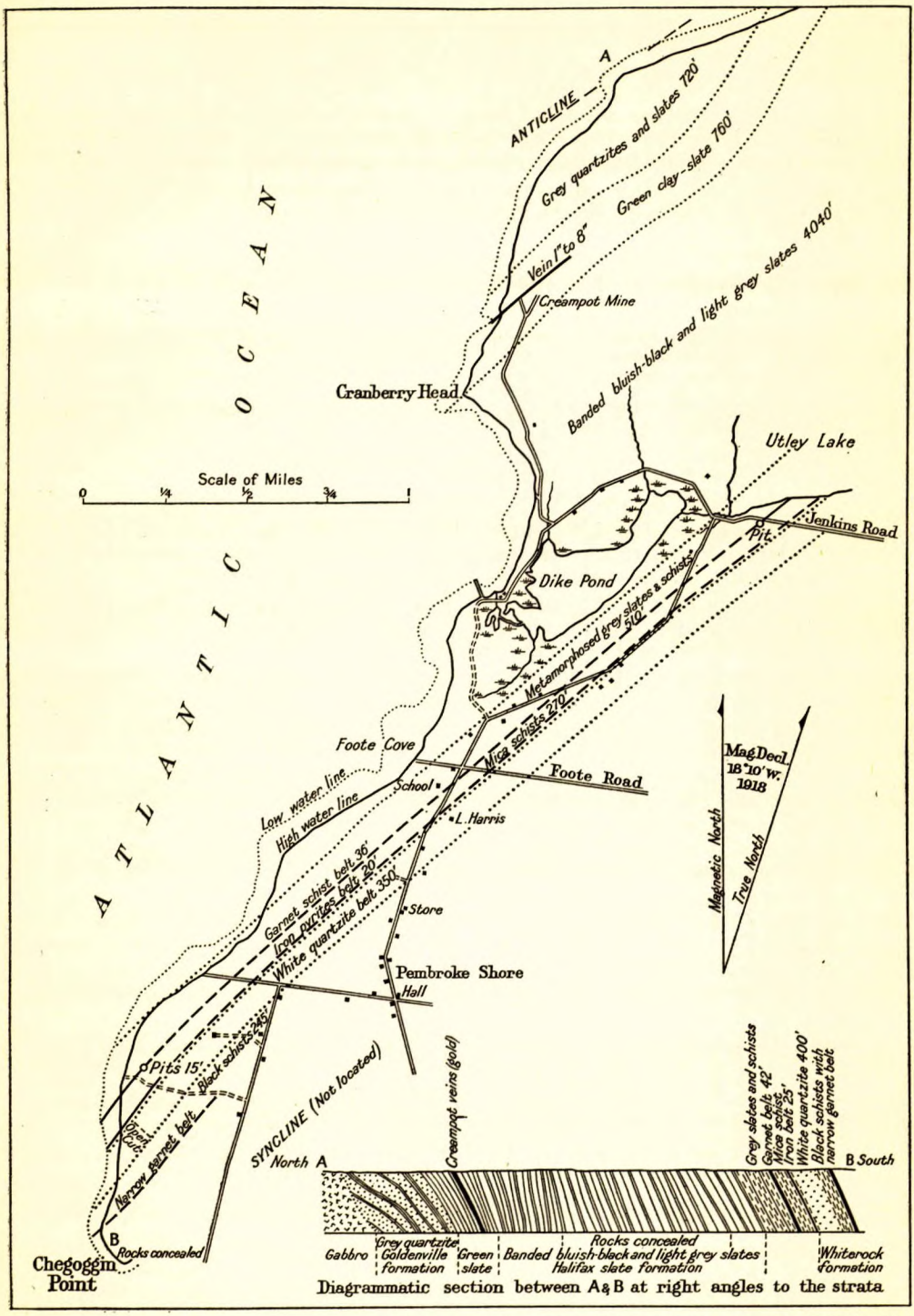


Figure 2. Garnet occurrences in New Brunswick and Nova Scotia. (For reference Nos., See Table I.)



Sketch by E. R. Faribault, Geol. Surv., Canada, Sum. Rept. Pt. F., 1919 (p. 14)

Figure 3. Geological plan and section showing the garnet zone at Chegoggin point, Yarmouth county, N.S.

ONTARIO

There are a large number of garnet occurrences in southern Ontario and the Sudbury district. The great majority of these are garnetiferous gneisses with hornblende and flake mica as the common accessory minerals. In some of the Sudbury deposits perfectly formed, though much shattered, walnut-sized, reddish crystals are evenly scattered throughout the schist; thus differing from any other deposits so far found in Canada. The deposits east of Bancroft, one of which, in Ashby township, has been worked for some years, are amongst the highest in garnet content. The Parry Island deposit in Georgian bay is one of the largest known and although somewhat low in garnet is now being worked. The garnets all appear to be of the almandite variety with the exception of those of the semi-massive or cryptocrystalline nature, which are andradites.

About a dozen of the occurrences here mentioned show possibilities of being of commercial value.

Frontenac County

Hinchinbrooke Township

Concession II, Lot 4, Campsall Deposit. Somewhat contorted and folded micaceous garnet-gneiss bands, totalling about 100 feet in width, occur on E. Campsall's farm at Godfrey station 300 yards north of the road. The garnet crystals are large but badly fractured and filled with quartz, mica, and other minerals. In places they occur in masses intimately mixed with these minerals, but large fragments of a good clear garnet were also noted. However, the deposit is of doubtful commercial value.

Olden Township

Concession VII, Lot 1. On Bismark Wager's farm near the south shore of Long lake there is a prominent ridge containing massive red-brown garnets of the andradite variety interbanded with white quartzite. The deposit which is about 50 feet wide occurs in a pink granite gneiss and is intimately mixed with quartzite, hornblende, calcite, and in places a considerable quantity of iron pyrites. The whole surface is stained by the weathering of the pyrites.

The garnet is of the semi-massive type and the deposit comprises clusters of innumerable, tiny, well-formed crystals, with occasional large crystals in the edge of vugs or cavities within the mass. It is unsuitable for use in coated papers, but could be used as a cheaper grade of abrasive garnet, such as for glass grinding. (*See* Table V, No. 28.)

Portland Township

Concession XI, Lot 12, Ludbrook Deposit. On A. Ludbrook's farm, 1 mile west of Verona, a garnet-gneiss band 30 feet wide crosses the road about 200 yards east of the farm. This belt can be traced from the southeast corner of lot 12 to about three-fourths up (north) the west line fence, and thence it turns about 40 degrees to the east until it disappears under the swamp of Mud lake. Where it turns, the belt is about 60 feet wide

and dips 70 degrees to the east. In the centre of this belt there is a 6-foot band, well studded with fairly large garnets, ½ to 1 inch in diameter, but towards the edges of the main belt the garnets are from pea size to smaller. The best showing is a quarter of a mile south of Mud lake where the garnet ridge is exposed and the deposit might be economically mined. (*See* Plate II A.)

The garnets are well-formed, dark red-brown in colour and in places make up about 40 per cent of the rock. The deposit has good possibilities of being of commercial value. (*See* Table V, No. 30).

Concession XI, W. ½ Lot 14, Card Deposit. On the farm of S. Card about one mile west of the above deposit several parallel belts of garnet gneiss occur. These belts strike approximately north and south and occur as parallel bands of gneiss, each 20 to 30 feet wide, which carry varying quantities of garnet, with intervals of 20 to 50 feet of gneiss, that are barren of garnets. In some of the gneiss bands in which the garnets are usually about pea size, there are 2- to 3-foot bands containing walnut-sized garnets. These alternate gneiss and garnet-gneiss bands, which are somewhat foliated and twisted, can be traced for 400 or 500 feet across the strike, and probably extend farther, for they are reported as occurring farther east close to the deposit on lot 12 which has already been described.

The garnet and mode of occurrence are very similar to the deposit on lot 12, but are on the whole poorer in quality. However, the whole area might be economically worked by one operator. (*See* Table V, No. 31).

Haliburton County

Harcourt Township

Concession IX, Lots 11 to 13, Fishtail Lake. Fishtail lake is 6 miles north of Mumford station by road, but the last 3 miles is only a rough wagon road.

On the north shore of the lake, where the garnet occurs, the rock is a dark brown, basic gneiss or amphibolite, a product of the extreme alteration of limestone by a granite magma.[1] The amphibolite mass is largely composed of anthophyllite and garnet associated with quartz, biotite, and the rare mineral cordierite. The garnet band lies in the granite gneiss between two narrow masses of limestone and has a general east and west strike.

On approaching from the east, or "tail" of the lake, the first garnet outcrop occurs on the southern shore of the narrows and again on a small island at the northeast end of the main body of the lake, where the garnets are small and not very plentiful. Farther west along the strike the ore again outcrops along the north shore, at the mouth of a small creek, about half way down the lake. Here there is a mass about 30 feet wide which averages 30 per cent garnet and is composed mainly of large, pink garnets many of which are over 1½ inches in diameter. (*See* Plate II B.)

These garnetiferous outcrops are exposed for about 500 yards and in places are rich in well-formed, large and clear red garnets. Near the west end of the lake the garnet ridge disappears into a marsh. Isolated and small patches of garnet can be traced for over 100 feet north across the strike but the main body along the north shore appears to be about

[1] Adams and Barlow: Geol. Surv., Canada, Mem. 6, pp. 170-173 and 383 (1910).

30 feet wide and dips flatly to the south and under the lake. Small bands of garnet gneiss also occur on the islands at the west end, and being south of the main belt are probably parallel zones.

Mr. E. Palmatier states that he has found garnet float north of his farm in concession VIII, lot 18, or 2 miles east of the lake outcrops.

Tests on small samples showed that there would be no difficulty in concentrating the ore by the ordinary gravity methods and the garnet appears to possess good abrasive qualities. The deposit, though at present difficult of access, is worthy of further investigation. (*See* Table V, No. 33.)

Hastings County

Elzevir Township

Concession II, Lot 2, Black River. South of the bridge across the Black river on the Madoc-Actinolite road, dark brown to almost black, well-formed garnets occur in a mica and hornblende schist. The best outcrop may be seen as a large protruding rock opposite the south point of an island a quarter of a mile south of the bridge. The garnet schists strike approximately northwest-southeast and can be traced for about a quarter of a mile from this outcrop in either direction along the strike. The belt is about 100 feet across with a band of micaceous argillites on the north contact and syenite gneiss on the south. The zone containing the largest crystals, which are about cherry size, is 15 feet wide and near the north contact.

Although the garnets may be considered too dark in colour, they are fairly large, well formed, and are easy to concentrate. They should have good abrasive qualities. (*See* Table V, No. 37.) The tailings, which consist mainly of pure white muscovite mica, might be saved as a by-product.

Madoc Township

Concessions X and XI, Lots 9, 10 and 11, Pyrite Mines. In the immediate vicinity of the Canadian Sulphur Ore Company's mine and the Queensboro pyrite mine dark, medium-grained garnetiferous schists occur at and near the margin of a felsite intrusion, the whole being between blue limestone with subordinate beds of greywacke, and a hornblende schist. The garnetiferous zone can be traced across lot 9 and across the east end of lots 10 and 11, the greatest width being about 1,500 feet.

The garnets are of a dark red-brown colour, opaque, and are from pea to cherry size. In many places they occur in masses as continuous beds, and are highly weathered and fractured on the exposed surfaces.

It is possible that the iron necessary to form such extensive garnet zones may have come from the felsite magma, for in places the garnetiferous schist passes gradually into greywacke. Some of the garnet schist may be altered hornblende schist.[1]

The garnets in the southern area on lot 9 do not appear to be of sufficient purity or rich enough to be commercially suitable for abrasive purposes. The larger bodies to the north seem, however, to be of better quality than the former.

[1] Ont. Bureau of Mines, Ann. Rept., Vol. XXII, pt. II, p. 91 (1913).

Monteagle Township

Concession V, Lots 3 and 4, Quirk Deposit. About 9 miles north of Bancroft a deposit, about 40 feet wide, of dark brick-red, fairly clear, massive or cryptocrystalline garnets of the andradite variety, occurs in granite gneiss. The garnet is much broken up and has quartz, hornblende, and feldspar freely scattered throughout it. The ridge in places has the appearance of solid garnet, but close examination shows it to be composed of masses of minute clear red garnet crystals with the above minerals sprinkled throughout.

The garnets would not be suitable for abrasive-coated papers, but could be used for glass grinding. The deposit has been staked by Mr. J. E. Quirk of Hybla. (*See* Table V, No. 39).

Lennox and Addington County

see AR 63-35

Ashby Township

Lot 3 Con 16

Concession XV, Lot 9, Bancroft Mines Syndicate. At present the only garnet deposit in Canada from which regular shipments have been made is situated near the extreme northwest corner of Lennox and Addington county, 4 miles south of Hardwood Lake post office and 15 miles (by a somewhat rough road) east of Bessemer siding, which is the nearest shipping point.

The garnet occurs in a quartzose hornblende-biotite-gneiss which has a general east and west strike. The garnetiferous zone as exposed by strippings is about 150 feet wide. The garnets occur in the fibrous hornblende and in a quartz mica schist. In the former they are somewhat smaller and of a paler pink colour than in the micaceous phase. The whole area runs exceptionally high in garnet, averaging 30 per cent, although some individual zones probably contain about 40 per cent. The garnets are about pea size or slightly larger and are very uniformly and thickly scattered throughout the mica schist. The crystals are well formed and of a clear, deep red, although in the hornblende there are some zones in which the garnets contain minute inclusions of quartz and other minerals. (*See* Table V, No. 43). Throughout parts of the ore-body there is a certain proportion (upwards of 5 per cent) of minute clear garnet crystals of pin's head size or smaller.

Near the shore of a small lake half a mile south of the workings there is an outcrop of narrow garnetiferous bands in flat-lying schist. The garnets are larger than in the main workings, being an inch or more in diameter and of good quality.

The work done by the Bancroft Mines Syndicate (head office in Toronto) during 1923 consists of a quarry of 40 feet into the face of the hill of solid garnet ore and a stripping for 100 feet to the south on the edge of the hill, all in good ore (*see* Figure 5). No attempts have been made to determine the limits of the ore zone and on account of the dense bush and undergrowth very few outcrops are visible.

There is a small creek about 200 yards east of the mill, east of which are precipitous bluffs, where bands of garnetiferous gneiss occur.

A small concentrator was erected in 1922 and in the following year over 1,200 tons of picked ore and concentrates were shipped to the United States abrasive paper and cloth makers. In the fall of the year the mill

Ruby? mine

was destroyed by fire and a new mill, with a flow-sheet based on the results of experiments made by the Mines Branch, was designed. (*See* "Concentration.") The new mill is at present only partly erected.

The garnet has been proved to be well suited for the abrasive purposes required, and commands a price equal to the best on the market. Negotiations are underway to resume operations.

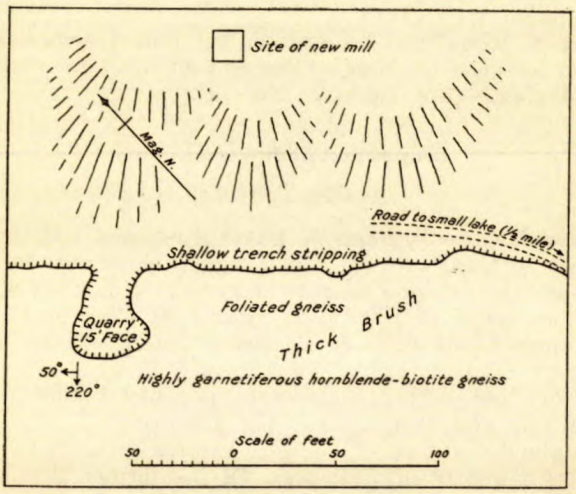


Figure 5. Garnet quarry of the Bancroft Mines Syndicate (1924), lot 9, concession XV, Ashby township, Ontario.

Concession XIV, Lot 26, Hanah Claim. On the same line of strike as the previous deposit and about 4 miles to the west, there is a band of hornblende-biotite gneiss about 400 feet wide carrying well-formed, clear red garnets. This zone contains alternate bands of coarse and fine-grained gneiss and mica schists. The garnets are scattered, but the best zone is near the north contact and is a coarse biotite schist which averages about 15 per cent garnet over a width of 30 feet. In the fine-grained phases of the rock the garnets are much smaller and paler in colour. The rocks are almost vertical with a slight dip to the south and are similar in every respect to those worked by the Bancroft Mines Syndicate, but not so rich in garnet. A few shots which were put in near the side of a small steep ravine, revealed the garnet as well-formed, deep red, and clear crystals. The claim is staked by Peter Hanah of McArthur Mills.

Along the line of strike, and in an easterly direction towards the Bancroft mine, some 400 acres of claims have been staked by Messrs. W. Shutte of McArthur Mills, John Inwood of Ireland, Morrison, Balm, and others. The nature of the ore in each case is very similar to that occurring on the Hanah claim. (*See* Table V, No. 44).

Figure 4. Garnet occurrences in Ontario and Quebec. (For reference Nos., see Table I.)

Kaladar Township

Concession V, Lot 5, Beatty Deposit. Two miles northeast of Addington station and half a mile south of the railway, there is a band of garnetiferous mica schist 50 feet wide. The zone, which occurs 200 yards north of James A. Beatty's farm (Kaladar P.O.), strikes approximately northeast-southwest and can be traced for about 1 mile east and a considerable distance west from the main outcrop on the Beatty farm. The ridge consists of about 30 feet of fairly thickly clustered pea-sized garnets on the southern part, then 6 feet of ½ to 1-inch garnets, which in places are a clear, deep red colour and in others almost black. The remainder of the ridge, across the strike, contains smaller sized garnets. The larger and clearer crystals of garnet occur in the coarse-grained, black biotite schists; the dark garnets are found in muscovite schists which in places almost resemble a sericite and shows flow structure around the garnets.

The garnets appear to be of good abrasive quality, and although the best zone is comparatively narrow, it is of considerable length and is close to transportation. (*See* Table V, No. 45).

Parry Sound District

Parry Island, Garnet Abrasives Corporation, Ltd. Wide, alternate bands of hornblende gneiss and mica schists, both containing garnets and striking east and west, occur on the north side of Parry island near Depot Harbour.

The garnets in these bands are a pale red, and average about pea size. They occur in zones, but there are several rich bands, 6 to 10 feet wide, of large garnets 1 to 2 inches across. Near and along the shore, just to the west of Depot Harbour, the garnets are small, but evenly scattered making up about 12 to 15 per cent of the rock (Figure 6).

The deeper coloured garnets occur in the mica schist which consists of both muscovite and biotite occurring in alternate thin streaks and in places exhibiting flow structure around the garnet crystals. The garnets in the hornblende gneiss are of a paler colour, are not so abundant, and are slightly smaller in size than those occurring in the mica schist. (*See* Table V, No. 47).

The garnetiferous bands can be traced inland from the shore across the strike for about 200 yards within which there are a few narrow zones that are barren of garnets. Beyond these, occasional garnet outcrops occur, but the undergrowth is too thick to determine the true width. The zone can be traced for several miles along the strike and outcrops are exposed at various intervals within the island as well as on the mainland to the east.

A considerable amount of work has been done in the way of prospecting and digging sample trenches. A complete mill test was made by the officers of the Mines Branch, Ottawa, in 1921, when 127 samples were taken from various parts of the deposit and a flow-sheet was evolved.[1] The results of these tests will be found under "Concentration." The mica associated with the ore can be separated and cleaned and might be sold as a by-product.

[1] Carnochan, R. K.: Mines Branch Sum. Rept. 1921, pp. 169-184.

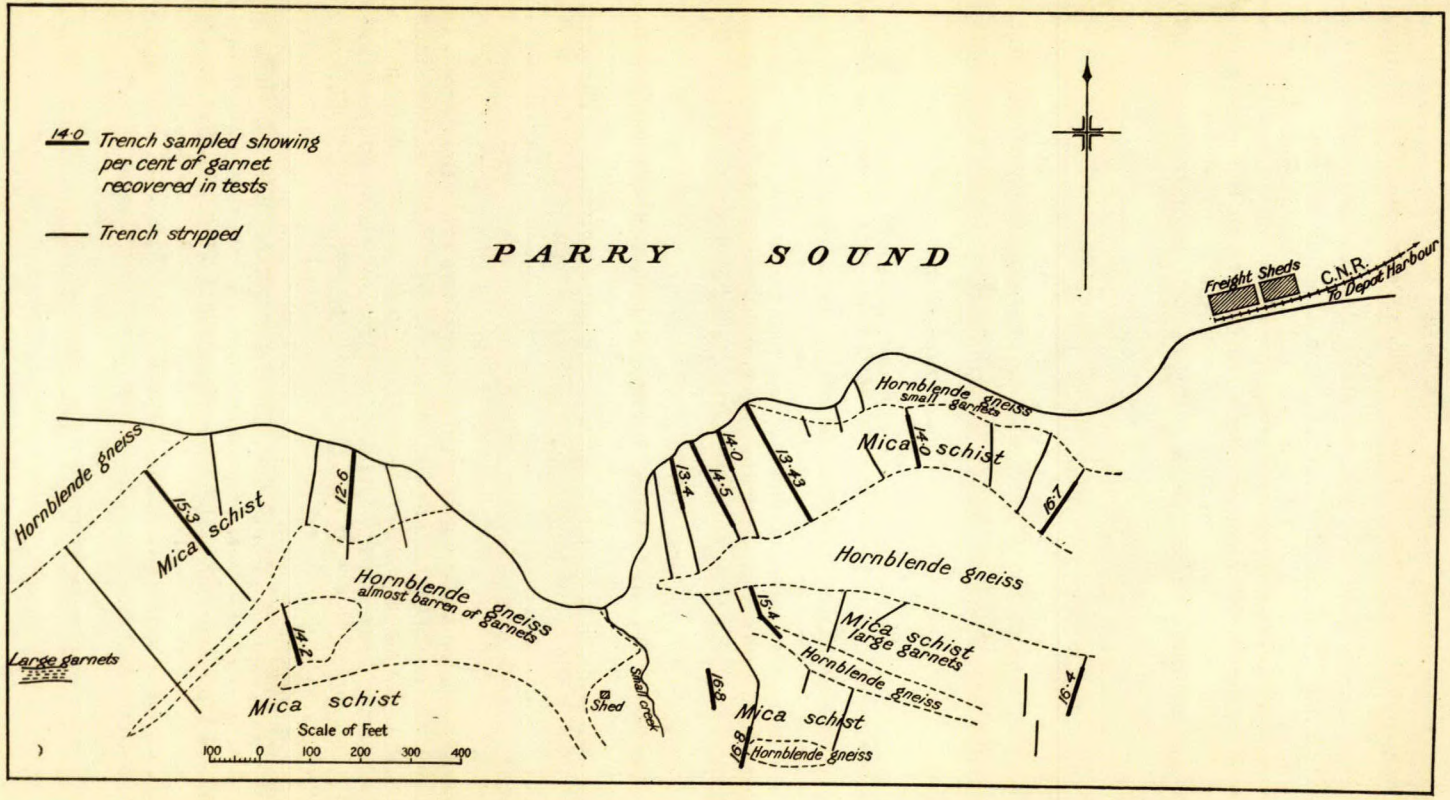


Figure 6. Plan of portion of garnet deposit, Parry island, Parry Sound district, Ontario.

Although the garnet is slightly paler in colour than the best grade American, it possesses a good sharp fracture and good abrasive qualities. The deposit is very extensive, easily mined and the ore is comparatively easy to concentrate, moreover both rail and water transportation facilities can be had alongside of the ore-body.

Mr. R. A. Bryce, Toronto, of the Garnet Abrasives Corporation, Ltd., states that a concentrator will be erected in the near future.

The sands in the bay at the mouth of the small creek are highly garnetiferous. About 100 yards to the west of the creek there is a pegmatite ridge in which blue and green cyanite occurs associated with garnet crystals. This association of cyanite with garnet has been noted in almost every case where the former mineral occurs.

In numerous places around and south of the town of Parry Sound, the mica and hornblende gneisses are studded with small, red garnets. The rocks are somewhat contorted and are also cut up by granite veins running in all directions. These garnet gneisses can be traced at intervals for almost 2 miles east of the town, and southerly across Rosetta island and for some distance south of Parry island. In the former island many of the individual garnet crystals in the hornblende schist are surrounded by a border of yellowish quartz.

Peterborough County

Belmont Township

Concession I, Lot 19, Belmont Iron Mine. The gangue mineral of the Belmont iron mine is almost entirely composed of massive, greenish black garnet which is intimately associated with the magnetite. Thousands of tons of this garnet-magnetite ore are lying on the waste dump. The garnet is very friable and readily crumbles up into a fine powder rendering it unfit for abrasive purposes.

A similar type of garnet occurs on limestone contacts in several other localities in the immediate vicinity.

Sudbury District

Dill Township

Concession IV, Lot 1, Coulis Deposit. Bands of garnetiferous biotite schists are exposed in the railway cuttings on the east bank of the Wanapitei river, 1½ miles north of St. Cloud station. The widest of these bands outcrops near the river, and can be traced in a northeasterly direction for several hundred yards. (*See* Plate III A.) The garnet zone, which dips about 55 degrees to the east, is about 50 feet wide. The richest part appears to be in the vicinity of the railway track along the east side of which the garnet zone follows for about 100 feet and eventually crosses the track and again outcrops on a steep bluff beside the river. Farther along the strike in a southerly direction the garnetiferous schists outcrop on the west side of the river, but the zone is much broken up and the garnets are of very poor quality. In a northerly direction, along the strike, the garnets occur in a foliated quartzose gneiss (Plate III B).

In the best showing, already referred to, which is staked by Louis L. Coulis, of Sudbury, the garnets vary from pea size to 2 inches across, but in nearly every case these larger crystals have a granular structure and are

full of minute crystals of hornblende, quartz, chlorite, and other minerals. (*See* Table V, No. 55). On the easterly contact there is a band of almost black fibrous hornblende. About 50 yards south of where this band crosses the track there is another parallel garnet zone about 10 feet wide with the same dip and strike. The garnets are very similar to those of the other zone, but are less abundant. (*See* Plate III A.).

No work has been done on the property except one or two small shots put in north of the track, but if the whole zone contains badly shattered garnets the deposit is unlikely to be suitable for high-grade abrasive purposes.

About 10 miles south of the above another garnet belt runs in a southwesterly direction from Burwash station on the Canadian National railway. These garnets appear in every respect similar to those described farther north. According to T. T. Quirke[1] the continuation of this streak is marked at Collins inlet, on Georgian bay, about 30 miles to the southwest, where the sands are garnetiferous.

Several other garnet zones have been reported as occurring in this region and garnets may be expected wherever the granite has intruded sedimentary or metamorphic rocks, particularly the dark-coloured gneisses and schists.

Loughrin Township

Concession 1, W. ½ of lot 12, MacDonald Deposit. On the farm of Alex. D. MacDonald, 4 miles north of Markstay station on the Canadian Pacific railway, garnet occurs in a coarse biotite gneiss. The belt is about 100 feet across and strikes approximately northeast-southwest, and is roughly divided into three zones of about 30 feet each containing very large, medium, and small garnets. The main ridge can be traced for about one-half mile northeasterly from the discovery outcrop before entering a swamp, but in the other direction it almost immediately enters low-lying swampy ground and is lost. The large garnets are nearest the eastern contact and occur as almost perfect dodecahedron crystals averaging 1½ inches in diameter. These garnets are spaced about 3 inches apart throughout the biotite gneiss. All the garnets so far examined, including the most symmetrically perfect crystals, have a granular appearance on the fractured surfaces, and in many cases contain inclusions of minute crystals of other minerals. On the exposed surfaces of the rock these garnets, although retaining their symmetrical outline, are very much pitted. At one foot below the surface the garnets appear to be more compact, so that at depth a better grade of mineral may exist. This peculiar occurrence of the garnet in such perfect crystals is the only one of its kind in Canada known to the writer.[2]

The medium- or pea-sized garnets are much clearer than the larger ones described above and are associated with quartz; and in places make up at least one-third of the rock constituents.

Concentration tests on small samples of both the large and medium garnets showed that clean material in the finer meshes can be made without much difficulty. (*See* Table V, Nos. 1 and 2.) No work has as yet been done except for a few inches of rock removed by a light charge.

[1] Quirke, T. T.: "Mineral Deposits of Rutter Map-Area, Ontario;" Geol. Surv., Canada, Sum. Rept., Pt. C, 1924, p. 93.

[2] Since going to press samples of a similar type of garnet have been received from J. T. Whalen, of Kipling, Ont., from a deposit 30 miles east of the above.

The deposit is well worthy of further investigation as a possible source for commercial abrasive garnets.

QUEBEC

Very extensive areas of garnet gneisses are known to occur throughout the region between Montreal and Quebec from 50 to 150 miles north of the St. Lawrence. The country rocks in the vicinity of Rawdon and St. Jean de Matha are largely garnetiferous, particularly north of the latter, where large laminated crystals are abundant near Black river. Sillimanite, in small crystals, is a common constituent throughout the majority of these Quebec occurrences. Garnetiferous quartzites are plentiful but are of doubtful commercial value as the garnets are usually small and of poor colour. However, the whole rock might be crushed up and used without concentrating as loose grain for such purposes as glass surfacing, etc. The majority of the garnet deposits are associated with, or in close proximity to, crystalline limestone.

At Labelle in Joly township, 100 miles northwest of Montreal there is an exceptional deposit in which deep red, clear garnet occurs in large lumps on the contacts of, and within a series of, parallel pyrrhotite veins.

No work has been done on any of these Quebec garnet deposits but preparations are now under way to exploit the Labelle veins.

Little is known concerning the Mattawin, St. Maurice, or the Saguenay Rivers regions, except that garnet-bearing rocks are abundant. From descriptions furnished by some of the older Geological Survey reports, a few of the areas might contain good abrasive garnet, but they are at present far from rail transportation. However, there are about half a dozen zones within reasonable transportation distance from which good quality abrasive garnet might be produced.

Joliette District

Cathcart Township

A series of bands of garnetiferous gneisses and quartzites run through the extreme southwest corner of Cathcart, and on both sides of the corner post of this township and the townships of Rawdon, Chertsey, and Kildare. The garnet zone can be traced across the strike, which is almost north and south, for at least a quarter of a mile. On the eastern contact there is a band of crystalline limestone beyond which more bands of garnet gneiss occur. Along the road-bed and 50 yards on either side, just within Cathcart, there are several good and well-exposed zones of hard quartzose garnet gneiss. The best exposure, which is about 30 feet wide, is on top of a short steep, hill about 100 yards within the township. In places the rocks average over 30 per cent garnet, the crystals being from $\frac{1}{4}$ to 1 inch in diameter. The garnet bands can be traced north along the road for several hundred yards and appear to be the most promising seen in this region. (*See* Montcalm occurrences; also Table V, No. 66.)

About 3 miles due east at right angles to the strike of the rocks similar garnet rocks again occur bounded on the east by limestone. Since these two limestone bands and the rocks between them dip towards each other, these bands are probably the same. They form the edges of a trough so that the garnet zones on either side of the western limestone band, and

those near the west contact of the eastern band, may be the same, which are exposed by erosion across the folding. A similar occurrence of the folding of the garnet and the limestone is found at Darwin falls, 8 miles to the south. (*See* description under Rawdon township, Montcalm county.)

DeRamsay Seigniory

Exposures of garnetiferous gneisses occur in the immediate vicinity of St. Jean de Matha, 8 miles by good road northwest of St. Felix de Valois station.

Horizontal bands of white garnetiferous quartzites, underlain by rusty crumbling garnet-sillimanite gneisses, occur west and northwest of St. Jean de Matha, and near St. Pierre. Small, pale pink garnets are sparsely scattered throughout the quartzite and in places there are small local concentrations forming clusters. The underlying gneiss, containing hornblende and mica, is badly weathered and rusted on exposed surfaces, and in places, in the unaltered zones below the weathering, bands of dark red, well-formed garnets occur.

East of the road leading to Mr. Durant's farm the outcrops stand out in bold relief, forming the west face of a cliff, and can be traced across their north and south strike for a quarter of a mile. In some of these exposures the garnets are cherry size with alternate bands of pea-sized crystals. On the top of the hill, above the quartzite, other garnet gneiss bands occur, but are not so good as those lower down.

One mile to the south, where the road takes a right angle turn east into St. Jean, a flat, much weathered band of mica gneiss containing very large garnets, some of which are 3 inches in diameter, outcrops on the road-bed. These garnets, which are plentiful, are badly altered and fractured on the exposed surfaces, but close examination of the individual crystals shows them to have been good, fairly dark pink garnets and it is probable that below the altered zone they would be suitable for abrasive purposes. These garnet-sillimanite-gneiss bands occur all along this road 1 to 3 miles west and northwest of St. Jean. They are highly altered and have a general north and south strike.

Farther north, near where the Black river turns south between the two road bridges, there are more of these horizontal bands of weathered sillimanite gneiss enclosing large garnets. This gneiss is fractured horizontally and the large garnets are coated with red-brown iron oxides. There is a little graphite mixed within the mass, and even in some instances within the largest garnet crystals. This flat band of large garnets extends under the south bridge and along the river for about a quarter of a mile northwards, and is about 100 yards wide. There is a band of unaltered greenish hornblende gneiss containing well-formed and good, deep red garnets, which strikes under a saw mill above the north bridge. This band is about 30 feet wide, as exposed, and appears to dip under the rusty weathered garnet-sillimanite gneiss mentioned above. The garnet content in the band is about 25 per cent and has good possibilities for commercial abrasive purposes. (*See* Table V, No. 67.)

An account of the garnetiferous zones farther north of this locality will be found under the Mattawin River area.

Labelle District

Joly Township

Range i, Lot 16. Garnetiferous biotite-quartz-gneisses interbanded with parallel veins of pyrrhotite and massive crystalline garnet occur on the east side of a small lake two miles southwest of Labelle station on the Mont-Laurier branch of the Canadian Pacific railway, 100 miles north of Montreal.

Massive, deep wine-coloured, crystalline garnet occurs on both contacts of the pyrrhotite which is 2 to 4 feet thick. The mineral zones, which are variable in width, occur in a series of lenses or pockets. In places the garnet is distributed throughout the pyrrhotite, almost to the exclusion of the latter, whereas in others about an inch of garnet crystals is along the contacts only. The widest part of one of the veins showed 3 feet of almost solid garnet and 4 feet of pyrrhotite. Small grains of quartz and fine garnet crystals are found in the centre of some of the large crystals of the red garnet. In other parts of the veins, fracturing has been more developed and the garnet, which is of a paler colour, is somewhat granular.

The pyrrhotite in places occurs as solid masses 2 to 4 feet wide and in others intimately mixed with finely divided quartz grains and garnet. The pyrrhotite occurs both fine and coarsely crystalline and in the former the garnet is more abundant, although even the solid pyrrhotite contains some garnet.

Four parallel veins, which are 50, 70, and 200 feet apart and which strike about north 30 degrees east, are exposed, the first being 250 feet east of the small lake. The most easterly outcrop, which is on top of a hill, is about 15 feet wide and consists of very rusty and almost black iron-stained gneiss, in which remains of decomposed garnet masses are visible.

For several yards on either side of the mineral veins the gneisses contain a high percentage of small, pale red garnets varying from the size of a pin's head to a pea. The veins near the lake can be traced at intervals along their strike for several hundred yards and in a southerly direction from the workings they continue to the south end of the lake. For at least a quarter of a mile easterly across the strike there are outcrops of four or five parallel rusty mineral zones, in some of which large garnets are visible. The ore in each of the exposures examined appears to be very similar.

The pure garnet has a clean, irregular, sharp to sub-conchoidal fracture with a highly vitreous lustre. It contains the usual parting planes common to this type of massive almandite, but the fragments are exceptionally hard and tough. It is usually of a dark wine-red colour, but there are pockets where the massive mineral appears almost black. In appearance it is very similar to that of the best American garnet from New York state and is of excellent quality both for colour and abrasive properties, and it is probable that the black variety is better than the New York garnet (*see* Table V, No. 71). Samples sent to some well-known makers of abrasive-coated papers have been very favourably reported upon.

The ore should be easy to concentrate, since the only impurities are pyrrhotite, quartz, mica and a little magnetite, all of which can be eliminated by the ordinary gravity methods and magnetic separation, the first named mineral, being a by-product having a possible market value.

Prospecting work in the nature of stripping and some trenching up to 5 feet in depth has been carried out on the second and third veins. The development and relative positions of the veins are shown in the accompanying sketch (Figure 7).

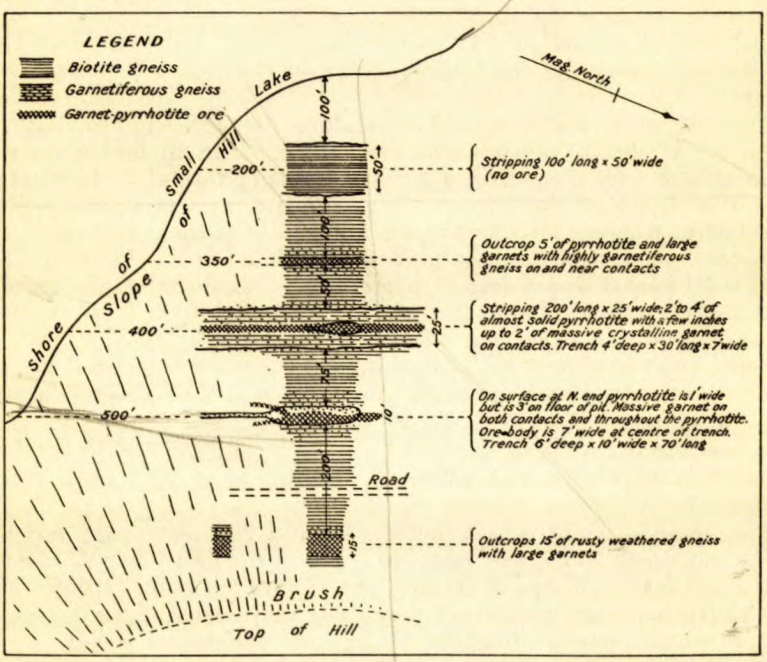


Figure 7. Sketch across strike of mineral-bearing zone of garnet-pyrrhotite veins, Joly township, Quebec.

Although the quantity of garnet in each vein appears to be small, a fair tonnage may be expected if several of the close and parallel veins are worked together. Since the ore-bodies are on the hill-side on the edge of a lake, they are well situated for economic mining and milling. A new road is being constructed to Labelle station, 2 miles to the northeast.

Operations are now being carried out by Messrs. H. Jodoin and F. H. Moranville of Montreal and the erection of a mill and the shipping of garnet concentrates is contemplated in the near future.

Mattawin-St. Maurice Rivers Area

Many exposures of garnetiferous gneisses occur within the area enclosed by the Mattawin and St. Maurice rivers with their tributaries, including parts of the districts of Joliette, Berthier, Maskinonge, St. Maurice, and Champlain. The locations of a great many of these garnetiferous exposures in this region are itemized in R. W. Ells' report on the "Geology of the Three Rivers Map Sheet,"[1] and include the area between latitude 46° 30′ to 47° and longitude 72° to 74° 30′.

[1] Geol. Surv., Canada, Ann. Rept., vol. XI, pt. J, pp. 27-55 (1900).

A few of the recorded exposures are briefly mentioned below but none of them has been investigated for the possible commercial value of the garnet, and no information in this respect is available.

Mattawin River

North of the Mattawin, in the vicinity of the sources of the Post, Hamel, and Milieu rivers in Maskinonge district, there are many outcrops of garnetiferous, reddish grey gneiss and rusty garnet-quartzose gneiss. Garnetiferous gneisses occur in the vicinity of the last rapids of the Milieu river before its junction with the Mattawin, about 7 miles north of St. Michel village. In places the garnets are very abundant and up to one inch in diameter. Similar garnet rocks are found 2 miles north of the village.

Farther east, where the Mattawin flows across the eastern part of St. Maurice district, between Red Pine portage and Bear rapids, there are exposures of over 5 miles of quartzose garnet gneisses, in some of which the garnets are very abundant and of fair size. Red-brown gneisses occur on the shores of Wessonneau lake in the northern part of Batiscan seigniory, Champlain district. In places these gneisses contain patches of bluish quartz and where this mineral occurs the gneiss is highly quartzose and holds larger quantities of garnets.

St. Maurice River

About 8 miles below the junction of the Mattawin with the St. Maurice and 2 miles above the mouth of Mekinac river, dark-coloured garnet gneisses occur associated with thin bands of limestone. Almost all the way down the St. Maurice from Mekinac river to Shawinigan Falls, a distance of about 25 miles, garnets and magnetite are common constituents of the gneisses and they continue down to the junction with the Potsdam sandstone, 3 miles below. The rocks below the falls are banded augen-gneisses containing large crystals of hornblende and feldspar and the garnets therein are also larger than in the gneisses above the falls.

Black, Mastigouche, and Du Loup Rivers

These rivers flow into the St. Lawrence west of the St. Maurice and have their sources in the hills and lakes to the south of the Mattawin.

Highly quartzose garnetiferous gneisses are exposed in numerous places along the banks of the Black river as it winds its way through the northern part of DeRamsay seigniory, Joliette district. Some of these garnets are of good size and quality and were examined for abrasive purposes, an account of which will be found under the St. Jean de Matha occurrences.

To the north of the source of the Black river in Provost township, Berthier district, highly garnetiferous gneisses are associated with bands of limestone that traverse ranges VI and VII to the south and southeast of St. Michel village, but in the occurrence at lake Trèfle there appears to be no limestone.

Brownish grey garnetiferous gneisses outcrop around Chute lake on the Mastigouche river, north of Peterborough township in Maskinonge district. From this point up to the Mattawin river, a distance of 30 miles, garnet rocks occur in many places. To the east and north of Peterborough as far as the Du Loup river the grey garnet gneisses are of very common occurrence, and are well exposed in the vicinity of Sans Bout, Sac-a-Commis, and Sorcier lakes.

Montcalm District

Rawdon Township

Darwin Rapids and Falls. Bands of hard sillimanite-garnet gneiss and quartzite occur at the head of Darwin rapids, half a mile south of Rawdon. The zone of quartzite and garnet rocks strikes about north and south, crosses the Ouareau river, and is about 150 feet wide. Some of the bands, 5 or 6 feet in width, contain up to 30 per cent garnets, which are, however, rarely larger than pea size. There are a few narrow bands in which the crystals are almost an inch across, but they are badly shattered and contain inclusions of other minerals.

At Darwin falls, about 500 yards below the rapids, another series of similar bands outcrop on the east bank of the river. These form a peninsula around which the river turns, and are the eastern edge of the falls. These alternate bands of garnet gneiss and quartzite are about 100 feet across. The garnets of small size are concentrated in parallel bands but on the whole are not so good as those occurring in the rapids above. (*See* Table V, No. 75).

Between the rapids and falls there is a band of crystalline limestone, which passes north through Rawdon village and forms the eastern contact of the garnet zone passing through the southeast corner of Cathcart township, Joliette district, already described. According to F. D. Adams[1] this limestone ridge is the apex of a syncline, the rocks on either side dipping in opposite directions, so that the parallel bands of garnets occurring both at the rapids and the falls may be the same, and are also the southerly continuation of the Cathcart occurrences 8 miles to the north. Since this limestone belt can be traced for a distance of about 20 miles north of Rawdon village, the same garnetiferous rocks may be expected to occur continuously for at least this distance on either side of the belt.

Saguenay District

Gulf of St. Lawrence

Garnetiferous gneisses and quartzites occur in a large number of localities on the north shore and rivers of the gulf of St. Lawrence, particularly on the Manikuagan river.

Proceeding up the river the first outcrop occurs at the Chesniup portage, 13 miles above the mouth, where dark greenish gabbro-gneisses are interbanded with medium-textured, highly micaceous, basic garnetiferous gneisses striking northeast. At Kikaskuatagan portage 20 miles

[1] Geol. Surv., Canada, Ann. Rept., vol. VIII, pt. J (1895).

farther north, coarse-grained, pink and grey garnetiferous augen-gneisses are exposed. At the outlet of Tshimanikuagan lake into the Manikuagan river, about 40 miles above its mouth, dark green garnetiferous schistose mica and hornblende gneisses are exposed for some miles, and contain bands of limestone. In places the garnets are very numerous, of a dark red colour, but small in size. In many places along both shores of Mushalagan lake, which is about 8 miles farther north, there are outcrops of fine-banded, red and grey garnetiferous mica-hornblende gneisses along a distance of at least 12 miles, the more northern exposures being coarser and containing larger garnets. At the head of the lake the rocks are almost wholly composed of dark green, scaly hornblende crystals and dark red garnets varying from pea size to over an inch across, and form a garnet-diorite rock. This garnet diorite appears to be associated with bands of crystalline limestone which also contains many garnets together with graphite and other minerals.

From Mushalagan lake up to the sources of the Manikuagan and Outardes rivers there are frequent occurrences of garnetiferous mica and hornblende gneisses, but the exposures of the best garnets both for size, colour, and quantity appear to be in the region north of Mushalagan lake, some 75 or 80 miles up the river. Transportation distances would, however, be at present too great for these deposits to be of economic importance.

Témiscamingue District

Boisclair Township

Mattawa mountain, about 600 feet in height, is situated near the north shore of the Ottawa river, immediately opposite the town of Mattawa. This mountain is composed of alternate light and dark bands of a greyish granite-gneiss striking east and west. In the darker or more basic parts of the gneiss small red garnets are abundant. Although occasional bands of larger garnets occur they are on the whole probably too small to be of commercial value.

Red garnets occur in the basic portions of the biotite gneiss, 9 miles northwest, farther up the Ottawa river, in the vicinity of Les Erables rapids and Snake creek. The garnet is associated with long, thin-bladed, blue to green crystals of cyanite, which is in places very abundant. The garnets and cyanite are exposed in the cuttings of the Temiskaming branch of the Canadian Pacific railway near Snake Creek station. A similar association of garnet with cyanite has been noted in several other instances. Garnets are reported as occurring 2 miles south of Kipawa, the terminal of the branch line of the Lake Temiskaming railway, 35 miles north of Mattawa. A very basic garnetiferous hornblende-biotite-gneiss occurs at Greenorton bay, 2 miles north of Kipawa station.

TABLE I

Garnet Occurrences and Deposits in Canada

Ref. No.	County, district, or mining division	Locality	Mode of occurrence and description	Rating	Reference	Remarks
			BRITISH COLUMBIA			
1	Ainsworth.....	Kootenay lake, west shore, north of Ainsworth	Pea-size garnets in mica schists 1,000 feet wide, between two belts of limestone	C	1	Garnet percentage small, zone traced for several miles
2	Fort Steele.....	St. Eugene mine, Moyie lake	Small garnets in gangue minerals	H	2. 1911, pp. 162-64.....	
3	"	Sullivan mine, Kimberley	Small garnets in gangue minerals	G	2. 1911, pp. 162-64.....	
4	Greenwood.....	Boundary district, various copper mines	Small garnets in gangue minerals	G.F.	2. vol. XIV, pt. A., pp. 62-63 (1902); also vol. XV, pt. A., pp. 107, 116-126 (1903)	Most abundant in B.C. mine, Summit camp
5	Kamloops.....	Salmon river, Davidson creek	Grey garnetiferous mica schists	C	1; also 2, vol. V, pt. AA., p. 18 (1892)	Garnets reported large and of good quality
6	Nelson.....	Queen Victoria mine Beasley station	Massive garnet as gangue and vein matter on limestone-granodiorite contact	E	2, 1911, p. 154.....	The quantity of garnet is large, but difficult to obtain a clean product
7	Osoyoos.....	Hedley camp, Hedley creek, Tulameen Bear creek	As a gangue mineral in various mines	G	2, 1907, p. 27; also 2, 1909, p. 114	In the Nickel Plate and Sunnyside claims
8	Portland Canal.....	Bear river.....	Disseminated garnet crystals in metamorphosed rocks	G	2, 1910, pp. 69, 71 and 86..	Most abundant at Bitter creek below Bear River canyon
9	Queen Charlotte....	Moresby island.....	As a gangue mineral in various copper mines	G	2, 1909, pp. 75-82	Mainly in vicinity of Jedway, Harriet harbour, and the Copper Queen mine
10	Quesnel.....	North Thompson river, Blue River station and Garnet Creek falls	Garnetiferous mica schists.....	E	2, Rept. of Prog. 1871-72, p. 65	
11	Revelstoke.....	Columbia river, Downie creek	Large, brown, massive intertwined crystals	C	1.....	Deposit 40 miles up Columbia river above Revelstoke. At present far from rail transportation

12	Vancouver island....	Cowichan lake, Alberni canal	Massive garnet as gangue minerals in various copper ore deposits. Limestone contacts	E.F.	2, 1908, p. 58; also 2, 1909, pp. 91-4; also 2, 1910, p. 108	Transportation poor
13	"	Shawnigan lake, Malahat mountain	Garnet in contact zones of metallic sulphides in limestone	F.H.	" "	
14	"	Esquimalt and Highland areas	Garnets sparsely scattered in contact metamorphosed rocks	F.H.	" "	
15	Yukon territory.....	Whitehorse district	Frequent gangue mineral in the copper mines and sometimes occurs in masses over large areas in metamorphic limestone	F.C.	2, 1909, p. 53.....	
			STIKINE AREA			
16	.....	Stikine river, Rothsay point	Perfect, clear red crystals up to 1 inch across in fine-grained siliceous mica schist	B	1, also U.S. Geol. Surv. Bull. 542, p. 51 (1913)	Some of the purest and most perfect garnet crystals have been mined. Used by firm in Victoria, B.C., very far from industrial centres.
			MANITOBA			
17	North of lake Winnipeg.	Reed and Wekusko lakes	Large, well-formed, red garnets in mica and staurolite schists	F.C.	2, 1917, pt. D., p. 12.....	Garnets good quality, and over large area but at present very far from rail transportation
17A	Southeastern area....	Rice lake, Beresford lake	Argillites grading into schists carry an abundance of small, red garnets	H	2, 1923, pt. B, p. 92.....	
			NEW BRUNSWICK			
18	Charlotte.....	Moore lake, 7 miles north of St. Stephens	Small, red garnets in crystalline mica schists and slates close to granite contact	H	2, Rept. of Prog. 1876-77, pp. 328-29; also 1870-71, p. 239.....	Garnets very small.
19	Gloucester.....	Millstream river, 9 miles north of Bathurst	As a gangue mineral in iron ore deposit	H	2, 1908, p. 131.....	Garnets all a greenish colour.

TABLE I—Continued

Garnet Occurrences and Deposits in Canada—*Continued*

Ref. No.	County, district, or mining division	Locality	Mode of occurrence and description	Rating	Reference	Remarks
			NOVA SCOTIA			
20	Cape Breton.....	Victoria, Ingonish river	Garnetiferous granites.....	F	2, Rept. of Prog. 1882-84, pt. H., pp. 16-21	In vicinity of Power brook and the Lake of Islands 8 miles farther north
21	Antigonish.....	Polson lake, 3 miles east of Lochaber lake	Garnets in argillaceous slates.	F	2, vol. II, pt. P., p. 128 (1887)	
22	Shelburne.....	Shelburne harbour..	Minute garnets in staurolite mica schists also garnet sands opposite McNutt island, near Carleton	H	2, vol. IX, pt. M., pp. 54 and 147 (1898)	Larger garnets said to occur more in the interior
23	Yarmouth.....	Stony Creek lake, 10 miles north of Pubnico	Garnets up to cherry size occur in gneiss along lake shore	F	" "	Far from rail transportation. No roads
24	"	Chegoggin point, Yarmouth	30-foot belt, thickly studded with garnets of good quality. Traced for several miles	B	1; also 2, vol. IX, pt. M., p. 147 (1898); also 2, 1919, pt. F., p. 17	Deposit very rich in garnets from pea to cherry size. Well suited for mining and transportation. Best showing so far discovered in Maritime Provinces
			ONTARIO			
25	Frontenac.....	Bedford tp., con. IV, lot 5	30-foot band of quartzite and gneiss, the latter carrying sparsely disseminated large, poor quality garnets	D		6 miles east of Godfrey station on J. J. Wilson's farm
26	"	Hinchinbrooke tp., con. II, lot 4	Badly fractured garnets in gneiss. Some garnets are large or concentrated in masses	D	1.....	
27	"	Loughborough tp., Buck lake	Red banded gneisses interstratified with beds of pea-size garnets	H	2, Rept. of Prog. 1872-73, p. 172	

28	Frontenac.....	Olden tp., con. VII, lot 1, Wager	50-foot ridge of massive to cryptocrystalline red garnets, mixed with pyrites, quartz, etc.	E	1.....	Good location for quarrying
29	"	Palmerston tp., con. II, lot 21	Garnets in hornblende and mica schists underlying dolomite	H	2, vol. XIV, pt. J, p. 42, (1904)	Traced for 4 miles along Ompah-Ardoch road
30	"	Portland tp., con. XI, lot 12, Ludbrook	30- to 60-foot bands of garnet gneiss; centre beds contain fairly large, red-brown garnets	C	1.....	Garnets of fair quality, easy to mine, transportation good
31	"	Portland tp., con. XI, lot 14, Card	Similar to above, but garnets less plentiful and not so large	C	1.....	Same as above. Both deposits should be worked together
32	Haliburton.....	Cardiff tp., cons. VI and VII, lot 22, Paudash lake	20-foot garnet gneiss band. Garnets of fair size but badly broken and of a pale red-brown colour	D	2, Mem. 6, p. 382, (1910)..	Best showing on road-bed where it crosses county line.
33	"	Harcourt tp., con. IX, lots 11-13, Fishtail lake	30-foot band of biotite gneiss and quartz seams between two limestone masses. In places garnets large and plentiful	B	1; also 2, Mem. 6, pp. 170-3, 383 (1910)	Garnets of good colour, easily mined but at present somewhat far from transportation
34	"	Snowdon tp., con. I, lot 20	Garnet found in iron mine. Quantity small	G	2, Mem. 6, p. 203 (1910)...	
35	Hastings.....	Carlow tp., con. XII, lot 24, 15 miles east of Bancroft	Badly shattered pale red-brown garnets sparsely disseminated in narrow gneiss bands totalling 30 feet	G	.....	Occurs on H. Miller's farm
36	"	Dungannon tp., York river	Shattered titaniferous garnets in hornblende syenite	H	2, Mem. 6, p. 251 (1910)...	
37	"	Elzevir tp., con. II, lot 2, Black river	Bands of muscovite-hornblende schists rich in cherry-size, dark garnets	B.C.	1.....	Mining possibilities, transportation and water-power favourable
38	"	Madoc tp., cons. X and XI, lots 9-11, pyrite mines	Shattered, red-brown, opaque garnets in schist on limestone and schist contacts. Area large	D	1; also Ont. Bureau of Mines, vol. 22, pt. II, pp. 90-94 (1914)	Close to transportation
39	"	Monteagle tp., con. V, lots 3-4, Quirk	40-foot ridge dark red massive to cryptocrystalline garnets	E	1.....	Transportation and water problems not favourable
40	"	Tudor tp., cons. XVIII and XIX, lots 7-10, Gilmour area	Irregularly shaped mass of garnet-epidote rock	H	Ont. Bureau of Mines, vol. 22, pt. II, p. 85 (1914)	
41	Kenora.....	Lac Seul, Pelican falls	Garnetiferous biotite gneiss on east end of Lac Seul, and at Pelican falls	H	2, vol. XIV, pt. A., p. 91 (1902)	Pelican falls is near junction of Transcontinental and Lake Superior railways
42	Lanark.....	Burgess North tp., east of Otty lake	Banded quartzose garnet gneisses totalling 600 feet in thickness. Garnet sands	F	2, Rept. of Prog., 1872-73, p. 168; also 2, pt. J., pp. 24-42 (1904)	

TABLE I—Continued

Garnet Occurrences and Deposits in Canada—*Continued*

Ref. No.	County, district, or mining division	Locality	Mode of occurrence and description	Rating	Reference	Remarks
			ONTARIO—*Continued*			
43	Lennox and Addington	Ashby tp., con. XV, lot 9, Bancroft Mines Syndicate	Wide and very extensive deposit of high-grade, pea- to cherry-size garnets in schists. In places 40 per cent garnet	A	1.....	1,250 tons of rough concentrates shipped. New concentrator partly erected. Transportation poor
44	" "	Ashby tp., con. XIV, lot 26, Hanah	Nature of rocks and garnet similar to above and also appears to be on line of strike, garnets not so plentiful	C	1.....	Four or five claims staked along a distance of 12 miles apparently on strike of above
45	" "	Kaladar tp., con. V, lot 5, Beatty	30-foot ridge of high-grade garnet schist traced for considerable length	B.C.	1.....	Close to rail transportation. Easy to mine
46	Muskoka.....	Muskoka river.....	Garnetiferous gneisses—garnets small	H	2, 1905, p. 86.....	
47	Parry Sound.....	Parry island, Depot Harbour, Garnet Abrasives Corporation	Wide, alternating bands of garnetiferous hornblende gneisses and mica schists. Area very extensive. Average 15 per cent garnet	A	1; also Mines Branch, Dept. of Mines, Sum. Rept. 1921, pp. 156-184	Extensively sampled and found easy to concentrate. Mill about to be erected. Mining, transportation, water supply very good
48	"	Rosetta island and mainland	Numerous garnet gneiss bands occur south and east of Parry Sound	C	1; also 2, Rept. of Prog. 1876-77, pp. 199-200	The Rosetta and other bands south of Parry Sound are probably a continuation of the Parry Island deposits
49	"	French river, mouth of	Dark mica schists carry garnets in vicinity of transverse granite veins	H	2, Rept. of Prog., 1876-77, p. 202	
50	Peterborough.....	Belmont tp., con. I, lot 19, Belmont iron mine	Massive, resinous, yellow to almost black, impure garnet as chief gangue mineral with magnetite	E	1.....	Large tonnage of garnet in gangue and in dump. Fracture poor; crumbles easily
		Two miles southwest of above	Similar, but small garnets in limestone belt on gabbro contact	H	.....	Pea- to walnut-size garnet, fairly concentrated in pockets
51	Rainy River.....	Jackfish lake, 25 miles north of Fort Francis	White garnets occur in basic diabase dykes that traverse the granite gneiss	F	2, vol. III, pt. F., p. 156 (1888)	Far from rail transportation

52	Rainy River.....	Hunter island.....	Biotite gneisses replaced by muscovite gneisses in presence of garnets	F	2, vol. V, pt. G., p. 20 (1892)	Between Russell and Sturgeon lake. Far from rail transportation
53	Renfrew.....	Raglan tp., con. XVIII, Craigmont	Large, badly fractured, red-brown garnet occasionally found in mining for corundum in the nepheline syenite	G	2, Mem. 57, p. 80 (1915)...	Besides in the Craig corundum mine, garnets also occur east of Madawaska river near the Jewellville corundum mines
54	Sudbury.....	Denison tp., con. IV, lots 5 and 6, Vermillion mine	Large, badly defined and shattered crystals of garnet occur in the greenstone of the mine	G	.....	
55	"	Dill tp., con. IV, lot 1, Coulis	50-foot band of garnetiferous biotite schist, garnets large, but shattered containing foreign inclusions	C	1.....	In places some good grade garnets occur. Richest zone about 15 feet wide. Deposit along side of railway and river
55A	"	Laura tp., Burwash station	Garnet zone similar to above.	C	1.....	Traced to Collins inlet on Georgian bay—garnet sands
56	"	Dryden tp., con. III, lot 8, 1 mile east of Wanapitei station	Garnet occurs in mica diorite and sillimanite gneiss in association with cyanite exposed in railway cut	H	.....	More of mineralogical interest than of commercial value
57	"	Loughrin tp., con. I, lot 12, MacDonald	3 zones totalling about 100 feet of large, medium, and small garnets in biotite gneiss	B	1.....	The large garnets are perfect crystals, but of pink colour and of granular structure. Near Markstay station
58	Thunder Bay.....	Pic river, McKay lake	Mica schists thickly studded with small garnets. At Long lake schists are 2 miles wide	C	2, Rept. of Prog., 1870-71, p. 329	Two miles west of Pagwachuan station
59	Victoria.....	Somerville tp., con. XI, lot 1, Bobcaygeon road	Pyritiferous rusty gneisses carrying pea-size garnets with crystalline limestone on both contacts	H	2, vol. VI, pt. J, p. 10, (1894)	Gneisses are 150 yards wide, in places rich in garnet

QUEBEC

60	Argenteuil.....	Grenville tp., range V, lot 3, 4 miles N.E. of Grenville station	Semi-massive garnet as gangue mineral in magnetite vein	H	2, Rept. of Prog., 1873-74, p. 201	
61	Beauce.....	Vaudreuil seigniory, 1 mile N. of Rivière des Plantes station	Grossularite forms chief gangue mineral of a molybdenite vein, on granite-peridotite contact	G	2, Mem. 127, p. 84 (1921)...	Noted while prospecting for molybdenite
62	Berthier.....	Brandon tp., range X, lot 4, 3 miles N.E. of St. Damien	Narrow bands of garnet-hornblende and quartz gneisses	D	2, vol. VIII, pt. J, pp. 51, 64, 84, 150 (1896)	Various outcrops along road over a distance of several miles

TABLE I—Continued

Garnet Occurrences and Deposits in Canada—*Continued*

Ref. No.	County, district, or mining division	Locality	Mode of occurrence and description	Rating	Reference	Remarks
			QUEBEC—*Continued*			
63	Charlevoix.....	Bay of St. Paul, St. Irénée and Malbaie	Large, brown garnet crystals up to 6 inches in diameter	F.C.	2, vol. V, pt. A, p. 49 (1893)	The St. Irénée garnets are more fractured than those at Malbaie
64	Hull.....	Wakefield tp., range I, lots 6 and 14	Brown and white garnets in limestone associated with zinc, galena, pyrites and graphite	H	2, Rept. of Prog., Pt. G, 1877-78, p. 26	Pits opened fifty years ago in search for gem garnets
65	Papineau.....	Templeton tp., range XII, lot 12	Red garnets in feldspar.....	H	" "	
66	Joliette.....	Cathcart tp.....	A series of bands of garnetiferous gneisses and quartzites with intermediate limestone bands	B	1; also 2, vol. VIII, pt. J, (1896)	Traced over area of several square miles. Some bands very rich in garnet
67	"	De Ramsay seigniory, St. Jean de Matha	Numerous exposures of garnet sillimanite gneisses and quartzites. Some large garnets	B	1; also 2, vol. VIII, pt. J, pp. 41-62 (1896)	Best exposures on road near and along the Black river N.W. of St. Jean
68	"	D'Argenteuil seigniory, lake Rocher	Cherry-size, red garnets in 30-foot band of sillimanite gneiss also in white quartzites	D	1; also 2, vol. VIII, pt. J, p. 52 (1896)	
69	"	Kildare tp., range X, lake Francis	Similar to above but less garnet	D	" "	
70	Labelle.....	Clyde tp., 5 miles S.W. of Conception station	Small, pink garnets occur in a 150-foot band of white feldspathic gneiss in limestone contact	F	2, Rept. of Prog., 1863, p. 24	Best showing in vicinity of Three Mountains lake
71	"	Joly tp., range 1, lot 16, 2 miles W. of Labelle station	Transparent and deep red masses of garnet in several parallel 4-foot veins of solid pyrrhotite	A	1.....	Garnet masses up to 100 pounds. Very high abrasive qualities
72	Maskinonge, St. Maurice, Champlain	Mattawin river, Mastigouche river, Du Loup river	Garnet gneisses and garnet-quartz gneisses	F	1, also 2, vol. XI, pt. J, pp. 23-55 (1900)	Numerous exposures in territory embraced by the Mattawin and Du Loup rivers

73	Maskinonge, St. Maurice, Champlain	St. Maurice river, Mekinac river to Shawinigan Falls	Dark garnet gneiss bands associated with thin limestone bands	F	1, also 2, vol. XI, pt. J, pp. 41-55 (1900)	Numerous exposures over a distance of 30 miles along river
74	Montcalm.....	Rawdon tp., 1 mile W. of Rawdon	Small garnets in narrow bands of gneiss and quartzites	D	2, vol. VIII, pt. J., pp. 55-56 (1896)	Exposures under bridge over Ouareau river
75	"	Rawdon tp., Darwin falls and rapids, Ouareau river	Sillimanite gneiss bands rich in small red garnets near limestone contacts	C	1, also 2, vol. VIII, pt. J, pp. 56, 84, 150 (1896)	The exposures at rapids are higher grade than at the falls
76	"	Rawdon tp., ranges VI to XI, lots 20-28	Garnetiferous-hornblende and graphitic gneisses	C	2, vol. VIII, pt. J, pp. 69, 85, 150, (1896); also 2, Rept. of Prog., 1853-56, p. 43	Numerous exposures
77	Labelle.....	Portland tp., W. range IX, lot 9, St. Helens lake	Green and red garnets associated with pyroxene	H	2, Rept. of Prog., 1882-84, pt. J., p. 11	
78	Abitibi.....	Baudin tp., 3 miles E. of Langlade station	Highly garnetiferous bands of gneiss. Garnets of cherry size	F.C.	Min. Oper. Que., 1916, p. 166	60 yards east of 70th mile post, rocks said to contain 40 per cent garnet
79	Pontiac.....	Mansfield tp., Fort Coulonge	Small garnets associated with mica and disseminated through quartzose limestone	H	2, Rept. of Prog., 1876-77, p. 284	
80	Portneuf.....	Montaubin tp., range I, lots 40 to 43, Notre-Dame des Anges	Garnet quartzites on limestone contact, and narrow bands of garnet gneiss	G	Min. Oper. Que., 1915, p. 119	Associated with the lead-zinc ore of the Tetrault mine
81	"	Montaubin tp., range V, lots 9 to 12	Garnet-sillimanite gneiss on white quartzite contact	D	" "	Garnet band is 20 feet wide and can be traced for over a mile
82	"	Bourglouis seigniory, lake Simon and Three Mountains lake	Garnet gneisses on limestone contact	F	2, Rept. of Prog., 1858, pp. 27-29	Garnets small
83	"	Ste. Anne river, St. Raymond and St. Catherine	Very small, red garnets in gneisses	G	2, vol. V, pt. L., pp. 15-25 (1892)	Numerous exposures but all very small garnets
84	Quebec.....	North of Quebec city, Stoneham and Tewkesbury tps.	Small, brown garnets in gneisses	G	2, vol. V, pt. L., pp. 15-25 (1892)	Several exposures, garnets all small
85	Saguenay.....	Gulf of St. Lawrence, Manikuagan river and Quetachu bay	Garnetiferous mica and hornblende gneiss	F	1; also 2, vol. VIII, pt. L., pp. 240-48, 1 (1896)	Numerous occurrences over a distance of 80 miles up the river. The Quetachu garnets occur in feldspar
86	St. Maurice.....	Caxton tp., St. Elie to Charette	Fractured, brown garnets in contorted gneisses	H	1; also 2, vol. IV, pt. AA., p. 51 (1894)	Can be traced for 4 miles
87	Sherbrooke.....	Orford tp., range XII, lot 6, Brompton lake	Green chrome garnet in calcite associated with nickel ore	G	2, vol. IV, pt. T., 1890, p. 28; also 2, Rept. of Prog., 1863, pp. 496-7	For gems only

TABLE I—Concluded

Garnet Occurrences and Deposits in Canada—*Concluded*

Ref. No.	County, district, or mining division	Locality	Mode of occurrence and description	Rating	Reference	Remarks
			QUEBEC—*Concluded*			
88	Sherbrooke.....	Orford tp., range XVI, lot 6	White to green lime garnet in serpentine	G	2, Rept. of Prog., 1853-56, p. 449	For gems only
89	Témiscamingue.....	Boisclair tp., Mattawa mt. and Snake creek	Red garnet in biotite gneiss associated with cyanite	F	1; also 2, vol. X, pt. I, pp. 178, 211 (1899)	Ore exposed in the Temiskaming railway cutting
90	"	Lake Timiskaming, Kipawa and Greenorton bay	Basic garnet hornblende-gneisses	F	" "	
91	Terrebonne.....	Terrebonne seigniory, St. Jerome	4- to 5-foot garnet bands in the quartzites on the west contact of the crystalline limestone	F	2, Rept. of Prog., 1853-56, pp. 43-4; also 2, vol. VIII, pt. J., p. 151 (1896)	Some bands are rich in garnet
92	"	Grandison tp., Trembling lake	Garnet-sillimanite gneisses exposed along shores of lake	G	2, vol. VIII, pt. J, pp. 54-5 (1896)	Considerable float containing large, pink garnets
93	Two Mountains.....	Two Mountains lake, 3 miles east of Oka	Garnet sands in narrow ridges up to 3 feet in depth	G	.....	Rocks of origin not located
94	Ungava (New Quebec)	Hudson strait, 4 miles up Whitby bay	Large garnet crystals in banded mica-hornblende sericite schists	F	2, vol. XI, pt. L, p. 39 (1899)	

In the above tabulation the following TENTATIVE classification has been adopted for grading purposes. For details see descriptions of individual properties.

Rating:
A. Extensive deposit of good abrasive garnet. Probable producer
B. Deposit high grade, fairly extensive and worthy of further investigation
C. Deposit has fair possibilities, but lacks detailed information
D. Garnets on surface poor quality, doubtful commercial value
E. Massive or cryptocrystalline garnets; no use for abrasive papers but possibilities as loose grain
F. Neither deposit nor samples examined for abrasive purposes
G. Deposit small and garnets unfit for commercial abrasive use
H. Very little information but probably no use for abrasive purposes

Reference to Reports:
1. *See* report in text
2. Annual and Summary Reports, Geological Survey of Canada

UNITED STATES

Garnet was first employed as an abrasive in the United States and has been mined for the last 50 years. The principal deposits occur in the Adirondack section of New York state and the mineral from this locality is at present recognized as the world's standard of abrasive garnet. The principal producing companies in this state are the North River Garnet Company, (Hooper mine); The Barton Mines Corporation; The Warren County Garnet Mills, and the American Glue Company.

PRODUCTION

The production of abrasive garnet in the United States since 1895 is as follows:—

TABLE II

United States Garnet Production[1]

Year	Short tons	Value	Year	Short tons	Value
		$			$
1895	3,325	95,050	1911	4,076	121,743
1896	2,686	68,877	1912	4,947	163,237
1897	2,554	80,853	1913	5,308	183,422
1898	2,967	86,850	1914	4,231	145,510
1899	2,765	98,325	1915	4,301	139,584
1900	3,185	123,475	1916	6,171	208,850
1901	4,444	158,100	1917	4,995	198,327
1902	3,926	132,820	1918	4,696	248,161
1903	3,950	132,500	1919	4,944	310,131
1904	3,854	117,581	1920	5,476	434,425
1905	5,050	148,095	1921	3,048	260,687
1906	4,650	157,000	1922	7,054	566,879
1907	7,058	211,686	1923	9,006	688,437
1908	1,996	64,620	1924	8,290	674,176
1909	2,972	102,315	1925	8,429	712,853
1910	3,814	113,574			

[1] Figures from Mineral Resources, U.S. Geol. Surv.

The following brief descriptions of the New York as well as the operating New Hampshire and North Carolina deposits are quoted from Messrs. Myers' and Anderson's reports.[1]

The North River Garnet Co. The quarry and mills of the North River Garnet Co. are located on the eastern side of Thirteenth lake in Warren county about 10 miles from North Creek, the nearest shipping point. The gneiss quarried carries 4 to 8 per cent garnet in crystals having a maximum diameter of three inches. Hornblende and feldspar constitute the most important gangue minerals. The quarry is in a large projecting knob of gneiss, and has a maximum diameter approaching 300 feet. The jointed structure of the rock is highly developed, and the horizontal partings are utilized as the base of small benches in quarrying. The rock is drilled to a depth of 15 feet and holes are sprung and then loaded with 60 per cent ammonia dynamite which is fired with a blasting machine. Large blocks are reduced by blockholing and the broken ore is loaded either by hand or by steam shovels to quarry cars which run to the head of the mill, a maximum distance of 200 yards.

[1] Myers, W. M. and Anderson, C. O.: U.S. Bureau of Mines Serial No. 2691, June, 1925; also Bull. 256 (1925), 50 pages.

For more detailed description *see* article by F. E. Wormser.[1]

The Barton Mines Corporation. The quarry of the Barton Mines Corporation is on Gore mountain, about 11 miles by road from the village of North Creek. The most characteristic feature of the dark-grey, massive rock quarried is the garnet crystals themselves, which give the rock a porphyritic texture. Mineralization is simple, as hornblende constitutes nearly 40 per cent of the rock mass, the remainder being divided between orthoclase and plagioclase feldspars, pyroxene and mica. Small amounts of pyrite and magnetite are also present. The garnet content of the ore averages about 13 per cent and occurs in crystals of unusual size. Single crystals a foot in diameter are common and individual ones from 30 to 36 inches in diameter have been found. The crystals have a very pronounced laminated structure by which they are divided into plates from a sixteenth to a quarter of an inch in thickness.

The garnetiferous rock has undergone considerable alteration at the surface, and the first mining was in this oxidized zone from which the garnet could be readily recovered. Later quarrying was started in the unoxidized rock, and with the erection of a modern concentrating mill in 1924, the quarrying was placed on a systematic basis. The quarry now consists of a series of open pits which are being developed into regular benches. Ten-foot holes are drilled with jackhammers and these are shot with 40 and 60 per cent gelatin. Boulders are blockholed with small charges of dynamite. The broken ore is loaded with three-ton cars with steam shovels and hauled to the mill with a gasoline locomotive (*see* Plate IVA). In breaking the ore in the quarry many of the garnet crystals are shattered. The largest fragments of clean garnet are picked and sacked for immediate shipment.

For more detailed description *see* article by T. S. Mennie.[2]

Warren County Garnet Mills. The Warren County Garnet Mills, Inc., operate a number of small scattered quarries in the vicinity of Weverton and Johnsburg. The garnet ore is removed from shallow excavations, seldom exceeding eight feet in depth. The rock is drilled by hand, with a single-jack, blasted, sledged and hand-picked, and trucked to the mill. The garnet content of the ore going to the mill is high, varying from 30 to 60 per cent.

The American Glue Company. A band of garnetiferous gneiss outcropping on Casey mountain about five miles northwest of North River, N.Y., the nearest post office, has been operated by The American Glue Company and has produced a considerable tonnage of garnet in the past. In August, 1924, the mill was not active and the only production was a small tonnage which was hand-cobbed and sacked for shipment at the quarry. The mill was built in 1920.

The Wausau Abrasive Company, New Hampshire. The mine and mill of the Wausau Abrasive Company is located in North Wilmot, Merrimac county. The garnet is present as numerous small crystals, $\frac{1}{4}$ to $\frac{3}{8}$-inch in diameter, forming 40 to 60 per cent of the total rock mass. Feldspar and biotite mica are the most prominent gangue minerals. The quarry is approximately 180 by 100 feet with a maximum depth of 25 feet. Holes are drilled to a depth of 6 feet and shot with 60 and 75 per cent gelatin. Boulders are bulldozed, and the broken rock is loaded by hand into cars, which are hoisted up an incline. The cars are then trammed by hand to an ore bin on the hillside above the mill. The ore from the bin is fed to a jaw crusher which crushes to $1\frac{1}{4}$-inch. The crushed ore falls into a loading bin which loads the buckets of an aerial tramway. This tramway conveys the ore to the mill, a distance of 1,200 feet.

The Rhodolite Company, North Carolina. The Sugar Loaf Mountain garnet deposit located $2\frac{1}{2}$ miles south of Willits, North Carolina, is being developed by the Rhodolite Company. In March, 1925, a new mill for treating the ores was nearing completion and preparations were being made to start quarrying. This deposit has been worked at intervals, and a considerable tonnage of garnet recovered in the past twenty-five years. The present activity is the first attempt to recover this garnet by systematic, large-scale operation.

The garnet occurs in small crystals, $\frac{1}{8}$- to $\frac{1}{2}$-inch in diameter, in a large body of mica and quartz-feldspar schist of unknown extent. The average garnet content of the rock is 20 to 25 per cent; local concentrations are as high as 60 per cent. The present quarry, which is a hundred yards up the valley from the mill, has been developed sufficiently to disclose a considerable tonnage of garnet ore.

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[1] Wormser, F. E.: "Mining, Concentration, and Marketing of Garnet," Eng. and Min. Jour. Press, Oct. 4, 1924, pp. 525-531.

[2] Mennie, T. S.: "Modern Garnet Mills Operated," Abrasive Industry, Feb. 1925, pp. 51-54.

A more detailed account of the Rhodolite deposit will be found in Abrasive Industry.[1]

Deposits in Other States. Deposits of garnetiferous rock from which a supply of the mineral suitable for the abrasive market may be obtained, are known to occur in Georgia, Virginia, Montana, Colorado, and many other western States. The ore reserves of the active producers are sufficient to supply the market at the present rate of consumption for many years.

SPAIN

The Spanish garnets which are of a pale pink colour occur as small, rounded crystals in the alluvial deposits of the province of Almeria. The garnets are inferior to the American mineral and when crushed do not yield the full range of sizes required by users. No published description of these workings has been found but it is believed that the deposits are now greatly depleted, if not actually approaching exhaustion. The material is only used for the cheaper forms of abrasive.

PRODUCTION

Previous to 1919 there is no record of production but in the earlier days of the garnet industry from 500 to 2,500 tons were exported annually. The following shows the approximate output in short tons for the last six years: 1919—882 tons; 1920—218 tons; 1921—5 tons; 1922—not reported; 1923—1,080 tons; 1924—300 tons.

INDIA

Red and brown garnets are common minerals in the gneisses and schists of India and in many instances the rocks are characterized by these garnets. Although there are numerous recorded deposits of gem garnets, the known occurrences of the good abrasive mineral are very few.

About 50 years ago an attempt was made to market a massive garnet rock in the Hazaribagh district of Behar and Orissa but it did not prove remunerative. Red garnets were at one time collected from the river sands in the Nellore district and sold as a substitute for emery.[2] In 1914 nearly 1,200 tons of garnetiferous sand was collected for abrasive purposes from the Tinnevelly district of Madras, but the workings were closed down the following year and have been idle ever since.

More attention has been paid to the occurrence of abrasive garnet in Mysore than elsewhere in India, where in the Taluk region the mineral occurs freely in cyanite schist and gneiss, and loose fragments about one-quarter of an inch in diameter can be washed from the soil.[3]

The present small output is obtained from Khammamet in the Warangal district of Hyderabad state.[4] The ore is mined by primitive methods, hand-sorted, and the garnets sent to the coast in bags.

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[1] The Rhodolite Company's Garnet Deposits, Abrasive Industry, Nov. 1923, pp. 323-4.

[2] Brown, J. Coggin: "Notes on Garnet," Bull. No. 12, Indian Industries and Labour, pp. 49-54 (1921).

[3] Smeeth, W. F. and Iyengar, P. S.: Mineral Resources of Mysore, pp. 128-130 (1916).

[4] Geol. Surv. India, Vol. LVII, p. 335 (1925).

PRODUCTION

The following table shows the output of abrasive garnet from India for the ten years 1914-1923.

TABLE III

Abrasive Garnet Production of India

Year	Short tons	Year	Short tons
1914	1,179·4 *(a)*	1920	23·2 *(d)*
1915	6·3 *(b)*	1921	5·3 *(d)*
1916	26·0 *(b)*	1922	Nil
1917	Nil	1923	3·1 *(d)*
1918	Nil		
1919	58·0 *(c)*		

(a) From Tinnevelly district, Madras; *(b)* Hyderabad (Deccan); *(c)* Mysore; *(d)* Hyderabad.

OTHER COUNTRIES

No garnet production has been recorded from any countries other than those mentioned above, with the exception of a very small output from Madagascar (10 tons in 1922 and 5 tons in 1923), and from Bohemia.

Samples have been obtained from Ceylon, South Africa, Nyassaland, and British Somaliland. A garnet deposit of good abrasive quality, associated with quartz and mica occurs on an island in St. Michael bay on the Labrador coast 35 miles north of Belle isle. The occurrence is stated to be 11 feet wide and exposed for over 300 feet in length. Near Prague in Bohemia, pyrope garnets occur loose in the soil or embedded in a serpentine, and were at one time separated by washing and treating in a crude jig.[1]

TESTS FOR THE ABRASIVE UTILITY OF GARNET

There is no efficient method of testing the abrasive quality of garnet or of any other loose grain abrasive. The real test is in its practical application. There are, however, several rough tests and examinations which serve to indicate their abrasive possibilities.

Size

The garnets in the original ore should be so large and pure that when crushed and screened they will yield a full range of grades from 20 to 200 mesh, particularly the former. Garnets smaller than pea size will make too many fines.

[1] Kunz, G. F.: Trans. Amer. Inst. Min. Eng., Vol. XXI, p. 241 (1892).

Fracture and Purity

A microscopic examination of the small broken particles of garnet will show whether the fracture is clean, sharp, angular, rounded, "slivery," etc. Grains exhibiting rounded or blunt edges are not likely to be of any abrasive use. In some garnets the individual grains tend to show fractures and have a "sugary" appearance under the microscope. These will break too easily when applied to the work. The term "granular" fracture has been applied to this phase in the accompanying table of tests (Table V). This kind of fracturing is in most cases due to weathering and the mineral should not be condemned until a fresh sample has been examined. Long "slivery," or flat-sided grains are a disadvantage, as they tend to present a flat surface when applied to the cloth or paper, or they may stick up above the other grains and be more easily torn away.

The microscope may reveal minute embedded impurities which are liable to affect the toughness and abrasive quality.

Toughness

A variety of garnets can be roughly compared for toughness by reducing them to the same grade (No. 1) and drawing a knife blade over a small quantity placed on a piece of steel or glass. Soft garnets will drag and soon break up into powder, while the knife will ride over the particles of a tough garnet without appreciably reducing their sizes. With a little practice a close approximation can be reached by comparing with a known or standard tough garnet.

Capillarity

This test depends on the capillarity of crushed garnet and serves to indicate its tenacity when applied to the glued surfaces of the paper or cloth. The higher the capillarity the tighter will each particle adhere when coated with glue. In making comparisons care should be taken that the grains are of the same mesh and are absolutely dry, clean, and free from dust. The apparatus simply consists of a glass tube about 10 inches long, 4 or 5 mm. inside diameter, and blocked at one end by a piece of fine screen. The tube, which should be dry and clean, is partly filled with the sample to be tested, gently shaken down, and the closed end dipped into a known height of water (about ½ inch). The water will rise up through the screen and into the garnet, and after 3 to 4 minutes the tube may be removed from the water and the dry garnet poured out. The remainder, which adheres to the inside of the tube, is measured. The height of water into which it was placed should be deducted.

The following scale (Table IV) shows the recognized standard capillarity for various grades of garnet. This scale is only approximate and a garnet can be 25 per cent below the standard without being condemned.

TABLE IV

Standard Capillarity Scale and Grades of Garnet[1]

Standard screen mesh used by abr. industry (not Tyler or U.S.)	Standard size opening in inches	Standard grades of garnet	Capillarity	
			Rise in centimetres	Time, minutes
−15	·0468			
−16		5		
−18		4		
−20	·0340			
−22		3½		
−24		3	3·5	2
−28		2½		
−30	·0198		4·0	2
−35		2	4·2	2
−40	·0140	1½	4·6	2
−46	0.351 mm		5·0	2
−50 approx 4 Tyler	·0114	1	5·4	2
−54	0.272 mm		7·5	3½
−60	·0097		8·0	3½
−63		½		
−70	·0073		8·5	3½
−80	·0068		9·8	3½
−83		0		
−90	·0059		10·7	3½
−100	·0055	2/0	11·3	4
−120	·0046		12·2	4
−130		3/0		
−140	·0042			
−145		4/0		
−150			13·0	4
−160	·0038			
−175		5/0	13·0	4
−180	·0033			
−190		6/0	13·0	4
−200	·0029			
−220		7/0	13·0	4

[1] Capillarity figures supplied by Abrasives, Ltd., Brantford, Ont.

As will be seen from the above scale all material coarser than 100 mesh will have to be very carefully and closely sized. The mesh selected for the tests in Table V was −48+58 silk cloth which would give a standard of about 6·5 centimetres for capillarity.

Colour

Although colour has nothing to do with the abrasive quality garnets of a deep red colour are preferred, and it is a noticeable fact that the fracture and toughness of the brown and yellow shades are not so good as those of the red and pink varieties.

Testing Machines

After a garnet has passed the above preliminary test it may then be tried out by applying the graded grain to a belt or disk. The glue used and

the method of adhering the garnet to the backing is almost as important as the quality of the abrasive itself, so that comparisons can be made only after the test samples have been made up by a manufacturer of coated papers. The following description is given by J. F. Adams[1] of the Manning Abrasive Company and reproduced in R. B. Ladoo's report.[2]

At the present time we have no method of testing the efficiency of abrasives in the form of loose grain. All of our testing is done after the grain has been deposited on our standard backings of paper, cloth, or a combination of the two.

Our testing machines are of two types, an abrasive disk tester and abrasive belt tester. The disk machine is illustrated in an article appearing in the December (1921) Abrasive Industry. For testing woodworking abrasives the belt tester is mechanically better adapted to the work. The machine consists of two pulleys, 10-inch diameter by 5-inch face, one driven and one idler. An endless belt of abrasive paper (made endless by our Uniflow joint) is placed over these pulleys, one of them being adjustable to hold the belt under the proper tension. This is accomplished by means of a lever arm from which weights are suspended. The belt is run at about 3,000 feet per minute. The test material consists of five oak blocks, $\frac{7}{8}$ x 1 x 5-inch, held in a regulation printer's frame. By means of a weighted lever device the blocks are applied to the under side of the running abrasive belt, the sanding being on the ends of the blocks which are cut so that this is done "with the grain." A test lasts ten minutes and the amount of wood cut per minute is noted and finally plotted in the form of a curve. The blocks are selected at random from a barrel-full cut from a *single* plank. When a test of an unknown is run, a belt is always tested from a standard lot of abrasive paper, made especially for the laboratory. Results are stated as a percentage of standard.

The reason that no standard tests for abrasive grains have been adopted is that the behaviour of an abrasive in actual use depends so much upon the method of use (that is whether as loose grain, as abrasive paper, in abrasive wheels, etc.), and upon the material to be abraded (that is wood, leather, brass, etc.). Thus while the artificial abrasives (carborundum, alundum, etc.) are harder than garnet, they can not replace garnet in many industries, wood-working, for example.

Some interesting experiments in the abrasion of metals were recently conducted by Messrs. J. R. Jenkinson and Dartrey Lewis of the British Non-Ferrous Metals Research Association, Sheffield, England. Considerable care was devoted to the testing of various forms of abrasives both as loose and fixed grain. A summary and results of these experiments are outlined in "Artificial Abrasives."

The following table shows the results of tests on some Canadian and United States garnets:

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[1] Adams, J. F.: Reducing Disk Grinding Costs, Abrasive Industry, Vol. 2, No. 12, p. 407, Dec. 1921.

[2] Ladoo, R. B.: U. S. Bur. of Mines, Serial No. 2347, April 1922,

TABLE V

Capillarity, Hardness, and Fracture Tests of some Canadian and United States Garnets

Reference in Table No. I	Source	Colour of garnet in No. 1 grade	Capillarity for No. 1 grade	Degree of toughness	Fracture	Purity and nature of concentrates tested
			Rise in cms.			
57	McDonald, Loughrin tp., walnut-size crystals	Pale pink	5·8	Good	Subangular	Very clean
57	McDonald, Loughrin tp., pea-size crystals	Brick-red brown	4·7	Fairly good	Granular to subangular.	Slightly weathered, considerable hornblende
55	Coulis, Dill tp	Deep pink	5·5	Fairly good	Sharp to subangular	Very clean
33	Fishtail lake, Harcourt tp	Deep pink	5·5	Good	Sharp to subangular	Clean
45	Beatty, Kaladar tp	Deep brownish pink	5·7	Fairly good	Sharp to subangular	Clean; some embedded impurities; weathered
37	Black river, Elzevir tp.	Purple-brown	7·3	Fair	Granular	Minute embedded impurities; weathered
28	Wager, Olden tp	Brownish black	6·9	Fair	Subangular	Fairly clean
39	Quirk, Monteagle tp	Brick-red brown	6·7	Fairly good	Granular to subangular.	Clean
31	Card, Portland tp	Pinkish purple	5·1	Fairly good	Slightly granular	Very clean, but weathered
30	Ludbrook, Portland tp.	Pinkish brown	4·0	Fairly good	Granular to subangular.	Clean but contains some hornblende; weathered
44	Hanah, Ashby tp	Brownish wine	5·0	Fairly good	Angular	Clean but has embedded impurities
47	Parry Sound	Deep wine	5·6	Good	Sharp and slightly slivery	Clean
43	Bancroft Mines Syndicate	Wine red	5·1	Good	Sharp to subangular	Very clean, but some embedded impurities
67	St. Jean de Matha	Pink	5·9	Good	Subangular	Very clean, but weathered
75	Darwin falls	Pinkish brown	5·5	Fair	Sharp to subangular	Fairly clean, but weathered
66	Cathcart tp	Rusty pink	6·2	Fairly good	Granular to subangular.	Clean, but much weathered
71	Labelle	Deep purplish wine	5·0	Very good	Sharp and angular	Very clean
.....	North River Garnet Co. N.Y.	Reddish wine	7·8	Good	Sharp and angular	Clean
.....	Barton Mines Corporation, N.Y.	Wine	5·8	Good	Sharp and angular	Clean
.....	Warren County Co., N.Y.	Deep wine red	7·4	Good	Sharp and angular	Contains considerable hornblende
.....	Wausau Co., N.H.	Purplish red	6·0	Good	Sharp to subangular	Clean, but contains embedded impurities

Note:—All material was screened to −48 + 58 through standard silk cloth and thoroughly dried immediately before testing.

CONCENTRATION

Garnet, being a heavy mineral (average sp. gr. 4·0), is usually concentrated by ordinary gravity methods, either wet or dry. The former, however, is the general practice and the more suitable for the majority of the ores.

IMPURITIES

Hornblende is one of the most common impurities and as its specific gravity (3·0—3·4) is very close to that of garnet, it is rarely, if ever, entirely eliminated from the final concentrate. Hornblende is fairly hard, but appreciably softer than garnet. It can, however, be effectively separated by means of the Ullrich magnetic separator, briefly described elsewhere.

Iron pyrites and pyrrhotite appear in the concentrates, but can be removed by careful tabling and the latter by ordinary magnetic separation. Quartz, feldspar, and mica being considerably lighter than garnet should be entirely removed during the process of gravity treatment.

In the wet milling of some pyritiferous garnet ores there is a probability of the formation of a solution which attacks the garnet. Although this does not appear to affect its abrasive quality, the outward appearance of the garnet is in time seriously injured. This might be overcome by the addition of some reagent, or by employing a dry method of concentration.

TYPE OF CONCENTRATES REQUIRED

The main objective in concentrating garnet for the paper trade is to obtain a material with as large a mesh, and as pure, as possible, and to avoid fines. The manufacturers of coated abrasives usually prefer to do their own grading (sizing) so they require coarse material from which varying proportions of any size can be obtained by crushing, but in doing so, fines are unavoidably produced. When standard grading is more universal, these grades may possibly be made direct in the course of concentration, but the present practice in milling operations is to mix together and bag all the grades obtained. The degree and stages of crushing are, therefore, of the utmost importance, and care must be taken that the coarse particles of garnet are free from attached impurities.

CONCENTRATION TESTS BY THE MINES BRANCH

During 1921 a series of experiments in the concentration of garnet ores from several localities were made in the Mines Branch Ore Testing Laboratories. Details of these tests will be found in the 1921 Summary Report.[1]

Large-scale tests were made on garnet ore from Depot Harbour, Parry island, Ontario. The deposit was sampled by means of a series of trenches across the ore-body (Figure 6). The ore averages 15 per cent garnet. The associated minerals are mainly mica, hornblende, and quartz. A large part of the mica can be removed in the early stages by suction, and the product so obtained may be marketed. The accompanying flow-sheets were finally evolved for the Parry Island garnet.[2] (Figures 8 and 9).

[1] Carnochan, R. K.: Sum. Rept. Mines Branch, Dept. of Mines, 1921, pp. 156-184.
[2] Op. cit., p. 189.

25076—4½

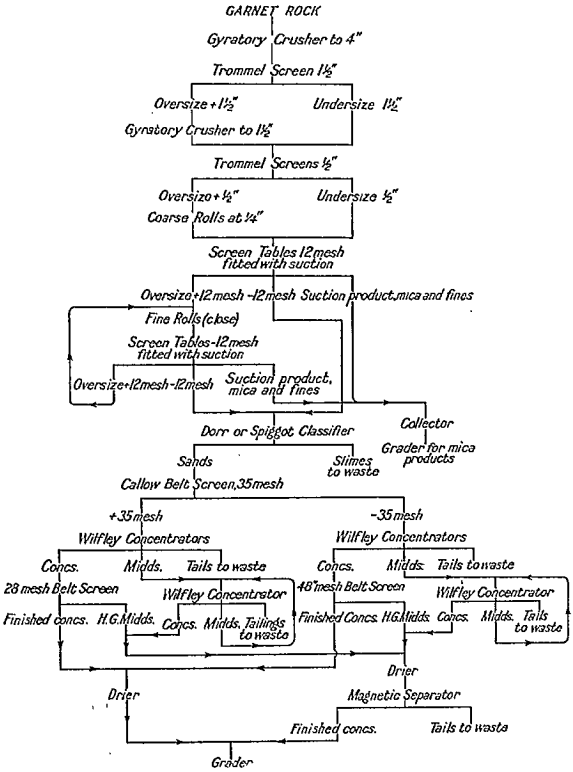

Figure 8. Flow-sheet of garnet concentrator, showing methods of treatment for recovery of garnet from the rock at Parry island, Ontario.

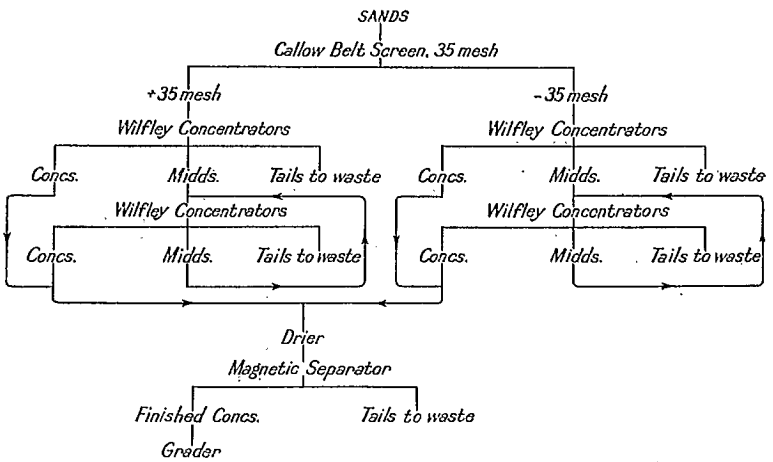

Figure 9. Flow-sheet of garnet concentrator showing treatment of table concentrates on magnetic separator.

The following shows the results of experiments in the concentration of the high-grade ore from the Bancroft Mines Syndicate's deposit in Ashby township, 15 miles east of Bancroft:—

Characteristics of the Garnet Rock

The rock which contains the garnets is a gneiss, consisting of about 40 per cent garnet mineral, and large amounts of black mica and hornblende. The garnets in the sample tested ranged in size from about three-eighth inch to minute crystals.

Experimental Tests

Lot No. 1—Wet Concentration by Jigging and Tabling

The lot was crushed to pass a 6-mesh Tyler standard screen, and on 40-and 100-mesh screens. The sizes coarser than 20 mesh were jigged on a laboratory Richards pulsating jig and the finer sizes tabled on a laboratory Wilfley table.

A concentrate was produced which represented 35 per cent of the rock treated. A clean tailing was obtained. The concentrate, both jig and table, contained some black hornblende, but would average 90 per cent garnet. The test indicated that this method of concentration could be applied successfully to the recovery of the garnet of this particular sample.

Lot No. 2—Wet Concentration on Wilfley Table

The sized material of the previous tests run on a dry table was concentrated on a standard Wilfley table. No difficulty was experienced in obtaining a good separation. The garnet concentrate obtained represented 51·8 per cent of the feed to the table. It contained an appreciable amount of black hornblende, but would contain approximately 90 per cent garnet. The tailing was clean. The good separation depended on the close sizing and the manipulation of the table, especially on the coarser sizes. The grade of the rock treated (50 per cent garnet) was a factor in obtaining such a good separation.

Lot No. 3—Wet Concentration by Jigging Unsized Material

This lot was crushed to pass a 6-mesh Tyler standard screen. An attempt was made to concentrate the −6-mesh material without sizing in a two-compartment James jig. It was found that a good concentrate and hutch product were produced by the first jig, but a very poor concentrate and hutch product were obtained from the second jig if a clean tailing was made. The test indicated the possibility of treating unsized material by jigging with the subsequent regrinding and jigging of a middling product from some of the compartments and the tabling of the hutch products of these compartments.

Lot No. 3—Wet Concentration by Jigging and Tabling Sized Material

The products from the previous test were dried and mixed with the remainder of the lot. The lot was then sized on 8-, 10-, 14-, 20-, 28- and 35-mesh Tyler standard screens. The sizes coarser than 20 mesh were

concentrated in a two-compartment James jig and the finer sizes on a standard Wilfley table. This lot was not so high grade as the previous ones and contained a larger amount of hornblende. Although a good separation was made with a comparatively clean tailing, the concentrate was not so high grade as in the previous small-scale tests made on the higher grade rock. The concentrate obtained represented 32 per cent of the material treated.

Summary of Experimental Tests

The three lots submitted varied in garnet content, in the amounts of hornblende present, and consequently in their amenability to concentration.

Dry concentration by means of the Sutton, Steele and Steele table was not successful. On the higher grade lot on which it was tried a satisfactory concentrate could not be obtained due to the closeness in specific gravity of the hornblende to the garnet.

Lots Nos. 1 and 2 concentrated very nicely by close sizing, jigging or tabling the various sizes. Lot No. 3 being of lower grade material, the concentrates produced were not so high grade nor the tailing so clean as from the other lots by the same methods of treatment.

Conclusions

The results of the test work show three simple methods of wet concentration that may produce a suitable article for the trade. All three gave good results and can be tried out at the mine in more detail and on a much larger scale to prove definitely which is the most economical:

1. *Table Concentration of the Sized Material.* The success of this method will depend on very close sizing of the rock crushed to 6 mesh, and on the careful manipulation of the tables in concentrating the coarser sizes.

2. *Jig and Table Concentration of the Sized Material.* Jigs, as a general rule, have been found to be more adaptable than tables to concentration of material coarser than 20 mesh. In most cases they will give a cleaner product, have a greater capacity, require less closely graded material, and are easily manipulated. Tabling does better work on the finer sizes.

3. *Jig and Table Concentration of the Unsized Material.* It may be found more economical to jig the unsized material, thus eliminating the cost of sizing. By using jigs of several compartments, a clean concentrate and hutch could be obtained from the first two compartments, a middling product and hutch middling from the remaining compartments, and a clean tailing. The middling product could be reground in wet rolls and returned to the jig circuit, and the hutch middling concentrated on tables.

Laboratory Tests

Small-scale tests were made on fourteen samples of Canadian garnet ores from different localities. In all cases where the garnets were pea size or larger, jigging followed by tabling gave good results, but with the small crystals the jigging was omitted. The majority of the samples were obtained from the surface and were consequently considerably weathered so that the concentrates were of lower grade than would be expected from the fresher ores. The concentrates were, however, treated over the Ullrich magnetic separator by means of which a good separation was made (Table VI). This material was used in making the capillarity and fracture tests already referred to.

Ullrich Magnetic Separator

Feebly magnetic minerals such as the iron garnets can be easily attracted by this machine which consists essentially of a taper-edged, annular inductor-ring capable of revolving above the poles. The inductor is either a single ring or it may consist of two or more concentric rings capable of adjustment, which are suspended from the rim of a horizontal disk revolving together with these inductor rings, about a vertical shaft.

The separator is provided with a smaller or a greater number of simultaneously acting magnetic fields depending on the material to be passed through the machine. The number of inductor rings is governed by that of the constituents into which the material is to be separated. Ullrich separators are made having 2, 4, 6, 8 and 10 fields acting upon 1, 2, 3, 4, 5, or 6 rings. The mixed material is passed in between the poles and the inductor rings by means of belt conveyers or shaking chutes. (Figure 10).

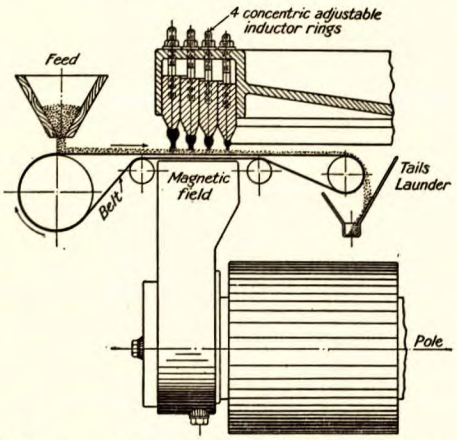

Figure 10. Ullrich magnetic separator, section through one pole and rings.

In the case of the impure garnet table or fine jig concentrates, all the non-magnetic minerals such as hornblende, quartz, feldspar, etc., which may be present, pass along with the feed belt and drop undisturbed into the waste launders. The garnet and other magnetic materials are picked off the belt by means of the pointed revolving rings. The rings become demagnetized where they pass out of the magnetic field and allow the material to drop off into long, narrow, metal concentrate boxes. Each ring can be adjusted to pick up minerals of varying magnetic permeability and thus separated. The final or inside ring, which is closest to the feed-belt, picks up the remaining garnet together with its attached impurities and may be regarded as a middlings product for further crushing and re-treatment.

A very clean separation can be maintained with this machine. The following table (Table VI) shows the proportion of impurities removed from table concentrates of a variety of Canadian garnet ores. In every case the Ullrich concentrates were very clean, and the tails were principally hornblende with a little garnet in a few instances.

The machine used was a 4-ring, 4-pole concentrator.

TABLE VI

Results of Passing Table Concentrates over the Ullrich Magnetic Separator

	Reference Table No. I	57	57	55	33	45	37	28	39	31	30	44	67	75	66
Ullrich concentrates	Location	Markstay, coarse	Markstay, fine	Dill	Fishtail*	Beatty	Black River	Wager*	Quirk*	Card	Ludbrook	Hanah	St. Jean	Darwin falls	Cathcart
	Mesh														
	−20+35 grms.	841	416	680	718	860	896	137	1,010	576	172	289	359	738	1,171
	−35+65 grms.	930	162	431	470	497	369	469	470	273	76	151	203	401	625
	−65 grms.	863	124	192	338	401	471	234	213	229	77	113	187	402	404
	Total	2,634	702	1,303	1,526	1,758	1,736	840	1,693	1,078	325	553	749	1,541	2,200
Ullrich tails	Mesh														
	−20+35 grms.	170	53	59	106	162	341	251	86	120	51	50	101	151	263
	−35+65 grms.	106	23	40	104	190	220	47	74	50	19	41	44	61	142
	−65 grms.	33	14	9	25	65	77	55	10	45	65	13	32	100	150
	Total	309	90	108	235	417	638	353	170	215	135	104	177	312	555
	Total feed	2,943	792	1,411	1,761	2,175	2,474	1,193	1,853	1,293	460	657	926	1,853	2,755
	Total extraction %	11·8	12·8	8·4	15·4	23·7	36·1	42·0	9·9	20·0	41·5	18·8	23·0	20·2	27·5
	Current used.	110 volts 9 amps.	95 volts 6 amps.	95 volts 6 amps.	95 volts 6 amps.	90 volts 5½ amps.	90 volts 5½ amps.	90 volts 5½ amps.	110 volts 10 amps.	110 volts 10 amps.	95 volts 8½ amps.	80 volts 7 amps.	90 volts 8 amps.	80 volts 7 amps.	110 volts 9½ amps.

*Contained garnet in tails.

Note:—In the above table the total extraction of impurities is given, but the extraction for each mesh can be calculated from the above figures, if required.

UNITED STATES GARNET CONCENTRATORS

The United States is the pioneer of the abrasive garnet industry and almost the whole of the world's output is now obtained from that country. A number of concentrators have been erected in the various producing states. There has been little change during the last decade in the methods of concentration other than a few small details accompanied by increased capacity of some of the mills.

The following is a brief account with flow-sheet of the principal producing plants. Elevators and belt conveyers are omitted for simplicity in the drawings.

The Barton Mines Corporation, Gore Mountain, North Creek, Warren County, N.Y.

The Barton garnet concentrator, which is the largest in the world, having a capacity of 250 tons of ore per day, was completed in March 1924. (*See* Plate IV). The garnet, which is of the almandite variety, occurs as large nodules from 2 inches up to 3 feet in diameter, in a dark grey massive rock of hornblende and feldspar enclosed in gneiss. The mill feed averages 12 per cent garnet.

A detailed account of the method of concentration will be found in the Abrasive Industry[1] from which the accompanying flow-sheet was derived (Figure 11). A somewhat novel feature of the procedure consists in treating the total undersize from the fines trommels over roughing tables, making a tailing, a middling and a rough concentrate, the last being cleaned in diaphragm jigs with a very fine screen, a bedding of bird shot, and a stroke of only $\frac{3}{16}$ inch. The tables make all the tailings which go to waste, and the jigs make all the concentrates. Both tables and jigs are of the James type. The mill is driven by two De LaVergne oil engines of 130 h.p. each, and high pressure air for starting the engines is furnished by a separate gasoline engine-compressor unit.

A separate mill has been erected to grind garnet of −200 mesh to supply the glass manufacturers.

North River Garnet Company, Thirteen Mile Lake, North Creek, Warren County, N.Y.

The mill feed consists of gneiss carrying from 4 to 8 per cent garnet in crystals from $\frac{1}{2}$ inch to 3 inches in diameter, hornblende and feldspar being the principal gangue minerals.

The mill of the Hooper mine is a wooden structure built in 1905.

The procedure consists essentially in liberating the garnet by stage crushing and its concentration by jigs and one table. The coarse sizes are treated with Harz and James jigs, and the fines are recovered in vanning and pneumatic jigs specially designed for this purpose by the manager, Mr. F. C. Hooper.[2]

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[1] Mennie, T. S.: "Modern Garnet Mills Operated," Abrasive Industry, pp. 51-54, February, 1925.

[2] Myers, W. M., and Anderson, C. O.: "Recent Developments in Abrasive Garnet," U.S. Bureau of Mines, Serial No. 2691, June 1925.

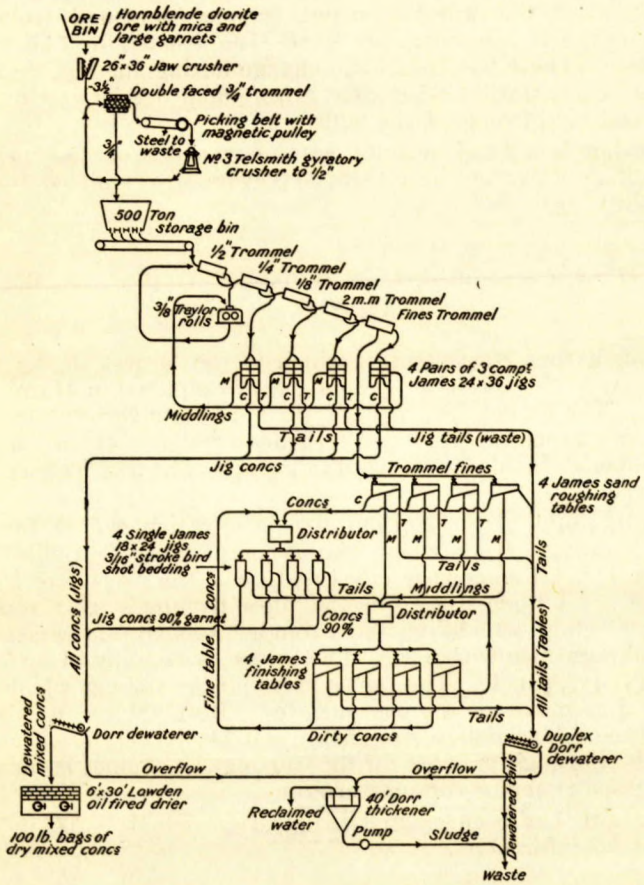

Figure 11. Flow-sheet of 250-ton garnet mill, The Barton Mines Corporation, North Creek, Warren county, N.Y.

A detailed description of the mine and concentrator is given in Mr. F. E. Wormser's article[1] from which the accompanying flow-sheet has been reproduced (Figure 12).

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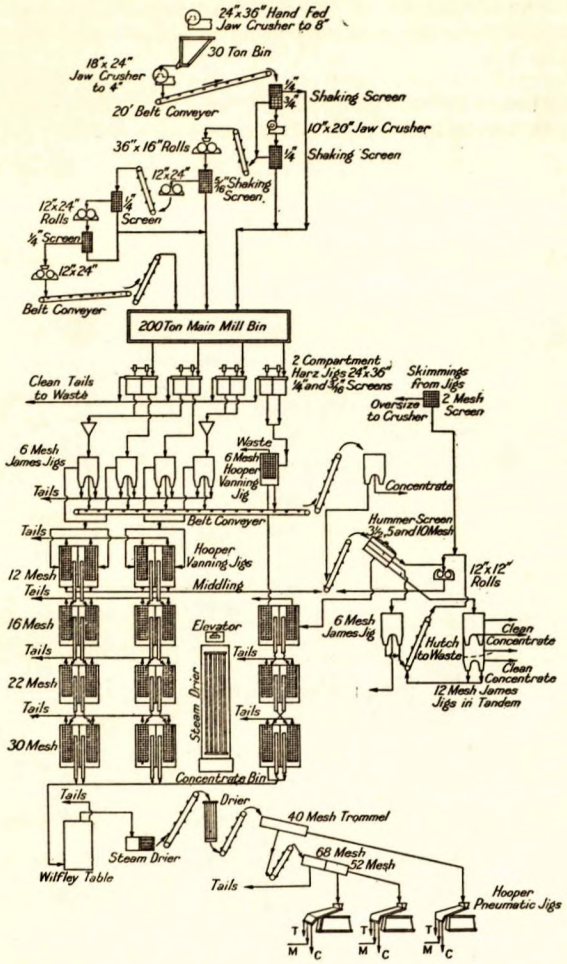
[1] Wormser, F. E.: "Mining, Concentrating and Marketing Garnet," Eng. and Min. Jour. Press, pp. 525-531, Oct. 4, 1924.



After F. E. Wormser, Eng. and Min. Jour. Press, Oct. 4, 1924.

Figure 12. Flow-sheet of garnet mill of North River (Hooper) Garnet Company, North River, Warren county, N.Y. (8% garnet in crystals ½ to 3 inches in diameter. Hornblende and feldspar are principal gangue minerals.)

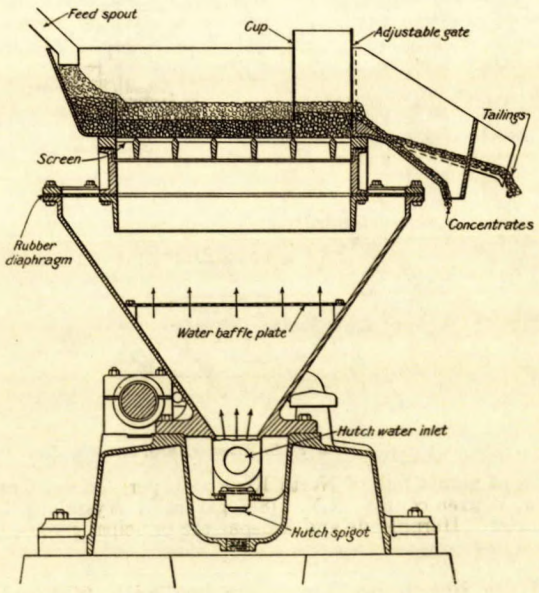
The coarse Harz jigs have 2-inch strokes with 200 pulsations per minute and the concentrates are skimmed every hour by hand and are re-treated. The four 6-mesh James jigs have a ½-inch stroke and 225 pulsations per minute. All the Hooper vanning jigs make a clean concentrate, with the exception of the first (12 mesh). The clean concentrates are removed by hand and sent to the Wilfley table which is run as a vanner and has a 1½-inch stroke and 250 r.p.m. The remainder of the operations can be followed from the flow-sheet.

The concentrates from the various machines are carried by hand to a bucket elevator near the centre of the mill and deposited on to an inclined 30- by 7-foot steam pipe drier at the base of which is a 10-ton finished mixed concentrate bin.

The average mesh percentages of the concentrates which average 90 per cent garnet are, according to Mr. Wormser, as follows:—

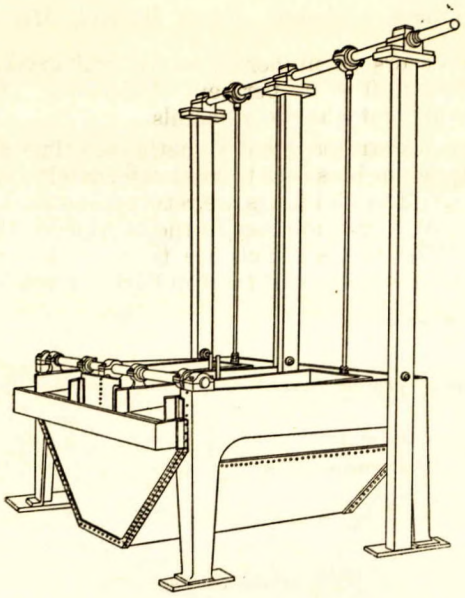
	Per cent
+ 6 mesh	17·1
+ 6–12 mesh	28·0
+12–16 mesh	14·3
+16–22 mesh	18·2
+22–30 mesh	9·2
+30–68 mesh	13·2
	100·0

The accompanying cuts show the James and Hooper jigs (Figures 13, 14, and 15).



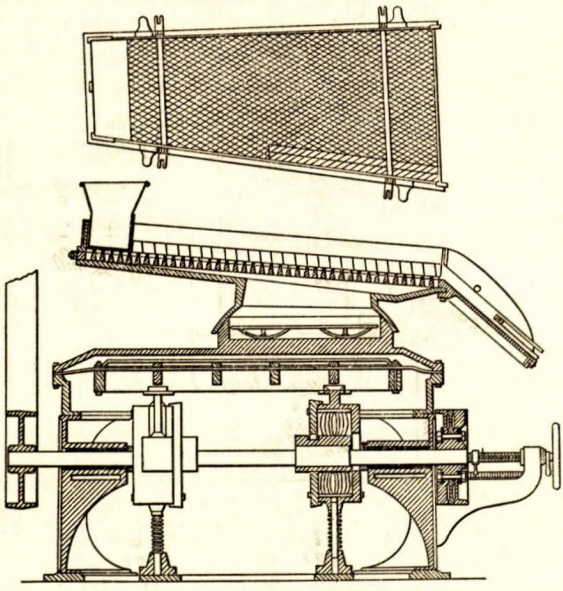
From Eng. and Min. Jour. Press, Oct. 24, 1924.

Figure 13. Cross-section of a James jig.



From Eng. and Min. Jour. Press, Oct. 24, 1924.

Figure 14. The Hooper vanning jig.



From Eng. and Min. Jour. Press, Oct. 24, 1924.

Figure 15. Cross-section of the Hooper pneumatic jig.

The Wausau Abrasive Company, North Wilmot, Merrimac County, N.H.

The garnet occurs as numerous small, red crystals, $\frac{1}{4}$ to $\frac{3}{8}$-inch in diameter, and forms 40 to 60 per cent of the rock. Feldspar and biotite are the most prominent gangue minerals.

The ore is concentrated by dry methods. The sized products after screening are stored in bins and treated alternately on two Sutton, Steele and Steele tables. The middlings are returned to feed, and tails and −48 mesh to waste.[1] At a certain stage in the operations the mica is drawn off by air suction. The tables which are tilted at a fairly steep angle are covered with fine wire gauze and the top part is blocked, while wood riffles

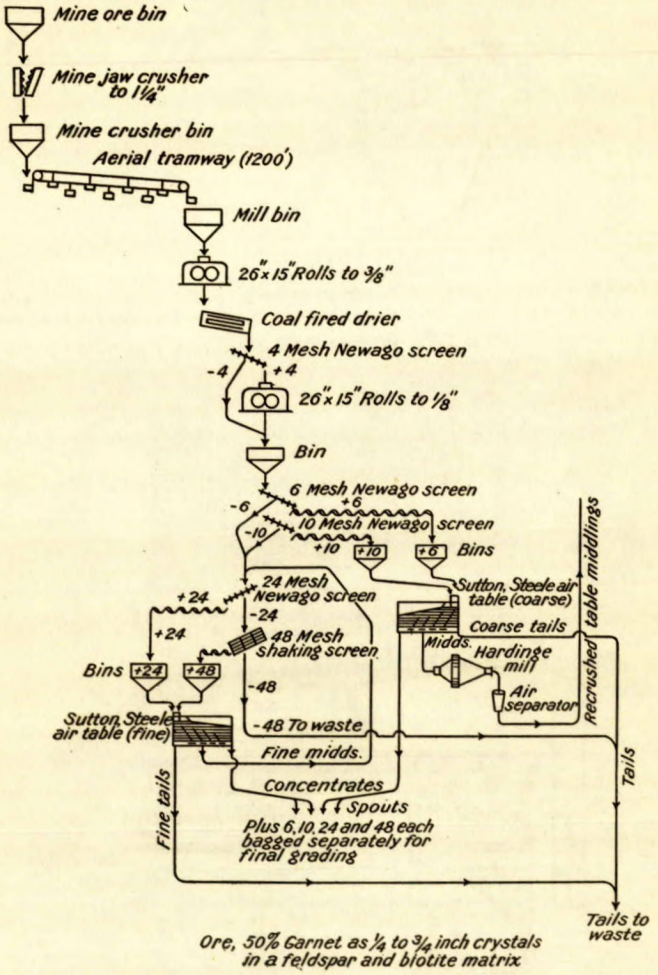


Figure 16. Flow-sheet of 25-ton garnet mill, Wausau Abrasive Company, North Wilmot, New Hampshire.

[1] U.S. Bureau of Mines, Serial No. 2691.

¼ inch wide, ⅛ inch high and 1 inch apart, traverse the tables longitudinally with a few cross diagonal riffles. The tails are conveyed to waste by a screw conveyer. By careful manipulation and sizing a high-grade garnet concentrate is produced and clean tails. The mill, which is driven by a 300 h.p. kerosene engine, has a capacity of about 25 tons per day of rich ore. A new part of the mill regrades the table concentrates over 4 sets of double vibrating screens.

The accompanying flow-sheet (Figure 16) has been mainly obtained from R. B. Ladoo's report.[1]

American Glue Company, Casey Mountain, North River, Essex County, N.Y.

The ore is somewhat similar to the Gore Mountain deposit but the individual crystals are smaller being 6 to 8 inches maximum diameter and occur in a black hornblende gangue.

The mill has not been in operation for the last few years. The procedure consisted in treating the various trommel products in James jigs and tabling the throughs of the fines trommel.

An approximate flow-sheet is given (Figure 17).

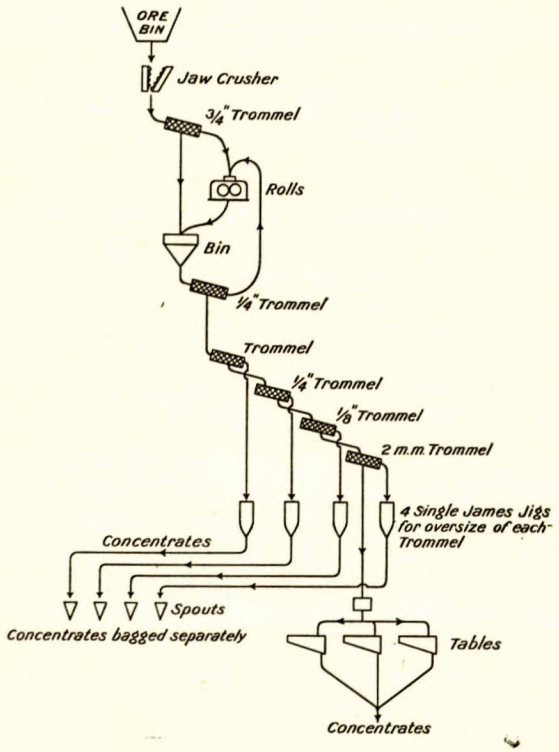


Figure 17. Flow-sheet of garnet mill (approx.), American Glue Company, North River, N.Y.

[1] Ladoo, R. B.: "Garnet," U.S. Bureau of Mines, Serial No. 2347, April 1922.

Warren County Garnet Mills, Johnsburg, N.Y.

The ore consists of small, light red garnet crystals intermixed with green pyroxene in a fine-grained gneiss. The ore is pockety but averages about 40 per cent garnet.

A dry method of concentration is employed which consists of crushing down to pass through a Keedy sizer having 15 sizes from 16 to 200 mesh, the last 12 of which are each concentrated in turn on a Sutton, Steele and Steele table.

A rough flow-sheet is appended (Figure 18).

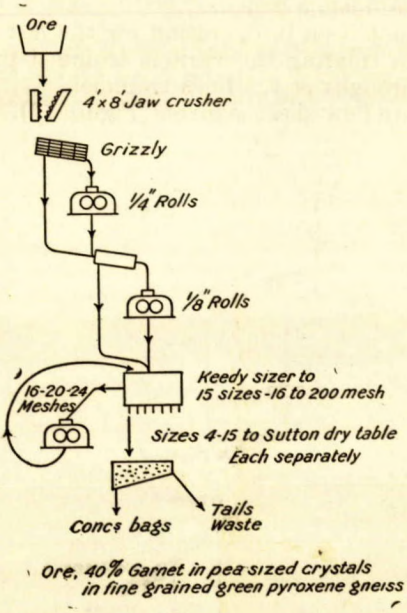
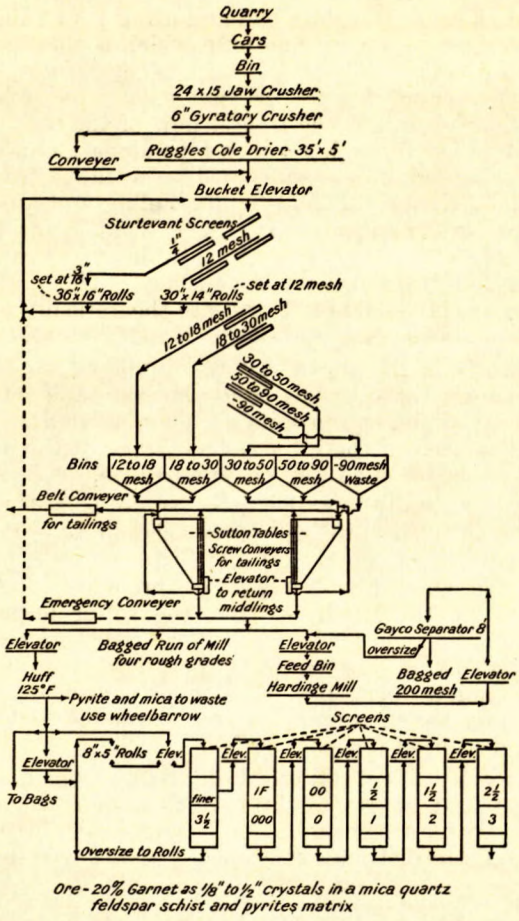


Figure 18. Flow-sheet of 25-ton garnet mill, Warren County Garnet Mills, Inc., Johnsburg, N.Y.

Rhodolite Company, Willits, N.C.

The new mill of the Rhodolite Company built in 1925 employs dry concentration according to the flow-sheet shown in Figure 19. Two 130 h.p. Diesel type engines with generator connexion, supply power for the mill. The capacity of the mill is about 12 tons of concentrates per 10-hour shift from ore containing 20 to 25 per cent garnet.



Flow-sheet by W. M. Myers and C. O. Anderson, U.S. Bull. 256, 1926

Figure 19. Flow-sheet of new garnet mill of the Rhodolite Company, Willits, North Carolina.

USE OF GARNET IN THE PLATE GLASS INDUSTRY

In recent years the utilization of very fine grades of garnet has found favour for the surfacing of plate glass. This material is now used by a few glass firms in the United States and may eventually be used by the European manufacturers.

The preparation of the material used by one firm is as follows:—

The crude ore which averages 35 to 40 per cent garnet in pea-size crystals is crushed at the glass plant in a jaw crusher. The product is then hand fed into a small Hardinge ball mill using $\frac{1}{2}$- to 1-inch chrome steel balls and is pulverized to a very fine pulp which is then pumped up to a series of 10 settling-tanks. These tanks are 14 inches deep but widen out horizontally in the shape of a fan so that each tank is larger than the preceding one, thus retarding the rate of flow of the solution. The pulp from the ball mill is fed through a $\frac{1}{8}$-inch pipe alongside of which water at about 24 gallons per minute is added. The settlings from the first six tanks are sent back to the ball mill for regrinding and are thus in closed circuit. The settlings from the next four—Nos. 7 to 10 fall into 4 agitation tanks from which they are pumped to the glass surfacing machines, each grade being fed to its own set of polishers. The grain sizes of the four grades used are all −300-mesh and are theoretically as follows: No. 7 − ·0011; No. 8 − ·0009; No. 9 − ·0008; No. 10 − ·0007 inch.

It will be seen from the above that the crude ore is used without any concentration, though the overflow from the last tank will eliminate an appreciable amount of the lighter minerals such as quartz, mica, feldspar, etc. The garnet is used in the intermediate stage of the surfacing of the glass between the coarser sand and the final rouge.

Prepared garnet ready for the glass trade is not on the market and it is doubtful in what state the garnet should be. Possibly a fairly high-grade concentrate of about 150 mesh which would then be ground and graded at the glass plant might be preferable. A pure garnet may be found to be too harsh, so that the softer impurities, such as are present in the ore, would tend to tone down the scratches and would be comparable to the use of fine emery rather than flour carborundum in certain metal polishing operations. The finer concentrates or middlings from the garnet mills which are not marketable for the coated trade, might be worked up and utilized for glass surfacing.

Certain deposits of garnetiferous quartzites which consist almost entirely of garnet and quartz might be well suited after crushing, and marketed direct without concentration. Some such deposits occur in Montcalm and Joliette districts of Quebec, Canada (see description).

ANALYSES OF GARNET ORE

The percentage of garnet in an ore or concentrate cannot be determined with any degree of accuracy by chemical analysis owing to the complex composition of the garnet and the minerals with which it is commonly associated. There are, however, mechanical means by which the garnet content can be roughly determined.

The usual method is to determine the percentage of garnet recovered from the concentration of a weighed and accurately sampled tonnage of the ore. This represents the actual percentage that would be recovered in practice. The garnet lost in the tails as a rule will approximately equal the impurities in the concentrate.

The garnet from a weighed part of the finely crushed sample of the ore can be picked out by means of tweezers and a magnifying glass and when entirely separated, can be weighed, and the garnet content calculated.

By the aid of heavy solutions, fairly accurate separation can be made. Abrasive garnet (almandite) has a specific gravity of 3·9 to 4·1, but the common gangue minerals do not exceed 3·4 so that with a liquid of specific gravity of 3·5 or a fraction over, the garnet will sink and all the usual gangue minerals will float. Hornblende with a gravity up to 3·4 is the most difficult to separate. For this purpose a solution of barium mercuric iodide having a specific gravity of 3·5 is the most suitable, but if hornblende is not present methylene iodide (3·3) or potassium mercuric iodide (3·1) may be conveniently used. After frequent stirring in the pipette funnel in order to liberate each particle of gangue the solution is allowed to stand until clear. The material that has sunk to the bottom is drawn off, filtered, and the residue after being carefully washed so as to remove all trace of the heavy solution is dried and weighed.

The following are some of the specific gravities of the common associated gangue minerals, garnet itself averaging 4·0; pyroxene 3·2 to 3·6; hornblende 2·9 to 3·4; mica 2·7 to 3·1; quartz 2·65; feldspar 2·6 to 2·7; also sometimes iron minerals such as magnetite 5·0 to 5·2, pyrite 4·9 to 5·1, and pyrrhotite 4·6.

Both pyrrhotite and magnetite can be readily separated before weighing from the final dry residue by means of a magnet. The pyrite becomes magnetic by roasting and may then be removed by a magnet or the iron oxide product can be dissolved out by hydrochloric acid. Finally the residue can be microscopically examined for any foreign minerals the percentage of which can be roughly estimated and deducted.

It is very difficult to separate very fine material such as −200 mesh, owing to the particles sticking together, but the best results can be obtained by first grinding the material in a mortar with a small part of the heavy solution thus breaking up the lumps and thoroughly wetting it. The mortar should be washed out into the pipette with fresh solution.

Heavy solutions are expensive and their use has consequently been limited, but very little need be wasted if they are carefully filtered and washed down and all the solutions evaporated to their point of saturation.

The heavy solution method has already been referred to in dealing with the analysis of corundum.

A detailed method of chemical analysis has recently been published in which each mineral constituent is estimated separately and the composition calculated.[1]

[1]Fermor, L. L.: "Composition of some Indian Garnets," Rec. Geol. Surv. of India, vol. LIX, 1926, pp. 191-207,

SELECTED BIBLIOGRAPHY ON GARNET

CANADA

For individual occurrences see reference column in general Table I.

Barlow, A. E.: "Corundum;" Geol. Surv., Can., Mem. 57, pp. 111-112 (1915).

Carnochan, R. K.: "Concentration Tests on Canadian Garnet Ores;" Mines Branch, Dept. of Mines, Sum. Rept., pp. 169-184 (1921).

Eardley-Wilmot, V. L.: "Increased Demand and Use for Garnet;" Can. Min. Jour., pp. 685-686 (July 18, 1924).

"Some Canadian Non-metallic Minerals—A Review of 15 years Progress"—Tr. Can. Inst. Min. and Met. vol. XXVIII, pp. 238-241 (1925).

UNITED STATES

New York

Merrill, F. J. H.: "Mineral Resources of New York;" New York State Mus. Bull. 15 (1895).

Hooper, F. C.: "The American Garnet Industry," Mineral Industry, vol. 6 (1897).

Kemp, J. F. and Newland, D. H.: New York State Geol. 17th Ann. Rept. p. 548-549 (1897).

Magnus, H. C.: "Abrasives of New York State; New York State Geol., 23rd Ann. Rept. (1904).

Miller, W. J.: "The Garnet deposits of Warren County, New York;" Econ. Geol., vol. 7, No. 5, pp. 493-501 (August 1912).

Katz, F. J.: "Notes on the Abrasive Garnet Industry;" Min. Res. of the U.S., pt. II, pp. 262-265 (1913).

Miller, W. T.: "The Garnet deposits of Warren County, New York;" New York State Mus. Bull. 164, pp. 95-102 (1914).

— — : "Geology of the North Creek Quadrangle, Warren County, New York;" New York State Mus. Bull. 170, pp. 78-82 (1914).

Newland, D. H.: "Mineral Resources of the State of New York;" New York State Mus. Bull. 223-224, pp. 79-85 (1921).

Skerrett, R. G.: "The World's Greatest Garnet Quarry;" Comp. Air Mag., vol. 28, No. 8, pp. 581-585 (August 1923).

Wormser, F. E.: "Mining, Concentrating and Marketing Garnets;" Eng. and Min. Jour. Press, pp. 525-531 (Oct. 4, 1924).

Mennie, T. S.: "Modern Garnet Mills Operated;" Abrasive Industry, pp. 51-54 (Feb. 1925).

— — : "The Use of Garnet for Glass Grinding;" The Glass Industry, pp. 51-52 (Describes the Barton mine and mill) (March 1925).

Other States

Watson, T. L.: "Mineral Resources of Virginia;" The Virginia Jamestown Exposition Comm., Lynchburg, pp. 287-289 (1907).

Richards, Louis M.: "Garnet Deposits of Georgia;" Min. World, vol. 34, p. 1135 (June 3, 1911).

Bardwell, E. S.: "Garnet Milling in New Hampshire;" Eng. and Min. Jour., pp. 1209-1210, (June 17, 1911) (Abstracts in Mineral Resources of the U.S., pt. II, pp. 848-850 (1911); also pt. II, pp. 265-267 (1913).

Gregory, H. E.: "Garnet Deposits of the Navajo Reservation;" Arizona and Utah Econ. Geology, vol. II, No. 3, pp. 223-230 (April-May 1916).

Katz, F. J.: "Garnet in North Carolina and the Market for Abrasive Garnet;" Eng. and Min. Jour. Press, vol. 107, pp. 903-906 (May 24, 1919).

— — : "Will Mine Garnet and Corundum in North Carolina;" Abrasive Industry, pp. 323-324 (Nov. 1923).

GENERAL

Merrill, G. P.: "Non-Metallic Minerals;" Smithsonian Inst., p. 307 (1901).
— — : Mineral Resources of the U.S., Chapter on Abrasives, U.S. Geol. Surv., Annual (particularly 1911 and 1913).
— — : Mineral Industry, Chapter on Abrasives, McGraw-Hill Book Co., Annual (particularly vol. III (1894); vol. VI (1897); vol. XXVII (1918); vol. XXVIII (1919).)
Ladoo, R. B.: "Garnet;" U.S. Bur. of Mines, Serial No. 2347, 16 pages (April 1922).
— — "Garnet Mining and Preparation;" Abrasive Industry, p. 174 (June 1923); also p. 214 (July 1923).
Myers, W. M., and Anderson, C. O.: "Recent Developments in Abrasive Garnet Production;" U.S. Bur. of Mines, Serial 2691, 11 pages (June 1925).
— — : "Garnet—Its Mining, Milling, and Utilization;" U.S. Bur. of Mines Bull. 256, 50 pages (1925).

INDIA

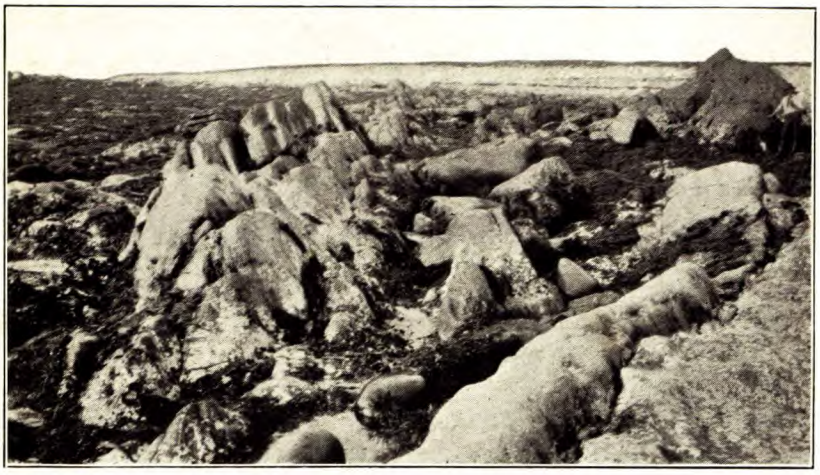
Smeeth and Iyengar: Mineral Resources of Mysore; pp. 128-130 (1916).
Brown, J. Coggin: "Notes on Garnet;" Indian Industries and Labour, Bull. No. 12, pp. 47-54 (1921).
— — : Rec. Geol. Surv. of India, p. 270 (1915); also (1921); p. 335 (1925).
Fermor, L. L.: "Composition of some Indian Garnets;" Rec. Geol. Surv. of India, vol. LIX, pt. 2, 1926.

General Uses

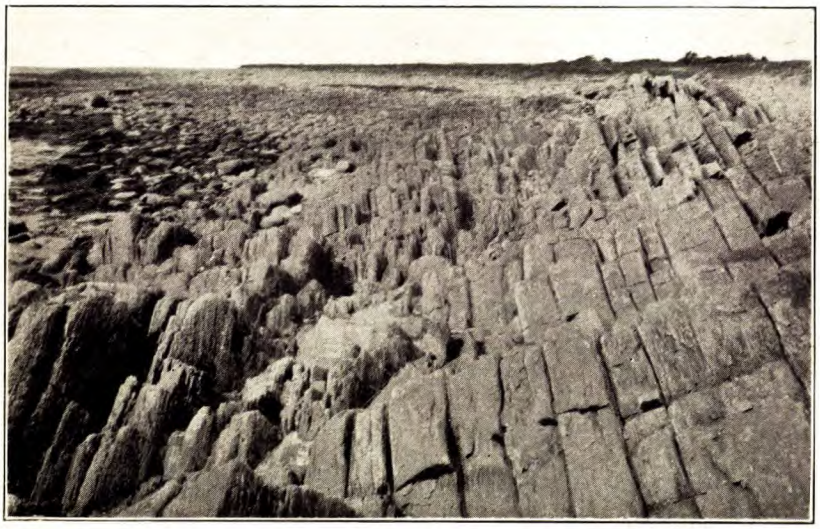
Numerous articles in periodicals describing the manufacture and various uses of abrasive-coated papers in which garnet is mentioned. The following are references in Abrasive Industry:—

Feb. 1921, pp. 54-56; July 1921, p. 228; Oct. 1921, pp. 337-339; Dec. 1921, p. 407; Jan. 1922, pp. 1-2, also 6-7, 9-13; Sept. 1922, p. 265; Oct. 1922, p. 309; March 1923, pp. 99-101, also 108 and 123; June 1923, p. 174, also 176; Jan. 1924, p. 143; Feb. 1924, p. 43; June 1924, pp. 148-152; Nov. 1924, p. 275.

PLATE I



A. Thirty-foot band of garnetiferous hornblende schist outcropping on seashore at Chegoggin point, Yarmouth county, N.S.



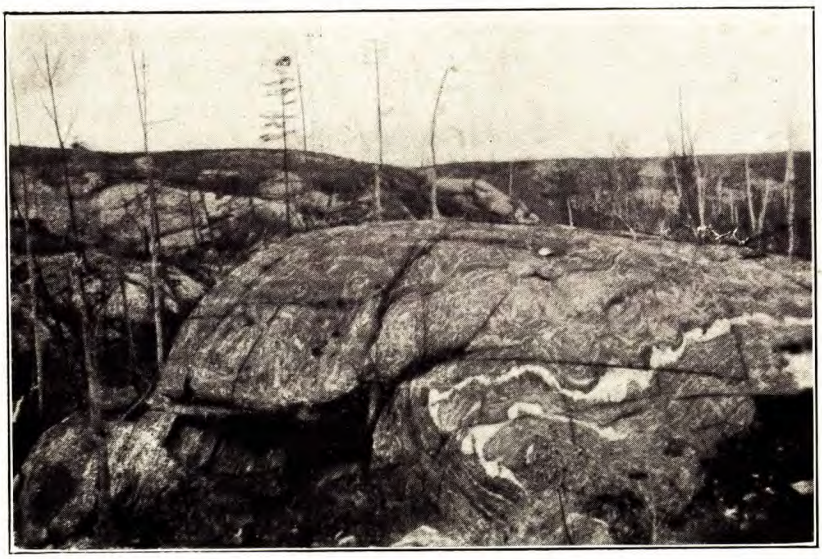
B. Garnet schist (left) and white quartzite on seashore at Chegoggin point, Yarmouth county, N.S.

A. Highly garnetiferous gneiss, Ludbrook farm, lot 12, concession XI, Portland township, Ontario.

B. Masses of walnut-sized garnet crystals at Fishtail lake, Harcourt township, Ontario.

PLATE III

A. Garnetiferous biotite schist exposures on east bank of Wanapitei river, lot 1, concession IV, Dill township, Ontario. Outcrops at curve and at telegraph pole in foreground.



B. Foliated garnetiferous quartzose gneiss, lot 1, concession IV, Dill township, Ontario.

A. Garnet mine, The Barton Mines Corporation, North Creek, New York, U.S.

B. Garnet concentrator, The Barton Mines Corporation, North Creek, New York, U.S.

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