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DAWSONITE-FLUORITE RELATIONSHIPS AT MONTREAL-AREA LOCALITIES

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Abstract

Dawsonite and fluorite, crystallized together, have been collected recently from three localities in the Montreal area, where they were found in particular dykes or sills which were only briefly exposed by quarrying and excavation. The intergrowth of the dawsonite and fluorite crystals and their frequent association with vein quartz gave evidence of hydrothermal origin. The fine-needle dawsonite in the assemblages is similar to dawsonite which occurs in fluid inclusions in gold-quartz veins. Field relationships support the conclusion that the Montreal-area dawsonite and fluorite are low-temperature hydrothermal minerals related in origin to the alkalic rocks of the area.

Sommaire

On a récolté récemment de la dawsonite et de la fluorite, cristallisées ensemble, dans trois localités de la région de Montréal. Ces minéraux ont été trouvés dans des dykes et des sills exposés temporairement, au cours des travaux, dans des carrières et des excavations. L'intercroissance de cristaux de dawsonite et de fluorite et leur fréquente association avec du quartz filonien indiquent une origine hydrothermale. La dawsonite aciculaire de ces associations ressemble à la dawsonite que l'on trouve dans les inclusions fluides des filons de quartz aurifère. Les observations faites sur le terrain étayent la conclusion que la dawsonite et la fluorite de la région de Montréal sont des minéraux formés à basse température, par voie hydrothermale, dont l'origine est liée à celle des roches alcalines de cette région.

Introduction

Although both dawsonite and fluorite have been collected separately from several localities in the Montreal area, occurrences are few where these two minerals have crystallized together and where their petrogenetic relationships may be studied. Our interest in this relationship first began with the collection of excellent specimens of well-crystallized dawsonite and fluorite from rock near University Street in Montreal which was being excavated for an underground portion of the Trans-Canada Highway. Later, good specimens were obtained from the Francon Quarry, St-Michel, Montreal, and from the De-Mix quarry, Mount St. Hilaire, Quebec (Fig. 1).

In a recent publication Clark (1972, p. 128-129) stated: "Dawsonite, first described from Montreal, may be the result of hydrothermal changes more nearly akin to weathering than to metamorphism." We believed a study of this new material might contribute further evidence in support of a truly hydrothermal origin for the Montreal dawsonite.

Dawsonite-Fluorite Localities

The Montreal Trans-Canada Highway dawsonite-fluorite was found in April, 1973, near the University Street entrance. This mineralization appeared to occur in a continuation of the feldspathic dyke associated with nepheline syenite (feldspathoidal monzonite of Gélinas 1972) of the McGill University type locality (Stevenson & Stevenson 1965), although dawsonite and fluorite crystallized together had not been found at the type locality. Construction work has made further collecting at the Trans-Canada site impossible.

In 1974-75 several specimens of dawsonite and fluorite were collected from sills in the Francon quarry, St-Michel, Montreal. This quarry has gained prominence as the type locality for weloganite and as a source of other rare minerals, including dresserite (Sabina *et al.* 1968;

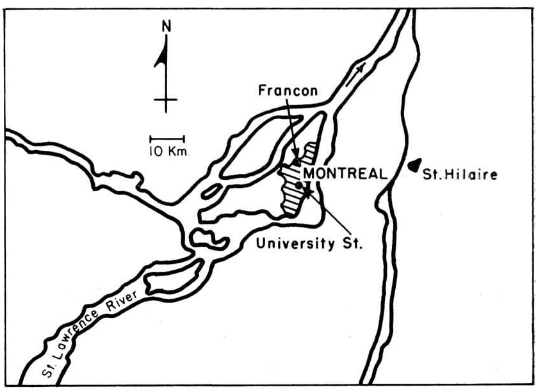

FIG. 1. Location of dawsonite-fluorite occurrences in the Montreal area.

Jambor *et al.* 1976; Sabina 1976), although the specimens we studied did not contain these rare minerals.

Dawsonite-fluorite material was collected from the De-Mix quarry, Mount St. Hilaire, 48 km east of Montreal, in 1974 and 1975. These specimens were associated with syenite breccia (Chao *et al.* 1967; Perrault & Mandarino 1972).

At all three localities, the dawsonite-fluorite is concentrated in relatively small areas of particular sills or dykes, as Sabina (1976) has noted at the Francon quarry.

Petrogenetic Studies

In the syenite breccia at Mount St. Hilaire, dawsonite-fluorite lines the walls of vugs which range from about 1 cm to 2 m in diameter. Vugs at other localities are generally smaller, 1 cm to 2 cm in diameter, and seem to represent filled or partly filled vesicles or amygdules, with flowage of groundmass plagioclase of the dyke rock around the vesicles (Fig. 2). Most dawsonite occurs as closely packed blades, some as large as 1 cm long by 1 mm wide, ranging down to 2.4 mm long and 0.04 mm wide, frequently intimately intergrown with fluorite in cubes or parts of cubes up to 2 mm on the edge (Fig. 3).

Although dawsonite usually occurs as closely packed blades, some of it occurs as needles, associated with the blades, up to 0.8 mm long and 0.09 mm wide; the smallest needles range down to a size so small that the individual crystals are barely detectable with the electron microscope.

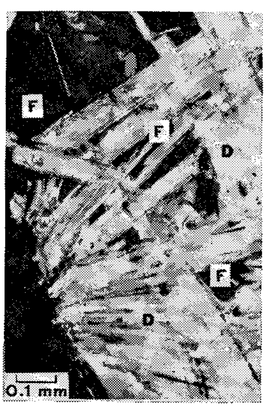

FIG. 2. (left) Completely enclosed smooth-walled vug containing intergrown dawsonite (D), fluorite (F), quartz (Q) and calcite (C). Francon quarry. Crossed polars.

FIG. 3. (right) Coarse bladed dawsonite (D) intergrown with fluorite (F) in open vug. Francon quarry. Crossed polars.

That the dawsonite and fluorite were crystallized together is suggested by the intergrowths illustrated in Figure 4, where delicate needles of dawsonite bridge space between fluorite crys-

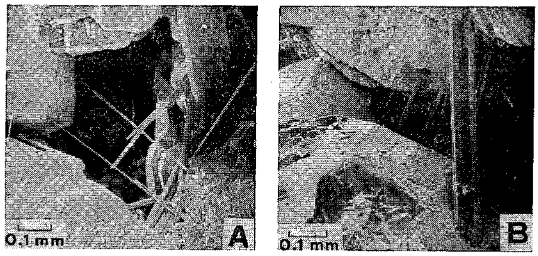

FIG. 4. Scanning electron photomicrographs of dawsonite and fluorite: (A) several needles of dawsonite bridging space between crystals of fluorite. University Street. (B) crystals of dawsonite, showing {100} and {110}, joining crystals of fluorite. Francon quarry.

tals. These photographs show interesting similarities to the SEM photographs of the Chihuahua geode minerals studied by Finkelman *et al.* (1972), in which delicate euhedral and subhedral crystals were interpreted as having precipitated simultaneously.

Both the dawsonite and fluorite are intergrown in places with minor amounts of coarse calcite crystals and coarse-grained hypidiomorphic quartz characteristic of vein quartz.

Another common occurrence of the assemblage dawsonite-fluorite-quartz-calcite is as gash veins from 0.025 mm to 2 mm wide within the grey feldspathic dykes (Fig. 5). Much of the daw-

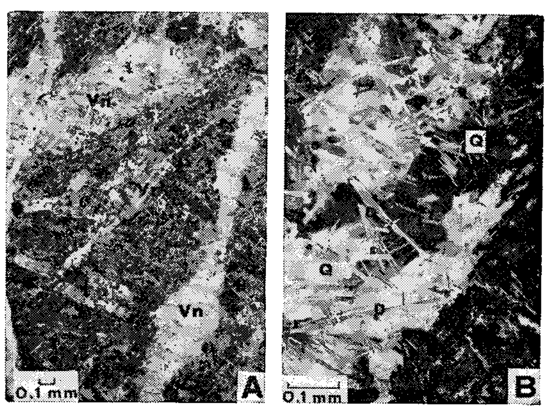

FIG. 5. Gash veins (Vn) of dawsonite and fluorite. Francon quarry: (A) outline and cross-cutting nature of the veins. Plane-polarized light. (B) Enlargement of portion of vein in A, lower right, showing intergrown dawsonite (D) and quartz (Q). Crossed polars.

sonite exposed in broken dump material represents the coatings of these vein walls. These veinlets have all the characteristics of filled, sharp-walled tension fractures. At Francon and Trans-Canada, they cut sharply across the feldspar phenocrysts and flow-aligned groundmass lath feldspar of the enclosing dyke rock. They frequently contain very jagged and irregular fragments of the wall rock. In places the fragments are almost sufficiently numerous to constitute microbreccia, and in others the veinlets are close and form a micro-stockwork pattern. Where breccia fragments are absent, both the dawsonite and quartz are normal to the vein walls, approximating a comb texture, and the fluorite occurs interstitial to both and also fills the medial parts of the veinlets.

Because these dawsonite-fluorite veinlets are confined to the dykes and do not extend into the wall rock, and because of their habit and textural features, they are thought to represent filled contraction fractures formed shortly after the consolidation of the dykes. Their origin is therefore similar to that of ladder veins in dykes (Lindgren 1933).

It is apparent from thin-section study that the filling of these veinlets occurred at the same time as the filling of the vugs and amygdules. The veinlets extend into vugs, join vugs to amygdules, and connect amygdules almost imperceptibly with hair-like stringers of dawsonite and occasionally fluorite.

Thus the formation of the dawsonite-fluorite is seen as a hydrothermal mineralization in vug fillings and in contraction fractures in the rocks, accompanied by widespread metasomatic replacement within the rock, all very shortly after consolidation of the enclosing igneous bodies. The hydrothermal solutions were apparently related to the alkalic igneous activity of the Mount Royal–Mount St. Hilaire syenites.

Origin of Dawsonite and Fluorite

Fluorite has always been thought of as a typical hydrothermal mineral, and the constituent fluorine generally accepted as a magmatic product (Lindgren 1933; Deer *et al.* 1966). Buddington (1933, p. 380) has noted: "Fluorine is considered . . . a characteristic and perhaps the most distinctive volatile element of alkalic magmas." The association of fluorine with alkaline rocks, such as alkaline syenite and nepheline syenite, is indeed widespread. Perhaps the most striking association is the extensive occurrence of fluorite with the alkaline intrusions of Cripple Creek, Colorado, a famous gold camp. There we have extensive replacements of feldspar phenocrysts by fluorite and quartz (Lindgren 1900, Fig. 10). The Cripple Creek occurrences are similar to the replacements in the Montreal-area dawsonite-fluorite. At Cripple Creek the fluorite is considered to be a low-temperature hydrothermal mineral of magmatic origin. Likewise, the Montreal-area dawsonite, by virtue of its close association with fluorite, is viewed as a low-temperature hydrothermal mineral related in origin to the alkalic rocks of the area.

For dawsonite to form, it is necessary that the requisite chemical constituents be present and that the right pH and pressure be maintained, but these requirements can be satisfied by a variety of geological environments. For example, in the Montreal and similar occurrences, an alkaline environment relatively rich in soda and alumina and deficient in the strong acidic radicals such as Cl and SO_4 would be natural in an area of nepheline syenite. Further alumina may also be contributed from the destruction of the feldspars.

On the other hand, a completely different but proper environment for the formation of dawsonite is in the saline soils of Olduvai Gorge, Tanzania (Hay 1963), in the marine strata of the Berry Formation of the Sydney Basin, New South Wales (Goldbery & Loughnan 1970), and also in the oil shales of the Green River Formation, Colorado (Smith & Milton 1966; Milton 1976). Another type of occurrence has been described by Aikawa *et al.* (1972) from the Izumi Group in southwest Japan, where mudstones with marine fossils are associated with layers of tuff and with mineral springs abnormally rich in $NaHCO_3$.

Dawsonite in fluid inclusions in gold-quartz veins of the Alleghany district, California (Coveney & Kelly 1971) is similar in habit to the Montreal-area fine-needle dawsonite. Coveney & Kelly suggest that the general rarity of dawsonite as a vein mineral may be due to its high solubility under normal hydrothermal conditions, but that the formation of dawsonite in low-temperature hydrothermal deposits would be favored by loss of dissolved CO_2 due to fluid cooling or boiling, sharp reduction in fluid activity due to wall-rock reaction, and high dissolved sodium and aluminum concentration.

Certainly the special conditions mentioned above are met in the Montreal occurrences of dawsonite and fluorite. Extensive wall-rock alteration of rocks rich in alkali and alumina reduced the acidity and increased the alkali and alumina content of the hydrothermal fluids. The near-surface nature of the occurrences, as attested by the breccia and gash veins, provided opportunity for rapid loss of pressure, loss of CO_2, and consequent precipitation of the dawsonite.

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