# MINERALS FROM THE NEPHELINE SYENITE, MONT ST. HILAIRE, QUEBEC

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## Abstract

Eighty-seven mineral species have been identified from the veins, vugs and inclusions in the nepheline syenite, Desourdy Quarry, Mont St. Hilaire, Quebec. Many of these are rare minerals, found only in a few similar occurrences in the world. Chemical, optical and crystallographic data on 10 unidentified minerals are also presented. An *x*-ray identification table is attached, giving six strongest diffraction lines and their intensities.

## Introduction

In the summer of 1963 Frank Melanson, an amateur mineral collector from the Montreal area, submitted several mineral specimens collected from Desourdy Quarry, Mont St. Hilaire, Quebec to one of us (G.P.) for identification. One of the minerals identified was serandite, a rare manganese analogue of pectolite. This finding was reported at the 1964 annual meeting of the Mineralogical Association of Canada (Boissonnault & Perrault, 1964). Since then, Desourdy Quarry has become a popular mineral collecting site. Work at École Polytechnique, Carleton University and the Royal Ontario Museum has resulted in the positive identification of 87 minerals from this quarry. Of these, many are rare minerals found only in a few similar occurrences such as the Kola Peninsula, USSR; Langesundfiord, Norway and the Narssarssuk-Kangerdluarsuk area, Greenland. In addition, there are at least ten minerals not yet identified.

Detailed studies on several rare minerals from this locality have already appeared in the literature. Pendlebury (1964) and Machairas & Perrault (1965) gave a detailed account on catapleiite. Boissonnault & Perrault (1965) published data on eucolite. Mandarino, Harris & Bradley published data on mangan-neptunite, epididymite and two new species. Perrault (1966) read a note on polylithionite. Boissonnault (1966) gave detailed descriptions of catapleiite, eucolite, serandite and some other minerals.

The purpose of this paper is to provide a list of minerals identified from this quarry, with a short account of their mode of occurrence. It is hoped that it may stimulate further research toward the understanding

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of the chemistry of the Mont St. Hilaire pluton, especially at the pegmatitic stage, and the genesis of its mineral assemblages.

## Geological Setting

Mont St. Hilaire, about 20 miles east of Montreal, is one of the nine well-known Monteregian hills, which extend for about 75 miles on a general east-west trend. These hills are all monadnocks, rising to some 700 feet above the essentially flat St. Lawrence lowlands (Fig. 1). Alkalic intrusive rocks form the core of each hill; gabbro and syenite are most common. The Oka complex is an ijolite-carbonatite body. Age determinations place the time of intrusion at between 90 and 125 million years (Lower Cretaceous).

Mont St. Hilaire (Fig. 2) is the product of two main intrusions; essexite, which forms the western half of the mountain, and nepheline

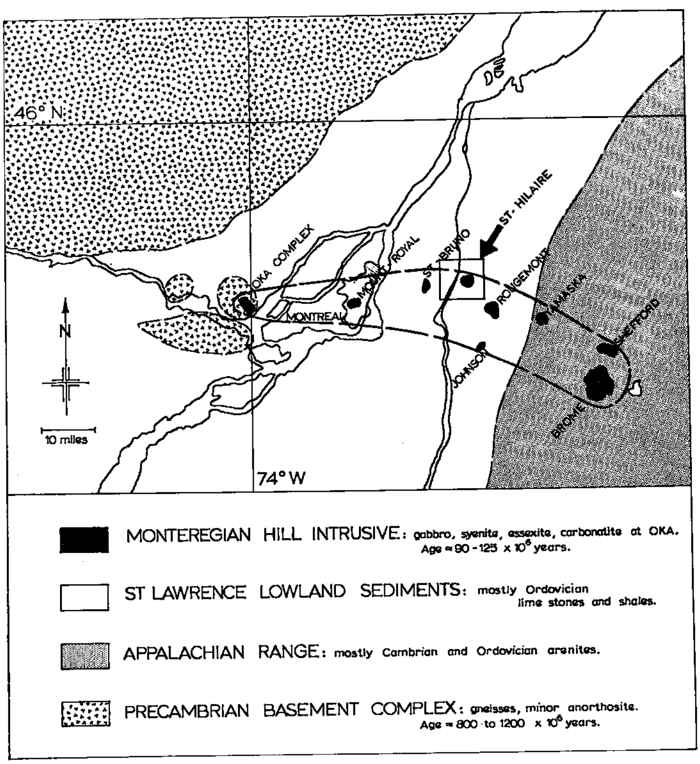


Fig. 1. The Monteregian Hills, adapted from maps 703 A and 704 A, Quebec Department of Mines and Natural Resources.

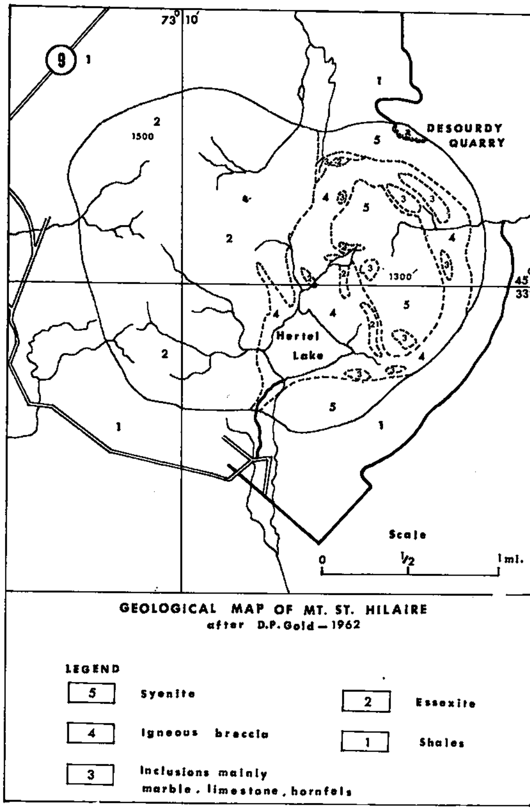


FIG. 2. Geological Map of Mont St. Hilaire.

syenite grading into nepheline-sodalite syenite, forming the eastern half. About the margins of the syenite there is an igneous breccia in which the fragments are mostly hornfels, marble and essexite. The surrounding plain is underlain by undisturbed Ordovician shales, interbedded with thin layers of limestone; these are recrystallized to hornfels in a narrow contact aureole (Dresser & Denis, 1944).

Desourdy Quarry (also known as Uni-mix Quarry) lies on the NNE slope of Mont St. Hilaire, in the nepheline syenite. It may be reached by a road branching from Highway 9. Detailed route instructions may be found in the guide book prepared by Clark (1962).

## Minerals and Mode of Occurrence

The 87 minerals positively identified by $x$-ray diffraction and optical methods are listed in Table 1, with the institutions at which they were identified. The number of rare species is notable. Chemical, optical and crystallographic data of the unidentified minerals, with brief descriptions, are given in Table 2. The six strongest $x$-ray powder diffraction lines of all these minerals are listed in Table 3.

According to the structural environment and the mineral association, three major modes of occurrence can be recognized: veins, vugs and inclusions in nepheline syenite.

(1) *Veins in nepheline syenite.* Most of the veins are from 10 to 30 cm wide. They can be divided into two groups, each having its own characteristic mineral associations.

(a) Veins showing little or no sign of alteration. The principal minerals are microcline, albite and aegirine, with local concentration of analcime.

TABLE 1. MINERALS IDENTIFIED FROM MONT ST. HILAIRE, QUEBEC

| | Identifying Institute | | |
|---|---|---|---|
| Minerals | École Polytechnique | Royal Ontario Museum | Carleton University |
| Actinolite | x | | x |
| Aegirine | x | x | x |
| Albite | x | x | x |
| Almandine | | x | |
| Analcime | x | x | x |
| Ancylite | | | x |
| Andradite | x | | x |
| Ankerite | | | x |
| Apatite | | x | x |
| Apophyllite | x | x | x |
| Arsenopyrite | | | x |
| Astrophyllite | x | x | x |
| Augite | x | x | x |
| Barite | x | x | |
| Bastnaesite | | | x |
| Biotite | x | x | x |
| Birnessite | | x | x |
| Brookite | | x | x |
| Burbankite | | | x |
| Calcite | x | x | x |
| Cancrinite | x | x | x |
| Catapleiite | x | x | x |
| Chalcopyrite | x | | x |
| Chlorites | x | x | x |
| Datolite | | | x |
| Dawsonite | | | x |
| Diopside | x | x | x |
| Dolomite | x | x | x |
| Elpidite | x | x | x |
| Epididymite | | x | x |
| Eudialyte-eucolite | x | x | x |
| Fluorite | x | x | x |
| Galena | x | x | x |

TABLE 1—*Concluded*

| Minerals | Identifying Institute École Polytechnique | Royal Ontario Museum | Carleton University |
|---|---|---|---|
| Genthelvite | x | x | x |
| Goethite | x | x | x |
| Götzenite | | | x |
| Grossular | x | | x |
| Grunerite | x | | |
| Gypsum | x | | |
| Helvite | x | x | x |
| Hematite | | | x |
| Hornblende | x | x | x |
| Idocrase | x | x | x |
| Ilmenite | x | x | x |
| Karpinskyite | | x | x |
| Leifite | x | | |
| Leucophanite | x | x | x |
| Leucosphenite | | | x |
| Limonite | | x | x |
| Magnetite | | | x |
| Mangan-neptunite | | x | x |
| Marcasite | x | x | x |
| Microcline | x | x | x |
| Molybdenite 3 R | | | x |
| Molybdenite 6 H | | | x |
| Muscovite | | | x |
| Narsarsukite | x | x | x |
| Natrolite | x | x | x |
| Nepheline | x | x | x |
| Pectolite | x | x | x |
| Phlogopite | | x | x |
| Polylithionite | x | x | x |
| Pyrite | x | x | x |
| Pyrochlore | x | | x |
| Pyrolusite | | x | x |
| Pyrophanite | | x | x |
| Pyrrhotite | x | x | x |
| Quartz | x | x | x |
| Ramsayite | x | | x |
| Rhodochrosite | x | x | x |
| Riebeckite (Crocidolite) | | x | x |
| Rinkite | | | x |
| Rutile | x | x | x |
| Sanidine | | x | x |
| Serandite | x | x | x |
| Siderite | x | x | x |
| Soda Amphiboles | | | x |
| Sodalite | x | x | x |
| Sodalite (Hackmanite) | x | x | x |
| Sphalerite | x | x | x |
| Sphene | x | x | x |
| Synchysite | | ? | x |
| Thomsonite | | | x |
| Willemite | | | x |
| Wöhlerite | | | x |
| Würtzite | | | x |
| Zircon | x | x | x |

## Table 2. Unidentified Minerals from Desourdy Quarry, Mt. St. Hilaire, Quebec

| Designation | General appearance | Chemical data | Optical data | S.G. | X-ray data: Single crystal | X-ray data: Powder | Remarks |
|---|---|---|---|---|---|---|---|
| *UK #4 | Brownish to grey, vitreous, short tetragonal prismatic crystals with pinacoid termination, up to 1 mm long | Major: Ca, Be, Mg, Mn, Al, Si<br>Minor: Na, Fe, Sr | | | $a = 7.54$ Å<br>$c = 7.31$<br>space group *P4/mmm*, *P4mm*, $P\bar{4}2m$ or $P\bar{4}m2$ | 7.50 (4)<br>5.32 (5)<br>3.39 (10)<br>3.32 (7)<br>2.65 (7)<br>2.17 (2) | Found in veins with analcime natrolite, microcline and eudialyte |
| UK #5 | Brown to orange, vitreous, fine acicular crystals (also in elongated plates) | Major: Na, Ca, Mn, Mg, Fe, Si<br>Minor: Al | | | $a = 14.25$ Å<br>$b = 13.81$<br>$c = 7.80$<br>$\beta = 116° 44'$<br>space group *C2/m* | 6.98 (8)<br>6.36 (3)<br>4.14 (7)<br>3.18 (10)<br>3.10 (9)<br>2.59 (10) | Found in silicate vugs with albite and soda amphibole |
| UK #6 | White, mauve, vitreous to silky, flat long prismatic crystals, one good prismatic cleavage | Major: Na, Ca, Mn, Yb, Y, Si<br>Minor: Al, Mg, Zr | $\alpha = 1.503$ (Na)<br>$\beta = 1.507$<br>$\gamma = 1.508$<br>$(-)2V = 42°$ | 2.42 | $a = 13.98$ Å<br>$b = 23.83$<br>$c = 2 \times 6.556$<br>Pseudo-cell<br>space group *Pmmb* | 12.0 (6)<br>6.99 (8)<br>6.56 (5)<br>4.41 (7)<br>3.05 (9)<br>2.87 (10) | Found in silicate vugs with calcite, albite, phlogopite and soda amphibole |
| UK #12 | Pale yellowish green, vitreous, slightly greasy hexagonal crystals, perfect basal cleavage | Major: Fe, Be, Al, Si<br>Minor: Mg, Mn, Na, Ca | $\xi = 1.580$ (Na)<br>$\omega = 1.760$ | | $a = 8.846$ Å<br>$c = 23.16$<br>space group $P6_3/mcm$ | 4.34 (4)<br>3.84 (3)<br>3.51 (9)<br>3.19 (10)<br>2.55 (6)<br>2.04 (3) | Found in silicate vugs with aegirine, calcite, rinkite, analcime, albite, apatite, pyrochlore, catapleiite and pyrophanite |
| UK #13 | Colorless to pale yellow, radiating prismatic crystal clusters | Major: Na, Zr, Si<br>Minor: Mg, Mn, Al, Ca, Nb, Ti, Sr, Hf | | | | 9.04 (8)<br>7.99 (10)<br>4.39 (7)<br>3.57 (8)<br>3.48 (8)<br>2.82 (8) | Found in altered veins with microcline, pyrite, limonite, chlorite |

TABLE 2—*Concluded*

| Designation | General appearance | Chemical data | Optical data | S.G. | X-ray data: Single crystal | X-ray data: Powder | Remarks |
|---|---|---|---|---|---|---|---|
| UK #15 | Vitreous, pink grades into pale blue. Massive, with 3 sets of good cleavage at right angles | Major: Na, Ca, K, Si<br>Minor: Mg, Al, Mn, B | | 2.45 | $a$ = 18.67 Å<br>$b$ = 18.74<br>$c$ = 16.70<br>Space group *Cmmm* | 8.36 (10)<br>5.58 (8)<br>4.84 (7)<br>4.19 (10)<br>3.35 (7)<br>2.91 (7) | Found in inclusions type A with quartz, fluorite, narsarsukite, calcite |
| UK #17 | Orange to brown, vitreous, fine tabular crystals, average size 0.3 mm | Major: Mn, Mg, Nb, Si, Be,<br>Minor: Ca, Na, Ba, Fe | | | | 3.47 (10)<br>3.19 (4)<br>2.87 (5)<br>2.60 (4)<br>1.729 (3B)<br>1.599 (3) | Found in veins with catapleiite, albite, aegirine |
| UK #18 | Brass yellow, adamantine, long prismatic crystals; one set of good prismatic cleavage | Major: Ce, La, Nb, Ti, Si<br>Minor: Mn | | 4.3±0.1 | | 13.7 (10)<br>6.82 (8)<br>4.54 (10)<br>2.40 (2)<br>2.77 (10)<br>2.72 (2) | Found in analcime, in silicate veins with aegirine |
| †ROM #1 Same as UK # 20 | Brownish, pseudo-hexagonal crystals, vitreous lustre, up to 1 mm | Major: Na, Ca, Zr, Si<br>Minor: K, Be, Fe, Nb | $\alpha$ = 1.593<br>$\gamma$ = 1.608 | 2.68 ±0.04 | $a$ = 12.24 Å<br>$b$ = 10.57<br>$c$ = 8.06<br>$\beta$ = 101° 10′<br>Space group $P2_1/a$ | 6.02 (9)<br>5.28 (7)<br>3.16 (10)<br>3.05 (7)<br>3.00 (5)<br>2.64 (3) | Found in silicate vugs.<br>Presented at 1965 MAC meeting; see Can. Min. Vol. 8, p. 398 |
| ROM #2 Same as UK #19 | Small, pink, vitreous, prismatic crystals with no terminations | Major: Na, Mn, Ti, Si<br>Minor: Mg | $\alpha$ = 1.639 (Na)<br>$\beta$ = 1.640<br>$\gamma$ = 1.740<br>(+) $2V$ = 14° | | $a$ = 7.37 Å<br>$b$ = 14.12<br>$c$ = 7.10<br>Space group *Pbam* | 7.12 (10)<br>6.56 (8)<br>5.03 (5)<br>3.27 (10)<br>3.18 (7)<br>2.65 (5) | Found in silicate vugs with analcime, aegirine, pyrochlore, rhodochrosite, microcline, polylithionite |

*Carleton University designations for unidentified minerals.
†Royal Ontario Museum designations for unidentified minerals.

The accessory minerals vary from vein to vein and from section to section in the same vein. The minerals found in these veins are:

| | | | |
|---|---|---|---|
| actinolite | cancrinite | leucophanite | sodalite |
| aegirine | catapleiite | microcline | sodalite (hackmanite) |
| albite | diopside | muscovite | sphalerite |
| analcime | elpidite | natrolite | wurtzite |
| ancylite | eudialyte | nepheline | UK #4 |
| astrophyllite | fluorite | pyrochlore | UK #5 |
| augite | genthelvite | rhodochrosite | UK #17 |
| birnessite | ilmenite | serandite | UK #19 |
| calcite | karpinskyite | soda amphibole | |

These veins are sometimes zoned. Figure 3 shows a good example, in which six zones have been recognized:

(i) The wall rock: a coarse-grained nepheline syenite with aegirine as the principal ferromagnesian mineral.

(ii) The vein border rock: a nepheline syenite finer in grain size and enriched in nepheline with respect to the coarse-grained wall rock.

(iii) The eudialyte contact band: eudialyte crystals in albite form a narrow band (1 cm) at the contact with the border rock.

(iv) The catapleiite zone: large masses of fine-grained catapleiite in a matrix of medium-grained albite. Dark zirconian aegirine needles (containing 2.4 per cent $ZrO_2$) are distributed in a subparallel fashion, approximately perpendicular to the wall of the vein. Felted masses (*ca.* 1 cm diameter) of aegirine, apparently of a second generation, are distributed at random in this zone.

(v) The cancrinite band: thin and discontinuous.

(vi) The serandite-microcline core: very coarse-grained (*ca.* 5 cm) serandite and perthitic microcline are the principal constituents. The microcline crystals frequently show a selvage of calcite at their contact with serandite.

(b) Altered veins. These veins are characterized by (i) coatings of dark ubiquitous amorphous material and limonite in the cavities, (ii) widespread pseudomorphs of limonite and goethite after rhombohedral carbonate (probably siderite) and (iii) chloritization and limonitization of aegirine. The principal minerals are microcline and/or albite. They are considerably enriched in sulphides with respect to the unaltered veins. The following minerals have been found:

| | | | |
|---|---|---|---|
| actinolite | chlorite | limonite | siderite |
| aegirine | elpidite | marcasite | sphalerite |
| albite | epididymite | microcline | zircon |
| apatite | galena | pyrite | UK #13 |
| catapleiite | goethite | rutile | |

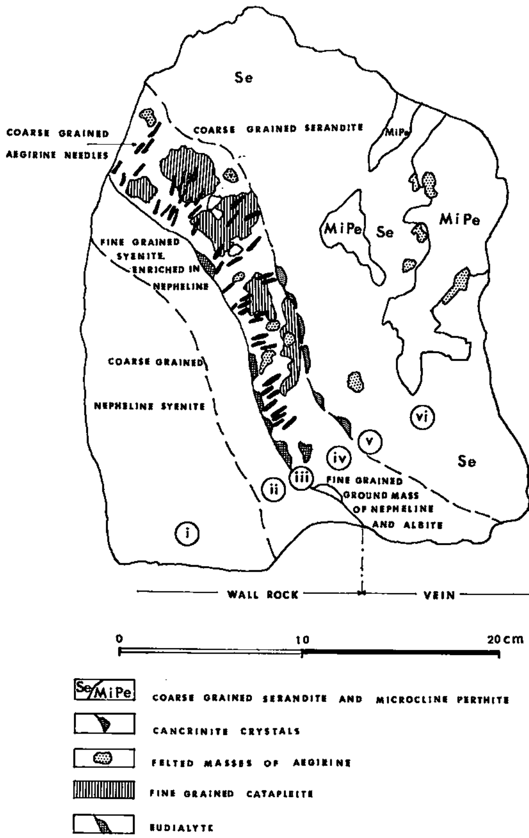


FIG. 3. Schematic sketch of specimen No. E.P. 12196, showing zones of minerals in vein.

It has been noted that most, if not all, of the large well-formed catapleiite crystals and elpidite specimens of display quality are from these veins.

(2) *Vugs in nepheline syenite.* The vugs are the source of many rare minerals. They vary in size from a few centimetres to several metres across. Two distinct types are recognized, based on the principal constituent minerals and their associations.

(a) Silicate vugs. The mineralogy of the silicate vugs is complex and variable. The principal minerals are usually analcime, aegirine, microcline, albite and natrolite. Carbonates are widespread in small quantities. Most rare minerals are found either in or closely associated with analcime. The minerals found in the silicate vugs are as follows:

| | | | |
|---|---|---|---|
| actinolite | cancrinite | microcline | sodalite |
| aegirine | catapleiite | natrolite | sodalite (hackmanite) |
| albite | diopside | polylithionite | sphalerite |
| analcime | elpidite | pyrochlore | sphene |
| ancylite | epididymite | pyrophanite | willemite |
| andradite | eudialyte | ramsayite | wöhlerite |
| apatite | fluorite | rhodochrosite | zircon |
| apophyllite | helvite | rinkite | UK #6 |
| astrophyllite | hematite | sanidine | UK #12 |
| augite | ilmenite | serandite | UK #18 |
| biotite | leucophanite | siderite | UK #19 |
| burbankite | magnetite | soda-amphiboles | UK #20 |
| calcite | mangan-neptunite | | |

(b) Carbonate vugs. The mineralogy of the carbonate vugs is relatively simple. The principal minerals are siderite and albite. The siderite crystals are usually large (average 5–10 cm across) and well-formed. Crystals over 20 cm across are not uncommon. The minerals found in the carbonate vugs are:

| | | | |
|---|---|---|---|
| albite | calcite | soda-amphiboles | synchysite |
| ankerite | pyrite | sphalerite | zircon |
| bastnaesite | siderite | | |

(3) *Inclusions in nepheline syenite.* Three major types of inclusions are recognized in the nepheline syenite, based on mineral association and general appearance. The size of these inclusions varies from less than one metre to several metres in diameter.

(a) Type A. Inclusions of this type are greyish green hornfels, frequently cut by quartz veins, some of which contain the rare minerals narsarsukite, leucosphenite and an unidentified mineral UK #15. The minerals found in Type A inclusions are as follows:

| | | |
|---|---|---|
| calcite | molybdenite 3R | quartz |
| fluorite | molybdenite 6H | ramsayite |
| leucosphenite | narsarsukite | UK #15 |

(b) Type B. These inclusions are characterized by coarse-grained pectolite and calcite with abundant fine to medium-grained dark green soda-amphibole. They are generally pale green and may be coloured purple locally by fine-grained fluorite. The following minerals have been found in this type of inclusion:

| | | |
|---|---|---|
| apophyllite | fluorite | phlogopite |
| calcite | microcline | soda-amphiboles |
| datolite | pectolite | thomsonite |
| eudialyte | | |

(c) Type C. These inclusions consist mainly of calcite with veins and patches of idocrase, occasionally with pyrite, fibrous pectolite and minor apophyllite and natrolite.

## Chemistry

The chemical elements present in these minerals in significant amount, as indicated by qualitative spectrographic analyses, are given in the form of a periodic table in Fig. 4. From the relative abundance and chemical composition of the minerals the elements can be grouped into three catagories as follows:

| | | |
|---|---|---|
| I. | Most abundant: | O, Na, Al, Si, K, Ca |
| II. | Moderately abundant: | H, Li, Be, C, F, Mg, Ti, Mn, Fe, Zn, Zr, Nb, La, Ce |
| III. | Less abundant: | B, P, S, Cl, Sc, V, Cu, As, Rb, Sr, Y, Mo, Ba, Hf, Ta, Pb, Dy, Yb, Pr, Nd, Sm |

Be, Ti, Zr and Nb are of particular interest. They are present as major constituents in most of the rare minerals.

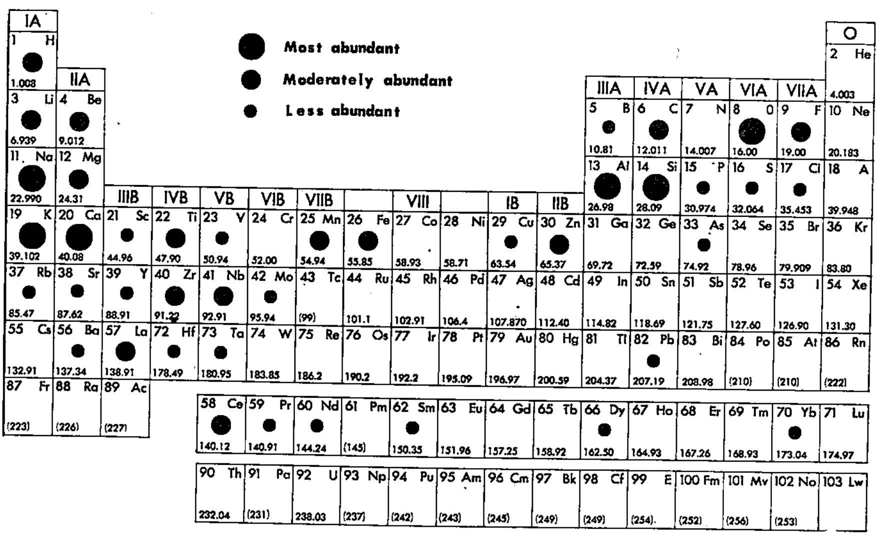


FIG. 4. Elements present in the minerals from Mont St. Hilaire.

TABLE 3. *X*-RAY DETERMINATIVE TABLE FOR MINERALS FROM MONT ST. HILAIRE†

| Strongest lines | | | | | | Intensities | | | | | | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.53 | 1.614 | 1.483 | 2.10 | 2.97 | 1.712 | 100 | 85 | 85 | 70 | 70 | 60 | Magnetite* |
| 2.64 | 2.84 | 3.44 | 1.423 | 2.32 | 1.863 | 100 | 100 | 100 | 60 | 55 | 50 | Willemite |
| 2.64 | 3.04 | 5.28 | 2.15 | 3.73 | 2.75 | 100 | 60 | 50 | 50 | 45 | 30 | Burbankite |
| 2.66 | 2.97 | 1.591 | 1.650 | 1.930 | 2.43 | 100 | 50 | 40 | 30 | 30 | 30 | Grossular |
| 2.67 | 2.44 | 2.41 | 1.818 | 1.635 | 3.66 | 100 | 90 | 90 | 60 | 50 | 45 | Arsenopyrite |
| 2.68 | 3.00 | 1.601 | 2.45 | 1.944 | 1.662 | 100 | 50 | 50 | 40 | 30 | 30 | Andradite |
| 2.70 | 1.629 | 2.42 | 2.17 | 3.12 | 1.909 | 100 | 100 | 50 | 40 | 30 | 30 | Pyrite |
| 2.70 | 2.52 | 3.69 | 1.840 | 2.20 | 2.15 | 100 | 20 | 20 | 10 | 10 | 10 | Hematite |
| 2.71 | 1.76 | 3.44 | 1.91 | 2.41 | 2.32 | 100 | 63 | 40 | 30 | 25 | 25 | Marcasite* |
| 2.74 | 2.53 | 2.98 | 1.720 | 1.862 | 1.623 | 100 | 85 | 80 | 60 | 30 | 30 | Ilmenite |
| 2.75 | 2.97 | 3.60 | 1.702 | 2.18 | 1.986 | 100 | 80 | 60 | 50 | 40 | 40 | Leucophanite |
| 2.75 | 5.46 | 3.34 | 3.03 | 2.45 | 1.602 | 100 | 90 | 90 | 60 | 30 | 30 | Ramsayite |
| 2.76 | 2.60 | 1.626 | 2.46 | 2.96 | 3.04 | 100 | 80 | 50 | 30 | 30 | 20 | Idocrase |
| 2.77 | 2.56 | 1.722 | 1.878 | 3.76 | 1.515 | 100 | 60 | 60 | 50 | 30 | 30 | Pyrophanite |
| 2.80 | 1.736 | 3.60 | 2.35 | 2.14 | 1.968 | 100 | 50 | 35 | 30 | 30 | 30 | Siderite |
| 2.80 | 4.15 | 3.39 | 2.71 | 1.845 | 1.941 | 100 | 50 | 40 | 30 | 30 | 20 | Apatite |
| 2.84 | 3.24 | 2.98 | 2.95 | 2.01 | 1.527 | 100 | 50 | 40 | 40 | 30 | 30 | Wöhlerite |
| 2.86 | 1.774 | 3.67 | 2.39 | 2.18 | 2.14 | 100 | 70 | 35 | 30 | 30 | 30 | Rhodochrosite |
| 2.86 | 4.63 | 2.68 | 6.55 | 4.13 | 2.18 | 100 | 80 | 70 | 60 | 60 | 60 | Thomsonite |
| 2.87 | 3.05 | 6.99 | 4.41 | 11.98 | 6.56 | 100 | 95 | 80 | 75 | 60 | 45 | UK #6 |
| 2.87 | 3.20 | 5.92 | 4.40 | 6.60 | 4.65 | 100 | 75 | 70 | 70 | 65 | 65 | Natrolite |
| 2.88 | 1.739 | 1.828 | 3.73 | 2.18 | 2.03 | 100 | 40 | 35 | 30 | 30 | 30 | Ankerite |
| 2.90 | 1.817 | 1.732 | 2.20 | 3.72 | 2.42 | 100 | 50 | 50 | 45 | 30 | 30 | Dolomite |
| 2.97 | 2.85 | 3.21 | 11.42 | 5.70 | 4.31 | 100 | 90 | 50 | 50 | 40 | 40 | Eudialyte |
| 2.97 | 3.43 | 2.10 | 2.790 | 1.327 | 1.713 | 100 | 90 | 70 | 50 | 40 | 30 | Galena |
| 2.99 | 2.91 | 6.40 | 4.43 | 2.48 | 2.54 | 100 | 70 | 60 | 60 | 60 | 60 | Aegirine |
| 2.99 | 3.17 | 2.84 | 2.20 | 7.52 | 6.74 | 100 | 95 | 90 | 70 | 60 | 60 | Serandite |
| 3.00 | 2.52 | 3.23 | 1.630 | 2.57 | 1.424 | 100 | 50 | 40 | 20 | 20 | 20 | Diopside |
| 3.01 | 1.843 | 6.02 | 1.572 | 3.15 | 2.61 | 100 | 60 | 50 | 50 | 40 | 40 | Pyrochlore |
| 3.02 | 3.85 | 4.20 | 3.28 | 2.35 | 2.89 | 100 | 90 | 70 | 60 | 50 | 40 | Nepheline |

TABLE 3—*Continued*

| Strongest lines | | | | | | Intensities | | | | | | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.03 | 1.913 | 1.874 | 2.49 | 2.10 | 2.28 | 100 | 50 | 50 | 40 | 40 | 40 | Calcite |
| 3.04 | 1.860 | 1.590 | 1.576 | 2.65 | | 100 | 50 | 30 | 15 | 5 | | Chalcopyrite |
| 3.05 | 1.859 | 1.877 | 1.597 | 2.08 | 2.66 | 100 | 50 | 40 | 40 | 20 | 20 | Pyrrhotite |
| 3.06 | 2.70 | 1.851 | 2.94 | 2.02 | 2.01 | 100 | 40 | 40 | 35 | 25 | 20 | Rinkite |
| 3.08 | 3.31 | 3.26 | 2.29 | 3.89 | 2.73 | 100 | 90 | 85 | 60 | 50 | 50 | Pectolite |
| 3.09 | 3.30 | 7.00 | 5.66 | 5.43 | 2.99 | 100 | 40 | 40 | 40 | 40 | 30 | Götzenite |
| 3.12 | 1.909 | 3.31 | 2.93 | 1.629 | 1.764 | 100 | 60 | 50 | 45 | 35 | 25 | Wurtzite |
| 3.12 | 1.913 | 1.632 | 1.104 | 2.71 | 1.242 | 100 | 50 | 40 | 30 | 25 | 25 | Sphalerite |
| 3.12 | 2.86 | 2.25 | 2.29 | 3.76 | 1.644 | 100 | 90 | 70 | 70 | 60 | 60 | Datolite |
| 3.13 | 8.39 | 2.70 | 4.47 | 2.80 | 3.39 | 100 | 100 | 90 | 70 | 55 | 50 | Actinolite |
| 3.15 | 1.932 | 3.43 | 1.645 | 5.61 | 2.87 | 100 | 100 | 50 | 45 | 30 | 20 | Fluorite |
| 3.18 | 2.59 | 3.10 | 6.98 | 4.14 | 6.36 | 100 | 100 | 90 | 80 | 70 | 30 | UK #5 |
| 3.18 | 9.56 | 3.51 | 2.94 | 2.48 | 2.89 | 100 | 100 | 80 | 50 | 50 | 50 | Neptunite |
| 3.19 | 3.51 | 2.55 | 4.34 | 3.84 | 2.04 | 100 | 90 | 60 | 40 | 25 | 25 | UK #12 |
| 3.19 | 4.04 | 3.66 | 3.78 | 2.95 | 6.40 | 100 | 40 | 30 | 25 | 20 | 15 | Albite |
| 3.22 | 4.64 | 3.64 | 6.31 | 2.73 | 2.41 | 100 | 50 | 40 | 40 | 30 | 30 | Cancrinite |
| 3.24 | 3.30 | 4.23 | 3.78 | 3.47 | 1.802 | 100 | 50 | 45 | 40 | 40 | 30 | Sanidine |
| 3.25 | 4.23 | 3.48 | 3.37 | 3.03 | 1.804 | 100 | 50 | 40 | 30 | 30 | 30 | Microcline |
| 3.26 | 1.691 | 2.49 | 2.19 | 1.629 | 1.364 | 100 | 50 | 30 | 20 | 20 | 20 | Rutile |
| 3.26 | 2.61 | 3.00 | 4.95 | 2.07 | 2.29 | 100 | 80 | 70 | 50 | 40 | 40 | Sphene |
| 3.28 | 6.58 | 5.19 | 3.14 | 2.60 | 1.958 | 100 | 40 | 40 | 25 | 20 | 20 | Elpidite |
| 3.32 | 1.918 | 2.18 | 2.57 | 1.661 | 1.485 | 100 | 40 | 30 | 30 | 20 | 20 | Genthelvite |
| 3.32 | 2.53 | 1.720 | 4.46 | 2.08 | 1.658 | 100 | 50 | 50 | 40 | 20 | 20 | Zircon |
| 3.34 | 4.26 | 1.817 | 1.541 | 1.373 | 2.28 | 100 | 40 | 30 | 25 | 25 | 20 | Quartz |
| 3.38 | 1.953 | 2.21 | 2.62 | 1.692 | 3.71 | 100 | 50 | 30 | 25 | 20 | 20 | Helvite |
| 3.39 | 3.32 | 2.65 | 5.32 | 7.50 | 2.17 | 100 | 70 | 70 | 45 | 35 | 20 | UK #4 |
| 3.41 | 3.01 | 1.805 | 6.39 | 2.50 | 1.647 | 100 | 100 | 60 | 60 | 60 | 60 | Epididymite |
| 3.43 | 5.61 | 2.93 | 1.746 | 2.51 | 4.86 | 100 | 70 | 50 | 30 | 20 | 20 | Analcime |
| 3.47 | 2.87 | 3.19 | 2.60 | 1.729 | 1.599 | 100 | 50 | 40 | 40 | 30B | 30 | UK #17 |

TABLE 3—*Concluded*

| Strongest lines | | | | | | Intensities | | | | | | Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.50 | 2.90 | 1.662 | 2.48 | 1.952 | | 100 | 90 | 10 | 10 | 10 | | Brookite |
| 3.56 | 2.81 | 9.16 | 4.55 | 2.05 | 1.920 | 100 | 100 | 75 | 70 | 70 | 65 | Synchisite |
| 3.63 | 6.29 | 2.09 | 2.56 | 2.37 | 1.570 | 100 | 40 | 40 | 30 | 30 | 20 | Sodalite |
| 3.95 | 2.98 | 7.81 | 2.49 | 3.57 | 4.52 | 100 | 90 | 70 | 60 | 50 | 50 | Apophyllite |
| 3.96 | 5.41 | 6.41 | 3.06 | 2.98 | 2.71 | 100 | 85 | 80 | 70 | 70 | 60 | Catapleiite |
| 4.19 | 8.36 | 5.58 | 4.84 | 3.35 | 2.91 | 100 | 100 | 80 | 70 | 70 | 70 | UK #15 |
| 4.21 | 2.69 | 2.44 | 1.719 | 1.563 | 5.00 | 100 | 80 | 70 | 50 | 30 | 20 | Goethite* |
| 4.23 | 8.46 | 3.38 | 2.89 | 2.82 | 2.28 | 100 | 50 | 40 | 30 | 30 | 25 | Leucosphenite |
| 4.34 | 2.96 | 3.71 | 2.35 | 5.49 | 3.36 | 100 | 100 | 95 | 75 | 50 | 40 | Ancylite |
| 4.70 | 3.16 | 2.40 | 4.15 | 3.38 | 3.11 | 100 | 80 | 70 | 60 | 50 | 50 | Karpinskyite |
| 4.90 | 2.89 | 3.57 | 2.02 | 2.06 | 1.901 | 100 | 90 | 80 | 70 | 60 | 55 | Bastnaesite |
| 4.95 | 3.30 | 1.981 | 9.56 | 2.59 | 2.56 | 100 | 100 | 90 | 80 | 60 | 50 | Polylithionite |
| 5.34 | 3.38 | 3.25 | 2.52 | 3.78 | 1.783 | 100 | 90 | 80 | 75 | 60 | 50 | Narsarsukite |
| 5.66 | 2.79 | 2.60 | 1.989 | 3.38 | 1.688 | 100 | 50 | 40 | 40 | 30 | 25 | Dawsonite |
| 6.00 | 5.29 | 3.05 | 3.17 | 3.00 | 2.00 | 100 | 100 | 100 | 90 | 75 | 25 | UK #20 |
| 6.12 | 1.530 | 2.84 | 1.581 | 2.63 | 2.04 | 100 | 45 | 40 | 40 | 30 | 30 | Molybdenite 3R |
| 6.14 | 2.28 | 1.533 | 2.74 | 2.05 | 1.581 | 100 | 50 | 40 | 35 | 30 | 25 | Molybdenite 6H |
| 7.11 | 2.45 | 1.422 | | | | 100 | 70 | 40 | | | | Birnessite |
| 7.12 | 3.29 | 6.56 | 3.19 | 5.03 | 2.57 | 100 | 70 | 50 | 45 | 35 | 30 | UK #19 |
| 7.99 | 9.04 | 2.82 | 3.57 | 3.48 | 4.39 | 100 | 80 | 80 | 75 | 75 | 70 | UK #13 |
| 10.02 | 3.34 | 2.00 | 2.55 | 5.00 | 4.46 | 100 | 100 | 70 | 50 | 50 | 30 | Muscovite |
| 10.11 | 3.36 | 2.60 | 1.525 | 2.42 | 2.01 | 100 | 90 | 70 | 60 | 60 | 50 | Phlogopite |
| 10.62 | 3.53 | 2.78 | 2.66 | 2.58 | 1.766 | 100 | 50 | 20 | 20 | 20 | 10 | Astrophyllite |
| 13.71 | 6.82 | 3.40 | 2.72 | 4.54 | 2.77 | 100 | 80 | 20 | 20 | 10 | 10 | UK #18 |
| 14.52 | 7.23 | 3.61 | 2.70 | 2.88 | 1.547 | 100 | 100 | 50 | 15 | 10 | 10 | Chlorite |

*Values taken from ASTM cards.

†Photographs taken by G. MacDonald with 114.7 mm diam. camera, using Carleton University specimens and measured by Miss M. Boyd.

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