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PAPER 44-8

OCCURRENCES OF QUARTZ CRYSTALS, LEEDS COUNTY, SOUTHEASTERN ONTARIO

(REPORT AND MAP)

By

J. M. Harrison and Y. O. Fortier

OTTAWA

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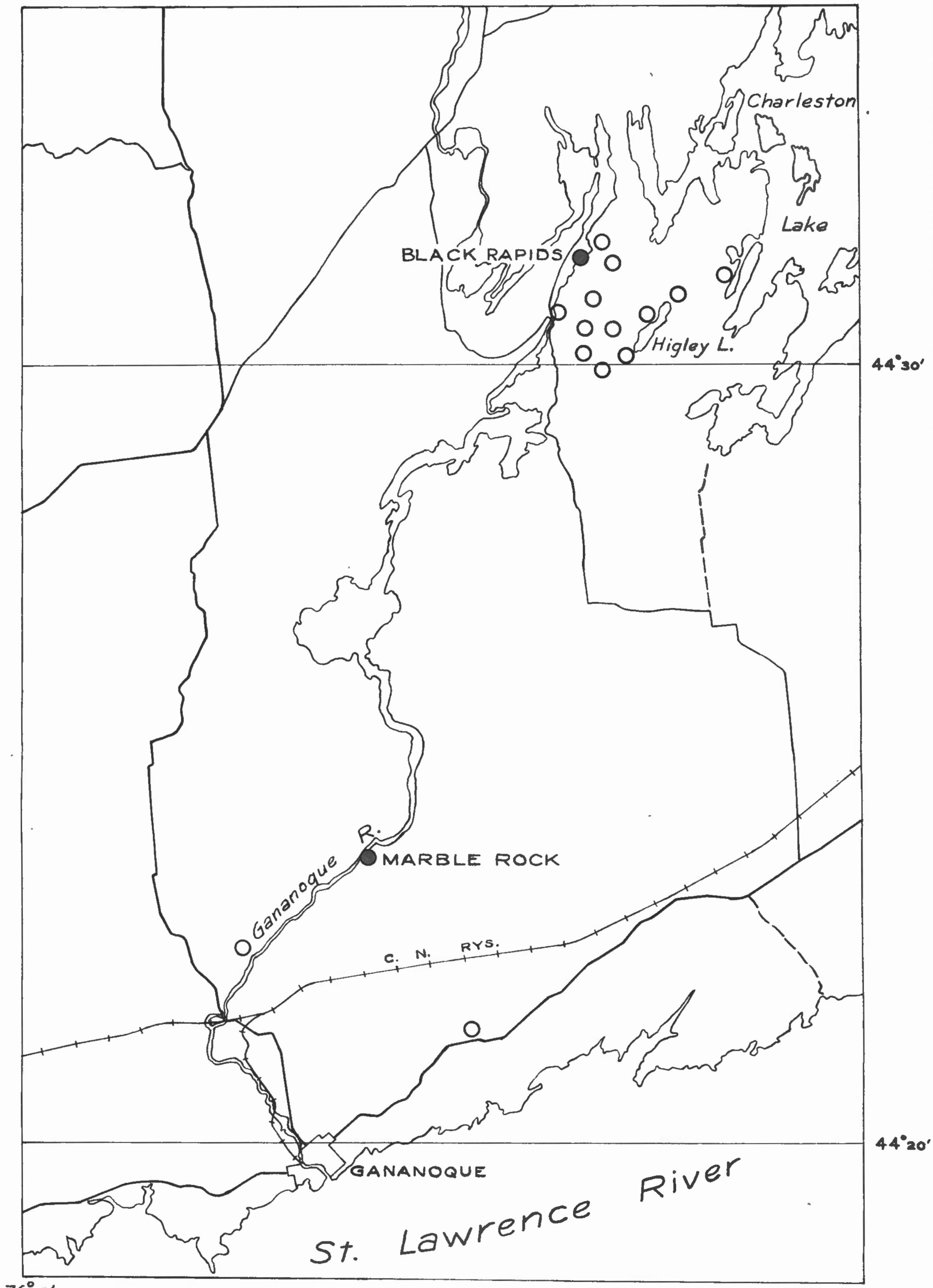
CONTENTS

Illustrations



Scale:- 1 inch to 2 miles

Figure 1. Index map of occurrences of QUARTZ CRYSTAL DEPOSITS, Gananoque River area, Leeds Co. Ontario. Solid circles indicate properties exploited for quartz crystals; open circles indicate other occurrences of quartz crystals.

OCCURRENCES OF QUARTZ CRYSTALS, LEEDS COUNTY, SOUTHEASTERN ONTARIO

INTRODUCTION

Increasing demands for quartz crystals suitable for use in radio and radar equipment have made such inroads on the available supply of Brazilian quartz that a domestic source would be of considerable value. Prospecting in Leeds county, southeastern Ontario, has disclosed the presence of a number of deposits containing crystals of quartz, some of which are of oscillatory grade. In the autumn of 1943 two prospects were being developed, one at Black Rapids and one at Marble Rock (See Figure 1).

Most of October and November 1943 was spent by the writers in making detailed studies of the deposits and in mapping an area considered favourable for the occurrences of quartz crystals. The area mapped (See map) comprises part of lots 7-15, cons.V11-1X, Rear of Leeds and Lansdowne tp., Leeds co.

Acknowledgments

Mr.J. B. Steele, who is directing development operations at both the properties being worked, gave every assistance. H. V. Ellsworth of the Geological Survey made a brief but effinient study of the Black Rapids deposit earlier in the year and the results of his work there provided a guide for the later studies of the larger area. With a few modifications the origin postulated for the deposits is the same as that suggested by Ellsworth from his examination of the Black Rapids prospect.

GENERAL GEOLOGY

Summary

Nearly all the deposits of quartz crystals occur in brecciated siliceous and brittle rocks of the Grenville series.,In the area mapped, the Grenville includes limestones,paragneisses and quartzites, intruded by basic dykes. These are invaded by quartz diorite that in turn is cut by white to pink massive syenites and granites,pegmatites,and,finally,by quartz veins. The entire assemblage is overlain unconformably by basal Nepean (Potsdam) conglomerate, now represented by one outcrop. Areas of glacial drift are locally large and except within areas of quartzite and granitic rocks, exposures are generally poor.

The geologic succession is summarized in the following table of formations:

Era	Period	Description
Cenozoic	Modern	Sands, soils, gravels, and clays
Palaeozoic	Cambrian or Ordovician	Basal Nepean (Potsdam) conglomerate

Table of Formations (Cont'd)

Era	Period	Description
	Post-Grenville	Quartz veins Pegmatite,mainly low in quartz. White to pink,medium-grained, massive syenites and quartz syenites Massive,grey,medium-grained quartz diorite. Fine-grained basic dykes, sparse gabbro. Biotite syenites and diorites,in part included in the Grenville.
Archaean	Grenville	Complex of intrusive syenites and diorites,altered limestone, paragneisses and quartzites; now heavily rusted. Nearly massive,white to pink to grey,medium grained quartzite. Coarsely crystalline limestone, varying from nearly pure lime-stone to calcareous quartzite and paragneisses. Dark grey, sedimentary hornblende-biotite-quartz-feldspar gneisses,locally containing abundant garnets, and interbedd-ed with layers of quartzite; dykes and lit-par-lit injections of granite pegmatites;altered equivalents.

Grenville

Rocks of the Grenville series are so contorted,crumpled and interbedded (See map) that no sharp distinction of lithologic and stratigraphic units could be made. However, the dominant structure of the area is a syncline, which indicates the rough stratigraphic sequence shown in the table of geologic formations.

Paragneisses. Hornblende-biotite-quartz-feldspar gneisses occur in the outer limbs of the syncline and are probably the oldest rocks in the area. They are typically medium-grained,rather dark grey,well foliated gneisses with interbeds of pink to white quartzite as much as 50 feet thick. Locally they contain abundant garnets, particularly in the northern part of the area mapped. They are everywhere characterized by thin layers of lit-par-lit injected pegmatites, and by dykes of pegmatite. Porphyroblasts of feldspar are present locally.

In the southeastern part of the area mapped, a zone of brown feldspathic quartzite and granite gneisses (1a)[1] lies between a

1. Numbers,with or without letters, appearing in brackets in the text of this report refer to map-units in the map legend.

band of white,pure quartzite and a grey gneiss rich in biotite. The granitic gneisses are injected by much pegmatite and occur as irregular patches in the quartzite.

Limestone. Grenville limestone members (2) vary widely in lithology, though all are coarsely crystalline. Most exposures are white to grey, but some of the more altered limestone weathers rusty. All of it carries flecks of graphite and, locally, many lime silicate minerals are present. In a few places the original limestone has been converted almost entirely to such minerals. To the west of Higley Lake five small bodies of coarse- to fine-grained,hornblende-rich rock (2a) lie at the contact between limestone and syenite and are probably a contact-metamorphic phase of the limestone.

Limestone is commonly interbedded with layers of impure quartzite that vary in thickness from less than ¼ inch to 5 or 6 feet. In places this quartzite comprises 75 per cent of the exposed rock, but has not been differentiated from the limestone on the map. It probably represents original lenses in purer limestone, and no sharp contacts between it and limestone can be distinguished.

Quartzite. Most of the Grenville quartzites (3) in the area mapped are white to light grey rocks containing minor amounts of magnetite and biotite as the only accessory minerals. Because of their purity bedding can rarely be distinguished, though locally it is indicated by thin layers with a higher concentration of magnetite or by occassional layers of dark grey to rusty gneiss. Sparse,irregular layers of crystalline limestone are interbedded with the quartzite.

In places the prevailing white quartzite takes on a pinkish cast due to the presence of discrete grains of pink feldspar. The depth of colour depends on the amount of feldspar present and is more pronounced near dykes of pink granite or pegmatite. In the south-east part of the area mapped, large numbers of these dykes have altered the quartzite to a point where it strongly resembles granite.

Rusty Gneisses. Included with the Grenville group is a group of rusty gneisses (4) in which the individual members are undifferentiated. The group consists of quartzites, hornblende-biotite-quartz-feldspar-gneisses, and extremely altered limestone that now consist mainly of silicates intruded by numerous syenitic dykes. The rocks are weathered to a deep rusty colour and in many places a limonitic crust as much as ½ inch thick has formed at the surface, though the zone of rusting commonly extends much deeper.

Post-Grenville Intrusive Rocks

Syenite and Basic Dykes. A number of fine-grained,dark, basic dykes and one of medium-grained gabbro (5) intrude the Grenville series. Some have a diabasic texture. All are somewhat altered,with plagioclase converted to scapolite and cloudy alteration products, and dark silicates changed to chlorite.

Associated with these dykes and altered to about the same degree, are the syenite dykes of the rusty zones in the Grenville series (4). Their principal constituent is microcline. Most of them contain biotite as the main accessory mineral, though some are rich in hornblende. They also contain as much as 10 per cent pyrite and magnetite. Apparently these dykes were responsible for the introduction of much pyrite,thus giving rise to the rusted gneisses already referred to.

Quartz Diorite. Quartz diorite (6) occurs in a single large dyke-like mass. It is a dark grey, typically massive, medium- to coarse-grained rock consisting mainly of andesine (An_{30}) and quartz with accessory biotite, hornblende, magnetite, apatite and titanite.

The rock transgresses foliation and schistosity in the enclosing Grenville formations.

Syenite and Pegmatite. White, massive, medium-grained syenite and quartz syenite (7), with associated pegmatites, are common in the area mapped. Less commonly they are pink. The syenites consist dominantly of microcline with subordinate albite-oligoclase and accessory quartz, biotite, magnetite, tourmaline, and apatite. Practically all grains, in thin sections examined, are rimmed by fine-grained, crushed material - mortar structure - indicating post-consolidation movement.

White syenite occurs at many places along the margins of the quartz diorite body (6), particularly along its contacts with limestone. Contacts between syenite and diorite are seldom sharp, though in one or two places syenite cuts diorite. It appears likely from the field relations that the two are closely associated genetically.

Pegmatitic phases of the syenite, most of them low in quartz, are numerous in the area. All are white except some pink members that intrude quartzite. Usually the quartzite in the vicinity of the pegmetites is impregnated with pink microcline. Pegmatites, or coarse-grained dykes of granite, are invariably present at, or near, deposits of quartz crystals.

Feldspar is the dominant mineral of the pegmatites and usually occurs as coarse crystals with finer grained interstitial material consisting of feldspar, quartz, magnetite, and biotite, with local tourmaline, hornblende, magnetite, ilmenite, garnet, and titanite.

Fragments of brecciated pegmatite are common in areas of contorted limestone.

Quartz Veins

Veins of milky white, massive quartz are common in the district. Locally the veins consist of subhedral crystalline quartz, and euhedral quartz crystals are abundant in vuggy parts of the veins.

Veins with the most vuggy quartz commonly occur in brecciated zones. The quartz acts as a cement for fragments of the brecciated rock, which includes Grenville gneisses and quartzites, diabase, and pegmatite. The quartz is not brecciated.

Nepean (Potsdam) Conglomerate

One small outcrop of basal Palaeozoic conglomerate (8) overlies Grenville quartzite and limestone with angular unconformity in the central part of the area mapped. It consists of an arkosic groundmass cementing pebbles and cobbles of Grenville rocks. Almost all of the pebbles and cobbles consist of pinkish white quartzite with grains of pink feldspar, a rock very similar to that occurring where pegmatite has intruded white quartzite. The remainder of the pebbles consist of fine-grained chert and a few granitic types. A few, small, loose, rounded crystals of quartz were also seen.

STRUCTURE

The presence of much limestone in the area mapped makes structural determinations extremely difficult. During folding the limestone yielded by plastic flow and is, therefore, exceedingly contorted. In many places contorted limestone is in contact with relatively undeformed quartzites or gneisses.

The major structure is probably a northeast-plunging syncline. Except on the northwest side of Red Horse Lake, wherever the direction and amount of plunge could be determined, as on linear elements and drag folds, these indicate a rather low plunge to the northeast. In the southeast part of the area dips are mainly westward and in the northwest part they are mainly eastward. Further, allowing for alteration and intrusion there is a rough duplication of lithologic units on either side of the axis (See map).

Subsidiary folds occur within the major synclinal fold. The axis of one of these passes through the garnet-bearing gneisses on the southeast shore of Red Horse Lake. As this subsidiary structure plunges northeast and closes to the southwest it must also be a syncline.

If the interpretation of the major structure is correct, the elongate mass of quartz diorite has been intruded near the axis of the syncline, and its intrusion may have caused some of the intense crumpling of the Grenville rocks near its western margin. Similar crumpling on a small scale may be observed in limy beds at the southern tip of the intrusive mass.

Further, at least two periods of folding are indicated. Quartz diorite truncates foliation in the gneisses and limestones, so that folding must have occurred prior to its intrusion. A later period of folding is indicated by the occurrence of fragmented dykes of pegmatite and syenite in limestone, the intrusive rocks being very similar to dykes that cut quartz diorite. Hence folding must have occurred after intrusion of pegmatite. Movement after emplacement of the syenite in this area is also indicated by granulation in the intrusive rock.

A later period of folding is further indicated by opposition in direction of plunge on the shores of Red Horse Lake. On the east shore all structures plunge to the north and northeast. North from Black Rapids bridge, on the west shore of the lake, plunges are rather low to the north for about $\frac{1}{2}$ mile. For another $\frac{1}{4}$ mile the direction and amount of plunge in the limestone is very irregular, but gradually changes to a regular southward plunge of about 30 degrees. It is probable that the axis of a gentle cross-axial syncline, with a very irregular trough, comes into Red Horse Lake from the west at a point about $\frac{1}{2}$ to $\frac{3}{4}$ mile north from Black Rapids bridge. The axis of the syncline is turned slightly more to the north where it reaches the more competent quartzites and paragneisses and passes northward through Red Horse Lake.

Again, post-pegmatite movement is indicated at the Black Rapids prospect. Here pegmatites cut the gneisses but are themselves brecciated and cemented by vuggy quartz, which is not fractured except, perhaps, to a very minor degree. As the quartz deposits are invariably associated with pegmatites and granite dykes there is probably a close genetic connection between them. Hence it appears that this later period of folding was of relatively short duration, probably commencing during intrusion of the syenite and continuing until emplacement and consolidation of the pegmatites.

QUARTZ DEPOSITS

Occurrences of crystalline quartz are fairly numerous in the district, but during the autumn of 1943 only the Black Rapids and Marble Rock deposits were being explored. The deposit at Black Rapids best exemplifies the mode of occurrence of the quartz crystals, though not all deposits are identical.

In this report the term 'massive quartz' refers to milky white vein quartz in which no crystal faces can be seen, and 'crystalline quartz' to quartz in which individual crystal faces are apparent.

Host Rocks

Veins of crystalline quartz occur in quartzite, limestone, gneisses, quartz diorite, granite, pegmatite, and contact-metamorphic hornblende-feldspar rock. The larger deposits are in siliceous, brittle rocks of which quartzite is by far the most favoured.

Bedding and foliation of the rocks surrounding the deposits are generally regular and dips are steep. The plunge of the rocks is indicated by the arrangement of linear elements and by faint ridges and striae along surfaces of schistosity. Locally rocks have been brecciated by movement; at other places numerous apophyses of quartz diorite, or multiple dykes of granitic rocks, have produced mosaics in quartzites that may be called intrusive breccias.

Alteration

Chlorite is characteristic of nearly all quartz deposits in rocks carrying dark minerals such as biotite and hornblende. Considerable epidote has also been formed at two places where quartz occurs in limy rocks.

At Black Rapids the host rock is, in part, chlorite-quartz-feldspar gneiss (1b), some phases of which consist dominately of chlorite with subordinate cloudy feldspar and a little quartz. It is surrounded by hornblende-biotite-quartz-feldspar gneiss with numerous garnetiferous interbeds. The chlorite-rich rock at the deposit is probably the alteration product of the surrounding hornblende- and biotite-bearing gneisses.

Structural Control

Local structural control appears to depend on brecciation of the host rock, though in some of the smaller deposits the quartz follows joint planes. The cause of the brecciation is not always apparent, but in places can be attributed to cross folding.

At Black Rapids (See Figure 3) brecciated rocks comprise an area about 60 feet wide by 180 feet long. They consist of white and grey quartzites, chlorite-quartz-feldspar rock, intrusive diabase, and pegmatite. The breccia is cemented by vuggy quartz and many of the cementing veins dip parallel to the plunge, rather than along the dip, of the host rock. This feature can be recognized best at the margins of the deposit where the rocks are least affected by the brecciation. The zone of brecciation is approximately in line with the projection of the axis of the synclinal cross fold that enters Red Horse Lake from the west (See map).

At Marble Rock the structural control is not clear. Foliation in the rocks strikes about northeast and dips nearly vertically. Northeast of the showing the rocks plunge to the northeast at low angles and dykes of granite roughly follow the plunge. At the quartz showing, striae on joint and schistosity surfaces indicate a plunge varying from 20 degrees northeast to 10 degrees southwest, whereas southwest of the showing the rocks have no plunge (See Figure 4). This arrangement suggests a gentle anticlinal cross fold with the axis approximately where the quartz occurs. However, brecciation is not marked and at least two ill-defined joint systems have exerted some control. Also, numerous granitic dykes of variable attitude may have acted as dams to incoming solutions bearing quartz.

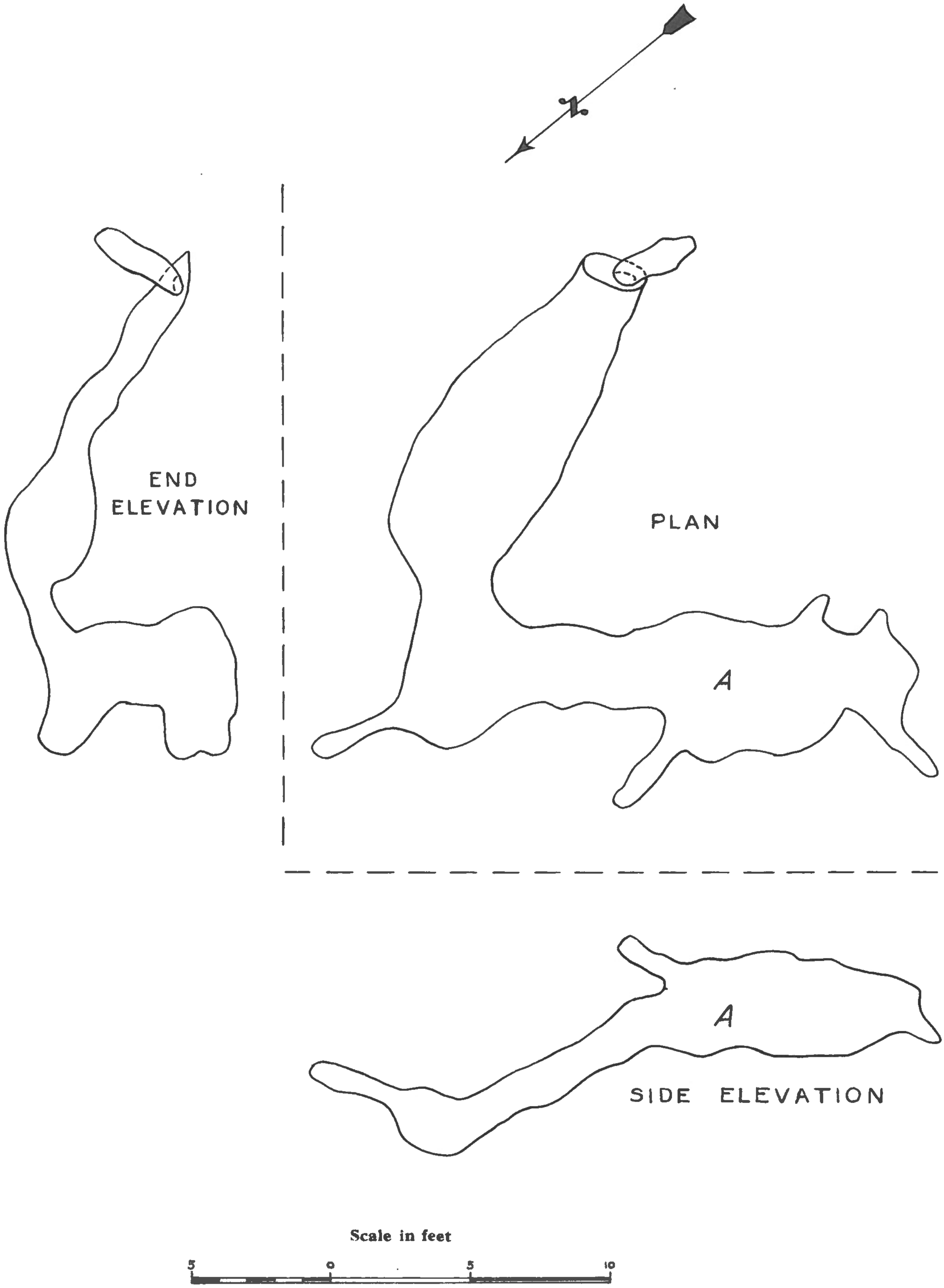
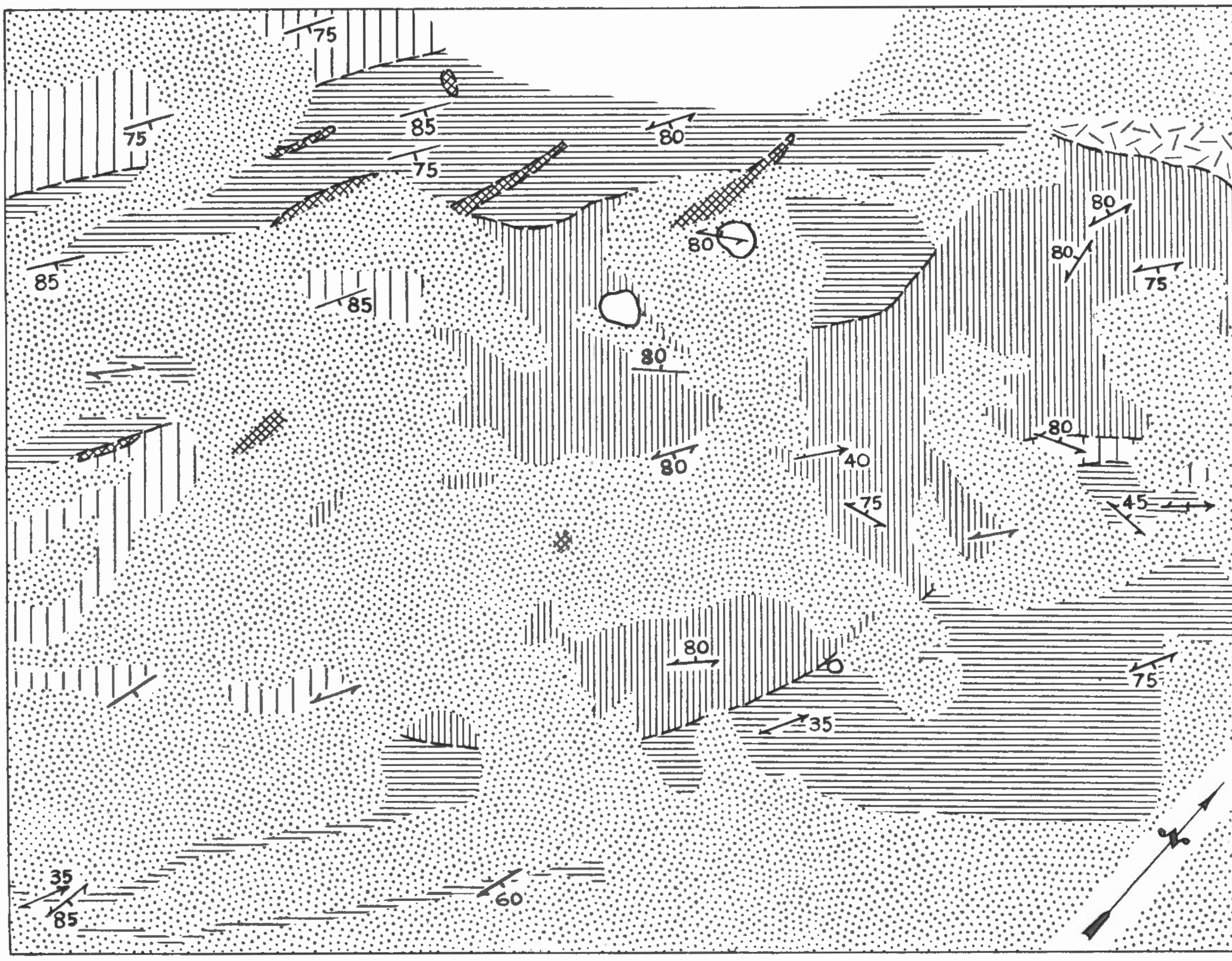


Figure 2. Sketch of vug at BLACK RAPIDS quartz crystal prospect.

G.S.C.



Scale in feet

LEGEND

Brecciated zone, including quartzite, quartz-feldspar-chlorite rock, and pegmatite cemented by vuggy quartz

Pegmatite, locally containing vuggy quartz

Diabase partly brecciated

Quartz-feldspar-chlorite rock, in part schistose

Pink to grey quartzite

Drift-covered area

Bedding (inclined) ....

Schistosity (inclined, dip unknown) ...

Arrow indicates direction of plunge from linear elements ....

Open cavity with quartz crystals ....

Figure 3. Geology of BLACK RAPIDS quartz crystal prospect.

G.S.C.

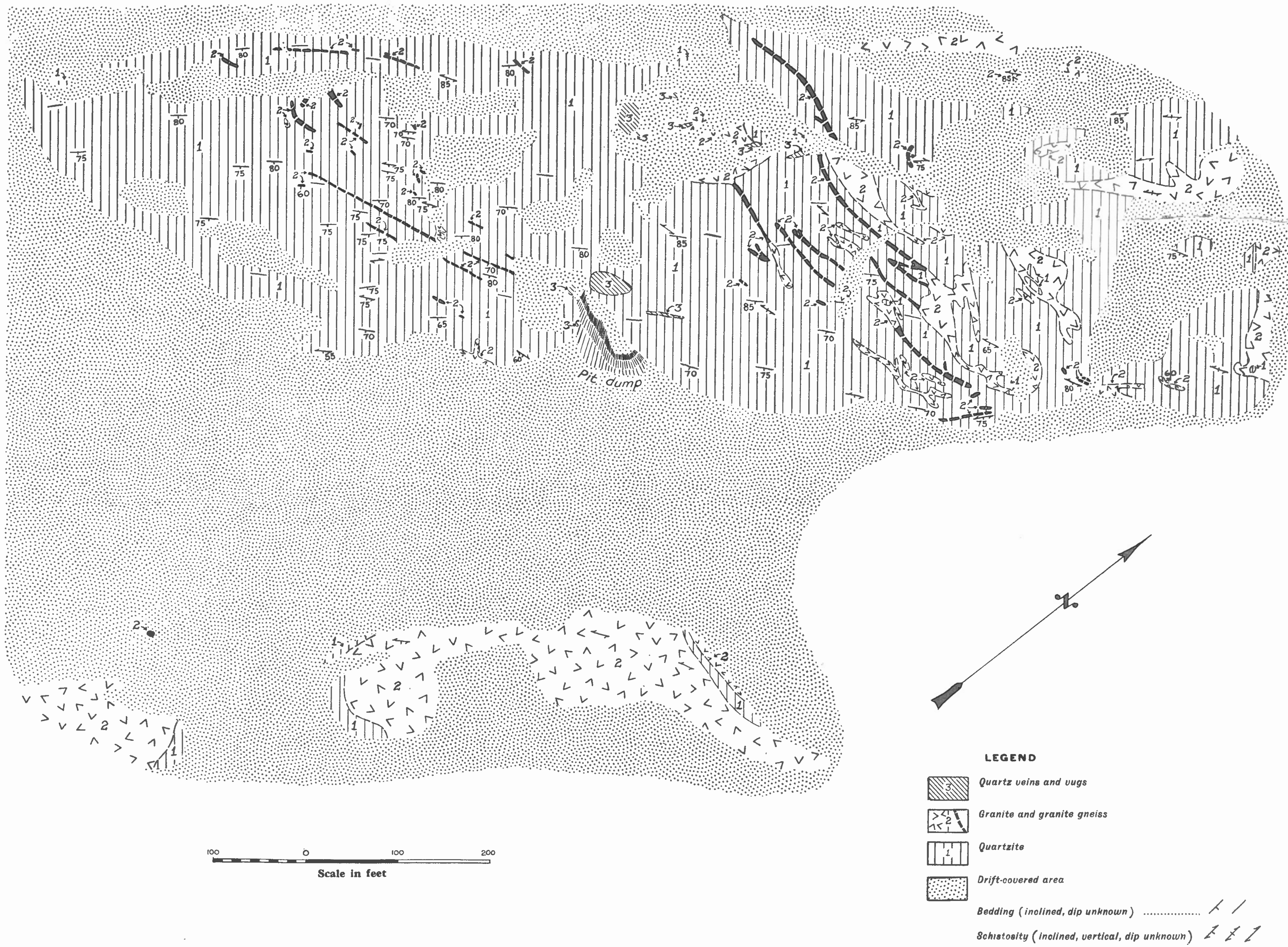


Figure 4. MARBLE ROCK quartz crystal prospect.

G.S.C.

Intensely brecciated zones were noted at a number of other places, some restricted to white quartzites, others including intrusive bodies in the quartzite.

Quartz Bodies

Quartz bodies have all forms. They may be irregular patches cementing brecciated rocks, crusts lining cavities, isolated pods, veins with straight or crooked walls, and lenticular masses. Individual cavities are locally 5 or 6 feet wide, but are usually less than 2 feet. At Black Rapids, one irregular cavity was followed for about 25 feet. It has a rude V-shape, which slopes towards the point along the plunge of the host rock (See Figure 2).

The quartz at the contact with country rock is massive and milky white. In thin section it is seen to be filled with minute, unidentifiable inclusions, probably of gas as they effect no discoloration. This milky quartz commonly has subhedral to euhedral crystals of quartz attached to it and projecting into cavities, the walls of which have, in consequence, a pronounced comb structure. The crystals vary in clearness. They are usually cloudy near the base, but commonly are much clearer toward the free end. Some large crystals, 2 inches or more in diameter, are 'crystal clear' at the terminated end. Commonly the interstices between quartz crystals contain fine micaceous specularite.

Some cavities are filled, or partly filled, with a very fine, iron-stained 'mud'. Apparently this mud is a product of disintegration of the host rock and consists mainly of clayey minerals. The appearance of the mud varies somewhat with the wall-rock - thus at Black Rapids, where much chloritic material is present, the mud is quite dark and contains flakes of chlorite, whereas at Marble Rock the mud is lighter in colour and contains no recognizable chlorite. Near Charleston Lake a zone of vuggy quartz is restricted to pure quartzite, with very sparse granitic material, and no mud was found in the cavities. Where this mud occurs it contains loose crystals of imbedded quartz. Some of the crystals have perfect terminations at both ends; others have one perfect termination and one irregular. Crystals have undoubtedly been regenerated, as shown by the following features: (1) broken quartz crystals have been rejoined by quartz that encloses limonitic and clayey material; (2) crystals lying in the mud show all stages of growth from singly terminated crystals with freshly fractured bases through partly healed fractures to perfectly formed, doubly terminated crystals; (3) crystals occur with a coating of red hematite on original crystal faces now enclosed by clear quartz of the same orientation as the original crystal.

This second generation of quartz is invariably clearer than the original crystal it coats. However, in some cases the crystals attached to the walls of the vugs show every gradation from milky quartz near the base to perfectly transparent material towards the terminated end, indicating that deposition of quartz was continuous.

A characteristic of many of the doubly terminated crystals is the development of one rhombohedral face, almost to the exclusion of the others, on the healed end, thus giving rise to a chisel-shaped termination. Most of the crystals attached to the walls of the vugs show nearly equal development of two terminal rhombohedrons on the free end. Both right- and left-handed crystals are present, though not abundant. Twinned crystals are not abundant, but parallel growth and intergrowths of crystal are common.

Most of the crystals, particularly those found loose in the mud, have a thin, but extremely persistent, layer of limonitic clayey material adhering to them. In some cases the coating cannot be removed even with hot, concentrated, hydrochloric acid.

Many of these coated crystals have a pitted surface, much as if they have been etched. These features make it difficult to estimate the worth of the crystals when extracted. They must be washed and scrubbed before sorting.

Origin of the Quartz Crystals

Deposits of quartz crystals are so closely associated with pegmatites and granite dykes that a close genetic connection is extremely likely. Further, where deposits occur in quartzite, they do so only in quartzite that has been feldspathized by acid intrusions. However, both the pegmatites and granite dykes have been brecciated and are cemented by quartz that is itself not visibly deformed, though some disturbance is indicated by the fact that quartz crystals found lying loose in the mud in the cavities must have been broken from the walls of the vugs.

The following sequence of events is proposed. Towards the close of igneous activity in post-Grenville time syenites and pegmatites were intruded just before, or during, a period of minor folding. Defprmation must have continued until after consolidation of the intrusive rocks, as shown by granulation in the syenites and by fragmentation of pegmatite dykes in bodies of incompetent Grenville limestone. More competent rocks, such as quartzite and gneisses, shattered instead of flowing, and left open cavities that could be entered by the quartz-bearing solutions from the magma. Milky quartz was deposited first along the walls of the cavities, probably at temperatures approaching those of the formation of the pegmatites, as indicated by the gaseous inclusions. As the temperature fell, and possibly also the concentration of the liquids decreased, crystals formed and clearer quartz was deposited. Minor adjustments to the final tectonic movement caused some crystals to break off the walls of the vugs and fall into the accumulated mud in the cavities, the mud being derived mainly from the alteration of aluminous minerals in the rocks through which the solutions passed. As more silica was brought in the fractured ends of the quartz were healed, the degree of healing depending on the stage at which the crystals were broken off. Some were healed completely, others only partly, and some scarcely at all. It is likely that solutions passed through some of these vugs for a long time, though emanations may not have been, and probably were not, continuous, as two or more distinct generations of quartz can be recognized at some places. Temperatures were high enough during emplacement of at least part of the quartz that the mafic silicates of the enclosing rocks were converted almost completely to chlorite. In some places where brecciation did not occur the solutions followed joint planes.

The time of formation of the quartz deposits is definitely dated as Precambrian, for the basal conglomerate of the Palaeozoic contains pebbles of quartzite verysimilar to that occurring with the quartz deposits. Further, rounded crystals of quartz are also present in the conglomerate. However, it is possible that slight regeneration took place after the close of Precambrian time.

Quality of Crystals

By far the majority of crystals are ¼ inch or less in diameter, though they may be as much as 4 inches thick. Most of them are less than 2 inches long, but some are 10 to 12 inches. The smaller crystals are usually clearer. Most of those with a minimum dimension of 1 inch or more are cloudy, but may contain clear parts large enough for radar and radio equipment. Crystals with a minimum dimension of ½ to 1 inch are more apt to be clear and flawless and could be used for radio. On the whole only a small proportion of the total crystalline quartz in any of the showings examined is of oscillatory grade.

Economic Possibilities

It is unlikely that any of the deposits seen will be a large producer of oscillatory quartz. In conjunction with the relatively small amount of quartz of suitable quality, some of the potentially marketable material will inevitably be destroyed by blasting operations. A large cavity or vug may, under suitable conditions, yield several hundred pounds of marketable quartz, but, judging from the prospects seen, such vugs are rare.

It seems best to develop these quartz prospects on a small scale, employing only local labour and with as little capital outlay as possible.

Guides for Prospecting

The quartz deposits are clearly associated with quartzites and other brittle rocks. Some milky quartz masses occur in limestone, but do not contain encouraging crystal deposits. Quartzite is by far the most favourable host rock, for, even at Black Rapids where the deposit occurs in paragneiss, the quartz is localized where there is a large proportion of interbedded quartzite. Pure white quartzite, however, does not appear favourable, as all quartz showings associated with quartzite occur where it has been feldspathized by granitic or pegmatitic dykes. And, finally, the host rock must have been brecciated, to provide space for adequate amounts of quartz to be deposited.

The most favourable areas for prospecting, then, are those underlain by brittle rocks, preferably by quartzite, that have been intruded by dykes of pegmatite or granite.