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PEGMATITES AT RYRS, SWEDEN—EXAMPLES OF FLUORITE EXOMORPHISM[1]

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Abstract

Two pegmatites near Ryrs, Sweden, Skuleboda and Gundlebo, contain unusual accessory mineral assemblages: Skuleboda—albite, allanite, yttrotantalite, sphalerite; Gundlebo—cleavelandite, lepidolite, topaz, sphalerite, fluorite. Both bodies, which have been intruded into biotitic gneiss, have an exomorphic envelope in which fluorite has been developed. Other examples of exomorphic fluorite around pegmatites are rare, and the formation of such fluorite does not depend on the presence of fluorite in the pegmatites themselves.

Introduction

Many pegmatite bodies are enveloped by haloes developed by recrystallization and metasomatism of their wall rocks. Information on pegmatite exomorphism has been summarized by Jahns (1955, p. 1069), who lists fluorite as one of many species

> " . . . whose occurrence in altered wall rock has been attributed to the introduction of material from adjacent pegmatite . . . "

However, Brotzen (1959, p. 59) points out

> " . . . that fluorite is not often met with in the alteration zones around granitic pegmatites. Not even in the most favourable situation, that is when the surrounding rocks carry carbonates is fluorite an important mineral."

Only a very few descriptions of examples of exomorphic pegmatitic fluorite are in literature surveyed by the writer (von Knorring and Hornung, 1961; Tyndale-Biscoe, 1951) and only rare examples have been observed in the numerous pegmatite districts studied by him. The purpose of this paper is to describe such an occurrence.

In July 1950, Professor Percy Quensel of the University of Stockholm and the writer examined the Gundlebo and Skuleboda pegmatites near Ryrs station, nearly half way between Uddevalla and Vänersborg, about 70 km north of Göteborg in southwestern Sweden. Although both pits were partly flooded, exposures on the walls permitted geological observations. Specimens collected were studied at the Department of Geology and Mineralogy, The University of Michigan. Field work was made possible by a grant from the Faculty Research Fund of the Horace H. Rackham Graduate School, The University of Michigan, and labora-

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Previous papers on these pegmatites are all in Swedish and describe or list the unusual pegmatitic accessory minerals: Almström (1931)—yttrotantalite, sphalerite, amazonite, topaz; Sandegren (1931)—native bismuth, sphalerite; Wallerius (1932)—topaz and its alteration, pyrophysalite; Sundius (1942)—fluorite; Quensel and Alvfeldt (1944)—beryllian allanite.

Geology

The two parallel pegmatites, which are exposed in two small cuts about two kilometers northeast of Ryrs, strike approximately north-south. The Skuleboda body, about 150 meters northwest of the Gundlebo pegmatite, dips to the east, whereas the Gundlebo pegmatite dips about 50–60° W.

Skuleboda

The Skuleboda pegmatite, which transects the foliation of a dark biotite gneiss, is about 3–4 m thick and indistinctly zoned. A core of quartz and microcline pods, $\frac{1}{2}-1$ m long, is flanked by a wall zone of finer-grained muscovite-rich pegmatite, also containing quartz, microcline, plagioclase and a little biotite and garnet. In addition, albite rock, with some pink cleavelandite, is localized chiefly along the core-wall zone contacts, replacing core rock. This rock contains also smoky quartz, relicts of buff microcline, aggregates of fine-grained muscovite, blades and sunbursts of beryllian allanite and small blebs and blades of yttrotantalite.

The allanite, which is markedly radioactive, occurs in thin blades as much as 20 cm long. It appears to be replacing albite, some of which remains as thin elongate relicts parallel with the axes of the allanite blades. The yttrotantalite, which is strongly radioactive, occurs chiefly within albite or in pink albite-gray quartz aggregates and is surrounded by the characteristic pale reddish radioactive oxidation halo. Some of it forms partly faced crystals; some of it is in clusters of blades.

Black to very dark reddish brown sphalerite occurs in thin vuggy veins in gray quartz together with scattered flakes and films of sericite. Associated are thin blades of yttrotantalite. The quartz is strongly fractured, and deposition of the sphalerite was fracture-controlled. Native bismuth has also been reported.

The sequence of mineral formation is reconstructed as:

Magmatic
1. Wall zone—biotite, muscovite, garnet, sodic plagioclase, microcline, quartz
2. Core—microcline, quartz

Hydrothermal
3. Albitic replacement unit
   a. albite, quartz
   b. allanite, yttrotantalite
   c. sphalerite, sericite, bismuth (?)

Gundlebo

The Gundlebo pegmatite, the larger, was excavated along the strike for about 30 m and to a depth of seven m. It is reported to have been as much as 10 m wide, but its true thickness appears to be 6–7 m. There are several irregular rolls along the footwall contact where the general westerly dip is locally reversed to steep to the east. The body cuts across the structure of a biotitic feldspathic gneiss.

The border zone is a thin unit of mainly quartz and small muscovite flakes. The wall zone, rich in books of muscovite as much as 15 cm across, also contains quartz and sodic plagioclase. There appears to have been an intermediate zone of quartz-microcline rock, much of which has been replaced. The core consists of white quartz.

Most of the intermediate zone, and parts of the wall zone and core, as well, have been replaced by albite-rich rock of varied texture and mineralogy. Conspicuous in it are pods of fine-grained, sugary albite, masses of cleavelandite, large books and aggregates of lepidolite, blocky subhedra and crystals of topaz, pods of vuggy purple fluorite and veinlets of several sericitic minerals.

One of the sugary albite pods, five feet long, microscopically is seen to consist of a uniform, unoriented aggregate of blocky subhedral albite grains (Ab_{92}). These show a characteristic twin pattern, with two nearly equal albite individuals and several thin albite twins along the contact between the two large units. Another albitic rock, porcelanoid in texture, can be observed microscopically to consist of a mosaic of quartz and subordinate microcline largely replaced by generally parallel, very fine-grained, stubby albite subhedra.

Lepidolite, deep mauve-purple in color, forms thin books as long as 20 cm. Many are marked by reeves, wedge-A or herringbone structure and some by minute crinkling. These books were formed along closely spaced fractures chiefly in white cleavelandite. Platy polygonal blocks, bounded by lepidolite sheets enclosing cores of cleavelandite or of cleavelandite-quartz, form characteristic specimens from this part of the replacement unit. There also are a few aggregates of lepidolite flakes, each as much as several centimeters across. Quensel (1944) reports, from a spectrochemical analysis by E. Dahlström, that the lepidolite (presumably from the large books) contains:

LiO (sic)	5.16%
Rb_2O	*ca.* 1.2
Cs_2O	*ca.* 0.5

Spectrochemical analysis of a carefully selected sample of lepidolite from the large books by C. E. Harvey gave the following results:

SiO_2 = 48.	SnO_2 = .006
Al_2O_3 = 30.	Ga_2O_3 = .016
K_2O = 11.1	TiO_2 = .005
Fe_2O_3 = .22	Sc_2O_3 = n.d.
MgO = .01	SrO = .006
Na_2O = .32	Cr_2O_3 = n.d.
MnO = 1.1	CaO = .002
BaO = .0008	V_2O_5 = .002
Rb_2O = .80	Cs_2O = .12
Li_2O = 4.1	F = 6.5

n.d. = not detected

Optical properties of most of the book lepidolite are:

$$\beta = 1.562\text{–}1.564$$
$$\gamma = 1.564\text{–}1.566$$
$$2V = 37°$$

Most of the lepidolite is biaxial, but a small amount of material in some sheets is uniaxial, or nearly so, with 2V = 0–5°. Contacts between the two varieties are microscopically sharp, but the two are megascopically indistinguishable. The biaxial lepidolite has crystallized as the one-layer monoclinic (1M) polymorph, which is in agreement with its Li_2O content of 5.16% as reported by Quensel but not with the Li_2O determination by Harvey (Levinson, 1953). However, the structure of the uniaxial lepidolite has not been determined definitely, but it is not one of the known mica polymorphs and may be a new type (Levinson, personal comm.). In view of this structural variation some compositional variation also is likely (Heinrich *et al.*, 1953).

Topaz (pyrophysalite) forms large, blocky, crudely faced crystals that show combinations of the front dome, front pinacoid and prisms. The mineral is strongly fractured both along basal cleavages and parallel with (010). The unaltered topaz is gray-white, but most masses and crystals show a characteristic scaley, waxy, marginal alteration, with an outer reddish purple zone that may grade into inner gray or greenish material of similar texture. Thin sections of the outer parts of altered crystals show that the alteration consists of very fine-grained sericite which veins and replaces the topaz along several fracture sets, forming, in some cases, a pseudo-breccia of lozenge-shaped topaz relicts in mica.

The purple tint of the mica is not apparent in thin section. Where topaz is in contact with cleavelandite, both it and the albite are replaced by the sericite. Analytical results by Almström, reported by Wallerius (1932), indicate that the secondary mineral consists chiefly of SiO_2 and Al_2O_3 with a trace of Mn (the purple chromophore) and with little or no F. Thus upon sericitization of the topaz, some F may be released. In some specimens the alteration is more general, and most or all of the topaz is sericitized. Pink (manganiferous) muscovite characteristically replaces topaz in several pegmatite districts (Heinrich and Levinson, 1953).

Masses of purple fluorite as large as 1–2 cm have been reported. Much of it occurs with cleavelandite, and some fluorite is pseudomorphous after cleavelandite, forming aggregates of thin plates that grade into plagioclase. In one specimen, vuggy fluorite rests on scattered grains and crystals of red sphalerite which lie on cleavelandite. A sprinkling of pale pink cryptocrystalline sericite dots some fluorite.

Also transecting cleavelandite are thin veinlets of a dark green to gray, cryptocrystalline earthy material, which, under the microscope, still appears very fine-grained even with highest magnification. It has a very low birefringence, a yellowish green color and a general index of refraction of about 1.65. It appears to be a chlorite.

Amazonite occurs both in the wall and intermediate zones, in the latter more abundantly. Most of the microcline of the intermediate zone is perithitic and flesh colored, forming crystals as much as 0.5–0.8 m across. Locally it is mottled pale to deep green. In some specimens the green penetrates the buff as irregular veins and tongues in a single crystal and thus is apparently younger. However, in another example a two-inch crystal of amazonite in quartz is enveloped by a thin shell of flesh colored microcline. Both varieties are transected by cleavelandite veins.

The sequence of mineral crystallization in the Gundlebo pegmatite is:

Magmatic:
1. Border zone—muscovite, quartz
2. Wall zone—muscovite, plagioclase, quartz
3. Intermediate zone—microcline (incl. amazonite), quartz
4. Core—quartz

Hydrothermal:
5. Replacement unit
   a. cleavelandite and sugary albite
   b. lepidolite and topaz
   c. sericite
   d. sphalerite
   e. fluorite
   f. sericite and chlorite (?)

Wall Rock Alteration

The wall rock of the Skuleboda deposit is a medium-grained black biotitic gneiss, well foliated but not banded, spotted uniformly with bright spangles of coarser biotite as much as 3 mm across. The unaltered rock contains chiefly quartz, sodic plagioclase and biotite. Along the contacts with the pegmatite the gneiss has been converted to a coarse-grained, nonfoliated muscovite rock, with some flakes of muscovite as large as 3 cm in diameter. This zone is about 5–8 cm thick (Fig. 1).

Thin sections of the gneiss from near the contact with the coarse-

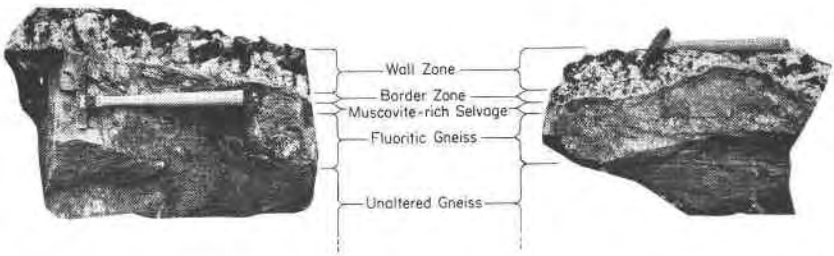

Fig. 1. Blocks of pegmatite and altered wall rock, Skuleboda pegmatite. Hammer is 45 cm long.

grained muscovite selvage show it to consist of biotite, muscovite, sodic plagioclase, quartz, fluorite and accessory sphene. The biotite is in subparallel subhedral plates of variable size. Muscovite, less abundant than biotite, here occurs in large flakes of uniform size, usually unoriented, which lie across the biotite and include ragged remnants of unreplaced biotite. Interstitial to the micas is the fine-grained, anhedral plagioclase-subordinate quartz matrix. The plagioclase is zoned, with cores slightly kaolinized; other parts are locally sericitized. Scattered throughout both the micas and the plagioclase-quartz phase is fluorite in small ovoid grains, constituting 8–10% of the rock.

At the Gundlebo deposit, the wall rock also is a biotite gneiss, somewhat lighter in color than at Skuleboda. In the partly altered wall rock, biotite, which is much less abundant than in the wall rock of the Skuleboda dike, is in clusters of thin parallel flakes and shows incipient chloritization. Microcline forms scattered, relatively large anhedra, showing minor perthite and a few quartz bleb inclusions. Quartz and sodic plagioclase occur in smaller anhedra. The plagioclase is indistinctly twinned, contains some quartz blebs and is locally sericitized, in its cores or intermediate parts. Accessories are zircon, apatite, granules of epidote associated with biotite and a few large skeletal crystals of sphene.

Fluorite and muscovite also are common locally, though not nearly so abundant as in the altered wall rock at the Skuleboda pegmatite. Muscovite replaces biotite, and fluorite (2–3%) forms as irregular grains along grain boundaries, replacing chiefly plagioclase.

Again directly along the pegmatite contacts, the gneiss has completely transformed into a coarse biotite-muscovite aggregate.

In the selvages directly along the pegmatite contacts the chief elements removed were Fe, Mg, Ca and Si, and K was the main element introduced. In the partly altered, fluorite-bearing biotite gneisses the main elements removed were Fe and Mg, whereas F was the primary addition.

Discussion

The two pegmatites are remarkable in several respects. Although they are very close together, they differ sharply in their accessory mineral assemblages and their minor element contents:

Skuleboda	Gundlebo
Ce, Y, Ta	Li
Th, U	Zn, S
Zn, Bi, S	F

Around both pegmatites fluorite has been formed in the wall rocks, but not directly along the contacts. Remarkably, fluorite has been found only in the Gundlebo pegmatite around which fluoritization is much less intense.

Pegmatites in two United States districts contain relatively abundant fluorite: South Platte, Colorado (Heinrich, 1958) and Petaca, New Mexico (Jahns, 1946). Nearly all the South Platte pegmatites occur in granite in which no exomorphic effects have been developed. The Petaca pegmatites, which have been intruded mainly into micaceous quartzite, have exomorphic zones rich in muscovite and some feldspar and locally tourmaline but no fluorite. The Sunnyside deposit in the Petaca district (Jahns, 1946, 1955, 1960), which had been suggested as an example of a pegmatitic exomorphic deposit, consists of metacrysts of beryl, fluorite, topaz, ilmenite and columbite disseminated through muscovite-impregnated quartzite. However, recent excavation, which has not uncovered any pegmatite at or near the occurrence, shows that the mineralization is associated with quartz veins. Thus, fluoritic pegmatites of these two districts are not attended by fluorite exomorphism.

Von Knorring and Hornung (1961) report fluorite in the wall rock of the Benson No. 1 pegmatite, Southern Rhodesia, and Tyndale-Biscoe (1951) notes fluorite in epidiorite altered to diopside rock along contacts of the Al Hayat pegmatite, Bikita, Southern Rhodesia. Fluorite is not reported to occur in either of these pegmatites.

From these comparisons it is clear that the development of exomorphic pegmatitic fluorite does not require the crystallization of fluorite within the pegmatite itself. In fact, the few examples available suggest that, if fluorite is formed as a pegmatite constitutent, it will tend not to be developed in the surrounding altered wall rock.

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