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Scapolite pegmatite from the Minas fault, Nova Scotia: tangible manifestation of Carboniferous, evaporite-derived hydrothermal fluids in the western Cobequid highlands?

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ABSTRACT

Pegmatite cutting chlorite schist in the Minas fault at McKay Head, Nova Scotia, consists of Cl-rich (2.7–3.8 wt.% Cl) marialitic scapolite ($EqAn_{21-32}$) with interstitial, apparently primary analcite, hematite and rutile, and later (including vug-lining) analcite, pyrite, chlorite, titanite and calcite, and cross-cutting epidote veins. Some of the latter phases might have crystallized from residual pegmatitic fluids. Unlike many other primary scapolite-bearing igneous rocks, the McKay Head occurrence has compositional affinities with mafic (rather than felsic) systems: it is enriched in transition metals (e.g. $Cr \leqslant 53$ ppm), and has very low LILE concentrations (e.g. $Rb<10$ ppm; $U<1$ ppm; $Th<2$ ppm; $Ba<20$ ppm) and Rb/Sr ratios (~0.05). The presence of interstitial rutile and hematite rather than ilmenite indicates that the pegmatitic fluid was oxygenated late (T~400°C) in its crystallization history.

The pegmatite is interpreted to be related to highly sodic hydrothermal solutions derived from (or affected by) early Carboniferous evaporites of the Windsor or Horton groups. Compositionally-similar fluids, perhaps also related to an evaporite source, may be responsible for a regional, early Carboniferous Na-metasomatic event that altered a suite of alkaline granitoid intrusions shortly after their emplacement.

KEYWORDS: scapolite, pegmatite, evaporites, Minas fault, Nova Scotia.

Introduction

SCAPOLITE is a common mineral in high-grade metamorphic rocks, but only rarely occurs as a primary phase in igneous rocks. Examples of what has been interpreted as igneous scapolite have been described in potassic basanites (Boivin and Camus, 1981), alkali basalt (Stolz, 1987), latite (Goff *et al.*, 1982), and granitic pegmatite (Mittwede, 1994). Primary scapolite can occur in cases where the magma is enriched in CO_2, SO_3 and/or Cl. It generally has meionitic (Ca-rich) rather than marialitic (Na-rich) compositions, reflecting elevated (liquidus) temperatures of formation.

This paper describes a rare occurrence of an analcite-, rutile-, and hematite-bearing pegmatite in which Cl-rich marialitic scapolite is the principal phase. On the basis of its mineralogy and geochemistry, together with regional geological considerations, the pegmatite is interpreted to have crystallized from evaporite-derived (or affected) hydrothermal fluids activated by early Carboniferous mafic plutonism.

Field setting

The scapolite pegmatite occurs in a tall (~20 m) chlorite schist sea-stack (Fig. 1*A*) within the Minas fault at McKay Head, Nova Scotia (Fig. 2). The Minas (Cobequid-Chedabucto) fault is a major, predominantly dextral (Mawer and White, 1987), shear zone that separates Nova Scotia into a northern segment (Avalon terrane), and a southern segment (Meguma terrane). Blocks of diverse lithology — including Carboniferous sedimentary rocks and diverse igneous and low- to high-grade metamorphic rocks — occur within

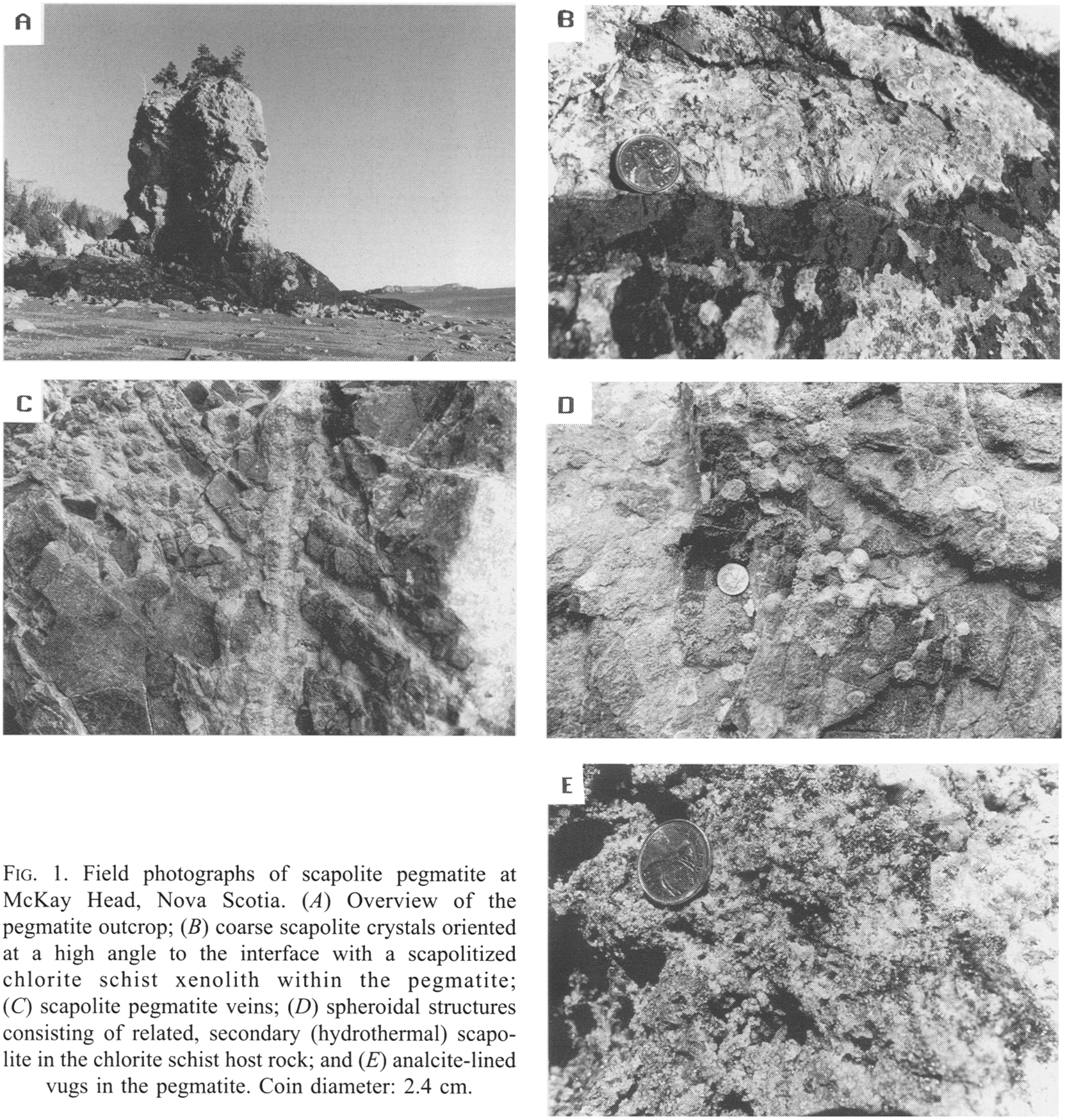


FIG. 1. Field photographs of scapolite pegmatite at McKay Head, Nova Scotia. (*A*) Overview of the pegmatite outcrop; (*B*) coarse scapolite crystals oriented at a high angle to the interface with a scapolitized chlorite schist xenolith within the pegmatite; (*C*) scapolite pegmatite veins; (*D*) spheroidal structures consisting of related, secondary (hydrothermal) scapolite in the chlorite schist host rock; and (*E*) analcite-lined vugs in the pegmatite. Coin diameter: 2.4 cm.

the fault zone (Gibbons and Murphy, 1995; Gibbons *et al.*, 1996). The unusual scapolite pegmatite described here expands the range of rock types known to occur in what has been described as a megabreccia (Gibbons *et al.*, 1996). Owing to its occurrence within the Minas fault, however, the age of the pegmatite relative to the ubiquitous Carboniferous rocks in the area cannot be deduced from field relationships. For the same reason, neither can the original site of its emplacement be identified. Evaporite-bearing early Carboniferous rocks occur both to the north and south of the Minas fault (Howie, 1988). Consequently, regardless of the kinematic history of the fault, these evaporites could well have played an important role in the genesis of the pegmatite, as is postulated here.

The area straddling the Minas fault has experienced a prolonged hydrothermal history. Immediately to the north, alkaline granitoid rocks in the western Cobequid highlands that yield U-Pb (zircon) ages of 358–363 Ma (Doig *et al.*, 1996) were metasomatized at ~355 Ma, based on an Ar-Ar plateau age determined for secondary

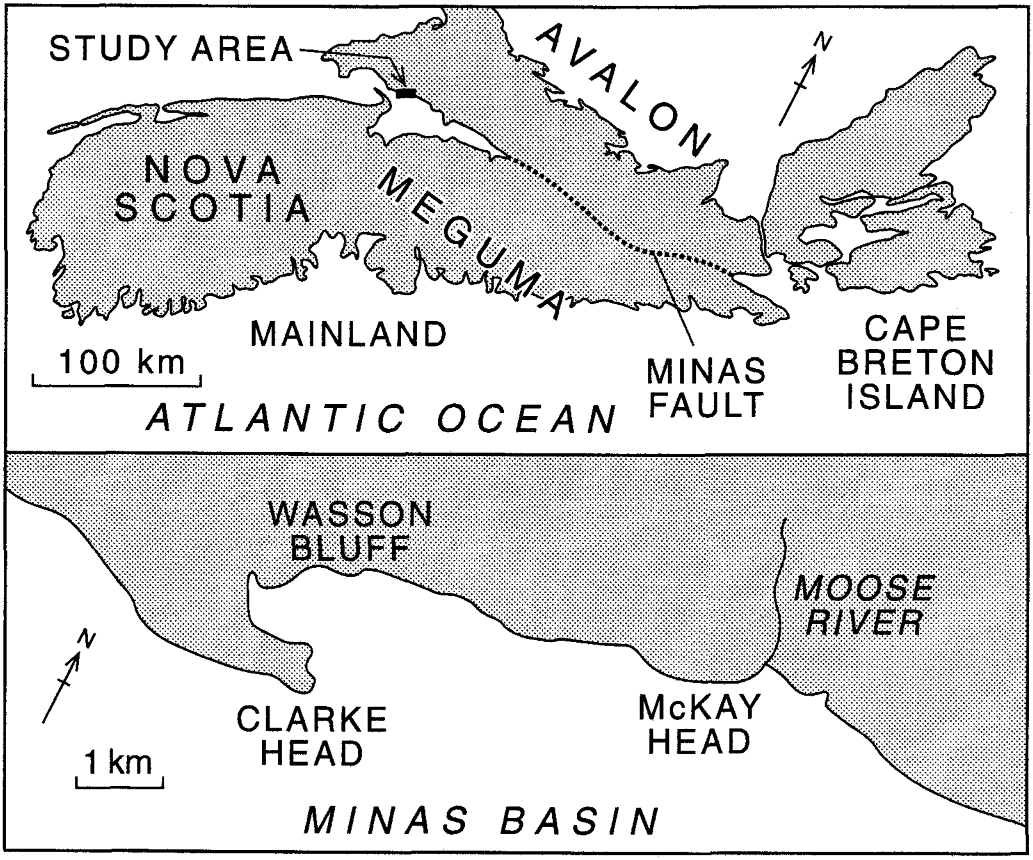


FIG. 2. Geological sketch map of the McKay Head region showing the location of the scapolite pegmatite. Inset shows the regional geology.

riebeckite (Nearing *et al.*, 1997). In contrast, rocks in the eastern Cobequid highlands experienced an episode of relatively potassic alteration. The age of this event is not known with certainty, but is suspected to be late Westphalian because related baryte mineralization (1) is hosted by lower parts (early Visean) of the Windsor Group, and (2) occurs along a fault separating Tournaisian and early Westphalian rocks. Subsequently, the circulation of hydrothermal solutions led to the crystallization of zeolites in vesicles within mafic flows (the North Mountain basalt; *c*. 202 Ma, Hodych and Dunning, 1992) cropping out on the southeastern coast of the Bay of Fundy, just west of the study area.

The principal accessible mass of pegmatite is ~5 m in diameter, but cm-wide veins of the pegmatite are pervasive throughout the sea-stack, and also cut chlorite schist of unknown age in the adjacent cliff face. Scapolite was not observed in fossiliferous mudstones flanking the chlorite schist. All rocks have been subjected to movement on the Minas fault, which is manifested by brittle structures (e.g. epidote-encrusted slickensided surfaces) that are concentrated in high strain-zones that slice up and juxtapose the diverse lithologies that crop out in the area. The absolute age of the schists is not known, but they probably predate the North Mountain basalt which is relatively undeformed and contains relict igneous assemblages overprinted by subgreenschist (i.e. zeolite) facies metamorphic minerals (Aumento, 1966). Xenoliths of the schist occur in the main mass of the pegmatite and these enclaves, and the *in situ* host rock, are extensively scapolitized (Figs 1*B,C,D*).

Petrography

In addition to scapolite, the pegmatite contains subordinate interstitial analcite, hematite, pyrite, calcite, chlorite, rutile and titanite, and is cut by epidote veins. Of these phases, the first three also occur as well-formed crystals that line vugs in the rock (Fig. 1*E*). Consequently, it is difficult to clearly distinguish between primary (igneous) phases and secondary phases; the latter could well have precipitated from residual fluids remaining after the crystallization of the scapolite.

Plagioclase is absent, and there is no evidence that scapolite has replaced this mineral (e.g. there are no relict plagioclase grains within scapolite; cf. Owen and Greenough, 1997, Fig. 2*D*). The scapolite occurs as randomly-oriented, subidiomorphic to idiomorphic crystals that generally are $\leqslant 5$ cm in diameter, but locally are up to 20 cm long. All other phases are relatively fine grained ($\leqslant 3$ mm), and occur interstitially (or within vugs) to the scapolite. However, vug-lining analcite, hematite and pyrite can form crystals up to 1 cm in diameter.

Scapolite constitutes at least 80 vol.% (visual estimate) of the rock. Scapolite crystals grew at a high angle to substrate surfaces (e.g. xenolith (Fig. 1*B*) and vein (Fig. 1*C*) margins). Although predominantly coarse grained, small scapolite crystals can occur on the margins of larger scapolites. Locally, one scapolite crystal encloses another (Fig. 3), and, as will be seen, these grains differ in their composition.

The relative timing of scapolite and analcite crystallization warrants some discussion, because both minerals can form as a primary phase in igneous rocks. Igneous analcite, for example, occurs in some teschenites (Dostal and Owen, in press). Vug-lining analcite clearly is a late phase in the McKay Head pegmatite. Furthermore, within the pegmatite itself, scapolite is locally enclosed by interstitial analcite. This can be taken as evidence that the latter mineral crystallized as a late phase. However, there is no compelling reason to assume that it did not crystallize from the same fluid from which the scapolite itself had previously formed.

The interstitial analcite generally occurs as mosaics of tiny, xenomorphic grains, but locally forms idiomorphic crystals that are separated by calcite. Calcite can also occur as idiomorphic crystals enclosed by analcite, implying the near-contemporaneity of both phases.

Chlorite ($X_{Mg} = 0.81$) forms mats of xenomorphic to subidiomorphic flakes, but can also occur as clusters of well-formed crystals that commonly display a partial fibroradial (i.e. bow-tie) structure. Rutile (and less commonly, scapolite) is enclosed by hematite, a mineral that is commonly present in altered Carboniferous rocks in the area.

The chlorite schist host rock has been scapolitized near the contact with the pegmatite (Fig. 1*C*). Scapolite in the schist occurs as: (1) ubiquitous trails (Figs 1*B,C*) and diffuse patches of small (0.5 mm) crystals that are clouded with opaque minerals, and (2) spheroidal structures (Fig. 1*D*) up to 5 cm in diameter.

Mineral chemistry

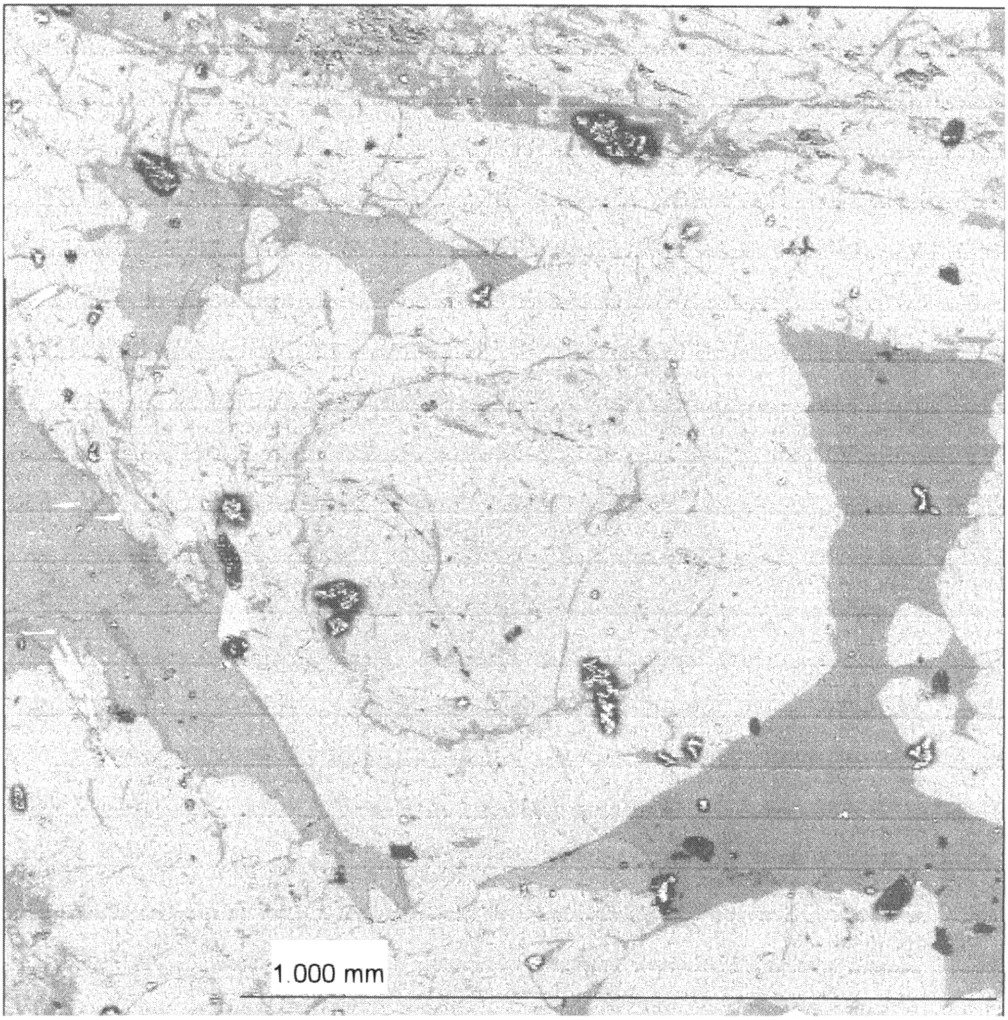
The composition of scapolite and affiliated minerals (Tables 1 and 2) was determined using a JEOL Superprobe 733 equipped with four wavelength-dispersive spectrometers and one energy-dispersive spectrometer, operated with a beam current of 15 kV. Analytical data were collected using the energy-dispersive system, and were reduced using ZAF corrections.

Most of the analysed scapolite has a meionite content of 30–33 (i.e. is a dipyre, *sensu* Shaw (1960*a,b*)), and a comparable equivalent anorthite content ($EqAn_{30-32}$). It is unzoned. There is some evidence that early-formed scapolite was relatively sodic, because in one sample (PAR7), an overgrowth rim conforming to the typical scapolite composition ($EqAn_{32}$) encloses relatively sodic scapolite ($EqAn_{23}$; cf. sample PAR7, Table 1, and Fig. 3).

The scapolite is Cl-rich (2.7–3.8 wt.%; i.e. $\leqslant 0.9$ Cl ions per formula unit), and devoid of sulphate. Calculated X_{CO_3} contents generally range between 0.25 and 0.32), but X_{CO_3} is relatively low (0.06) in the most sodic scapolite in sample PAR7. Scapolite in the metabasite is compositionally-similar to that in the pegmatite (i.e. $EqAn_{27}$).

Geochemistry

Major and selected trace elements (Rb to V in Table 3) were determined by X-ray fluorescence spectrometry using a Philips PW1400 with a Rh-anode X-ray tube. Total Fe is expressed as Fe_2O_3; FeO contents were not measured. To calculate norms, a value of 0.5 was chosen for the FeO/FeO_T ratio of the pegmatite.



IG. 3. Backscattered-electron image showing relatively sodic scapolite enclosed by more calcic scapolite. Note the interstitial analcite [grey image].

Analytical precision of the XRF data, based on replicate analyses, is generally better than 5 % (relative) for major oxides, and between 5 and 10% (relative) for trace elements. The rare earths and Cs, Hf, Ta, Th, U and Sc were determined by instrumental neutron activation analysis (INAA). Gd for Eu* was determined by extrapolating between Sm and Tb values ($Eu^* = Eu_N/(Sm_N{}^2Tb_N)^{1/3}$).

The major element compositions of three of the four analysed samples are relatively uniform, indicating that the coarse grain size of this material did not adversely affect the analytical data. The fourth sample (PAR15), however, is relatively calcic, and depleted in silica and alumina. These features are explained by the elevated LOI value (10.7 wt.%) for this sample, consistent with a relatively high modal calcite content. One sample (PAR3) is strongly depleted in TiO_2, $Fe_2O_{3(t)}$ and various trace elements, including the rare earths, indicating that the analysed material contained low concentrations of oxides and other accessory phases that preferentially partition these components. We therefore conclude that PAR1 and PAR2 are most representative of the bulk of the pegmatite,

TABLE 1. Chemical composition of scapolite in pegmatite and its host rock from McKay Head, Nova Scotia

	PAR 1	PAR 2	PAR 3	PAR 7		PAR 8	
				Core	Overgrowth rim	Pegmatite	Metabasite
SiO_2	57.18	56.74	57.26	59.61	56.16	57.42	57.87
Al_2O_3	23.38	23.77	23.09	21.97	23.16	23.42	22.23
CaO	8.23	8.24	7.76	4.47	7.95	7.85	7.33
Na_2O	9.30	9.89	9.36	11.12	9.34	9.05	9.14
K_2O	0.14	0.10	0.28	0.12	0.15	0.27	0.28
SO_3	0.00	0.00	0.00	0.00	0.02	0.00	0.5
Cl	2.72	2.89	2.87	3.77	2.72	2.87	3.00
Total	100.9	101.6	100.6	101.1	99.5	100.9	99.8
Number of ions on the basis of 12 (Si, Al)							
Si	8.097	8.032	8.133	8.365	8.075	8.103	8.259
Al	3.903	3.968	3.867	3.635	3.925	3.897	3.741
	12.000	12.000	12.000	12.000	12.000	12.000	12.000
Ca	12.48	12.49	1.181	0.672	1.225	1.187	1.121
Na	2.553	2.715	2.578	3.026	2.603	2.477	2.529
K	0.026	0.018	0.050	0.022	0.028	0.049	0.051
	3.827	3.982	3.809	3.72	3.856	3.713	3.701
S	0.000	0.000	0.000	0.000	0.002	0.000	0.000
Cl	0.672	0.018	0.709	0.926	0.67	0.705	0.736
EqAn	31.5	32.4	30.4	23.3	32	32.3	27.1

and our discussion will focus on these two samples.

The pegmatite is nepheline-normative, consistent with the absence of free quartz. Unlike typical granitoid rocks, it has low large-ion-lithophile element (LILE) concentrations (e.g. Rb<10 ppm; U<1 ppm; Th<2 ppm; Ba<20 ppm) and very low Rb/Sr ratios (~0.05). Furthermore, the concentrations of certain transition metals, especially Cr ($\leqslant$53 ppm), are higher than typical felsic pegmatites. Chondrite-normalized *REE* patterns are flat and virtually unfractionated ($(\mathrm{La/Lu})_N$ = 0.98–1.3), and do not display prominent Eu anomalies (Eu/Eu* = 0.91–1.01; Fig. 4) that characterize many fractionated mafic or felsic systems.

Discussion

The scapolite pegmatite is unusually sodic. The presence of primary marialitic scapolite (without attendant calcite) with an EqAn content of ~30 suggests that the pegmatite crystallized from an aqueous fluid that contained at least 40 mol.% NaCl (Vanko and Bishop, 1982; cf. Orville, 1975), assuming a temperature of ~700–750°C. We emphasize, however, that there are no mineralogical constraints on the peak magmatic temperature of the pegmatitic fluid. There are,

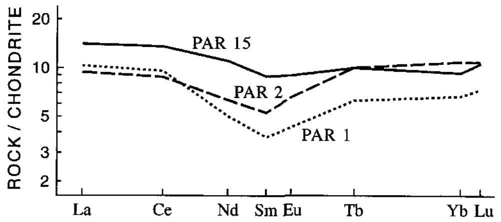


FIG. 4. Chondrite-normalized *REE* patterns for scapolite pegmatite from McKay Head. Data for one sample (PAR3) with anomalously-low trace element concentrations (cf. Table 3, and text) are not shown.

TABLE 2. Chemical composition of selected[1] interstitial phases in scapolite pegmatite from McKay Head, Nova Scotia

	Anl	Mt	Rt	Ttn[2]	Chl[2]	Chl[4]
SiO_2	57.6	0.11		31.12	27.67	27.07
TiO_2			99.4	37.8		0.04
Al_2O_3	21.27	0.34		1.14	20.26	22.14
Cr_2O_3			0.22			
FeO_2		91.23	0.39	0.37	22.58	11.16
MnO					0.15	
MgO					17.49	26.12
CaO				29.22		0.02
Na_2O	12.31	0.01			0.07	
K_2O					0.05	
Total	91.2	91.7	100.0	99.6	88.6	86.6
Oxygen basis:	7	3	2	20	28	28
Si	2.447	0.004		4.075	5.682	5.352
Al	1.065	0.016		0.176	4.905	5.16
Ti			0.996	3.723		0.006
Cr			0.002			
Fe^{3+}		1.984	0.004	0.041	3.878	1.845
Fe^{2+}		0.983				
Mn					0.026	
Mg					5.353	7.696
Ca				4.1		0.004
Na	1.014	0.001			0.028	
K					0.013	

[1] interstitial calcite, pyrite and quartz are also present

[2] idiomorphic grain enclosed by quartz

[3] enclosed by analcite; grain also contains 0.20 wt.% Ni0 and 0.05 wt.% Cl

[4] in scapolitized metabasite (chlorite schist) host rock; grain also contains 0.06% Cl

however, some constraints on the conditions at which some lower temperature phases formed. For example, the presence of interstitial rutile+ hematite suggests that this assemblage formed at the expense of early ilmenite:

$$4 \text{ Ilm} + O_2 = 4 \text{ Rut} + 2 \text{ Hem}$$

in which the lower temperature assemblage is written on the righthand side of the reaction. Updated Ge0-CALC (Brown *et al.*, 1988; Berman and Brown, 1988) software (TWQ; Berman, 1991) indicates that this pressure-insensitive oxidation reaction occurs at a temperature of ~400°C. This result is consistent with the presence of chlorite, epidote and analcite in the rock, and indicates that the pegmatitic fluid was oxidized late in its crystallization history.

Microstructures provide clues concerning the crystallization history of the pegmatite. Notably, sodic scapolite (Me_{18}) is locally enclosed by relatively calcic scapolite (Me_{32}). This violates normal fractionation trends, but can be explained by the crystallization of primary analcite, provided that the latter is, at least in part, a primary phase. Being a sodic mineral, analcite will strongly partition Na relative to scapolite, forcing the residual liquid to have a more calcic composition than it would have had prior to the crystallization of analcite.

The pegmatite is compositionally-distinct from most other scapolite-bearing granitoid rocks described in the literature (cf. Table 3), and these differences reflect, in large part, contrasts in scapolite compositions. For example, compared

TABLE 3. Comparison of the chemical composition of scapolite pegmatite from MacKay Head, Nova Scotia, with igneous-scapolite bearing rocks described in the literature

	PAR1	PAR2	PAR3	PAR15	Goff *et al.* (1982)	Mittwede (1994)
SiO_2 (wt.%)	58.02	58.39	58.97	53.26	67.53	71.69
TiO_2	2.04	1.72	0.02	0.85	0.33	0.16
Al_2O_3	22.27	22.5	23.86	19.08	17.41	15.07
Fe_2O_3	1.83	1.44	0.01	4	1.27	1.78
FeO		n.d.	n.d.	n.d.	1.45	n.d.
MnO	0.02	0.02	0.01	0.04	0.06	0.02
MgO	0.96	0.97	0.59	1.51	0.92	0.82
CaO	4.77	4.3	5.81	11.57	2.44	3.21
Na_2O	9.34	10.08	10.45	8.25	4.3	1.44
K_2O	0.73	0.56	0.26	1.25	4.08	5.78
P_2O_5	0.02	0.01	0.01	0.18	0.21	0.02
Total	100	100	100	100	100	100
LOI	5.5	4.6	3.9	10.7	n.d.	n.d.
Rb (ppm)	7	8	7	25	n.d.	n.d.
Sr	159	154	218	113	n.d.	n.d.
Ba	18	12	n.d.	125	n.d.	n.d.
Zr	11	103	12	98	n.d.	n.d.
Nb	18	11	n.d.	2	n.d.	n.d.
Y	8	11	3	12	n.d.	n.d.
Cr	53	51	15	35	n.d.	n.d.
Ni	14	5	5	11	n.d.	n.d.
Cu	6	7	n.d.	7	n.d.	n.d.
Zn	9	10	8	10	n.d.	n.d.
Ga	12	11	6	7	n.d.	n.d.
V	42	35	n.d.	45	n.d.	n.d.
La	2.18	2.19	n.d.	2.98	n.d.	n.d.
Ce	5.39	5.07	0.36	8.06	n.d.	n.d.
Nd	2.24	2.87	n.d.	4.58	n.d.	n.d.
Sm	0.59	0.79	0.04	1.19	n.d.	n.d.
Eu	0.23	0.37	0.02	0.45	n.d.	n.d.
Tb	0.21	0.35	0.06	0.34	n.d.	n.d.
Yb	1.06	1.74	n.d.	1.41	n.d.	n.d.
Lu	0.18	0.24	0.01	0.24	n.d.	n.d.
Cs	20.07	21.35	13.54	20.15	n.d.	n.d.
Hf	3.05	3.03	0.01	2.5	n.d.	n.d.
Ta	1.09	0.87	0.27	0.33	n.d.	n.d.
Th	1.26	1.72	n.d.	1.07	n.d.	n.d.
U	0.35	0.52	n.d.	0.23	n.d.	n.d.
Sc	3.85	5.22	0.2	2.73	n.d.	n.d.

n.d. = not determined
Major element data have been normalized to 100 wt.%, volatile-free
(LOI = loss on ignition)

with the McKay Head occurrence, scapolite-bearing granitic pegmatite from South Carolina is relatively silicious (71.2 wt.% SiO_2) and depleted in Al_2O_3 (14.97%), CaO (3.19%) and Na_2O (1.43%), and contains relatively calcic scapolite (Me_{59}, Me_{70}) (Mittwede, 1994). Similar compositional characteristics apply to the meionitic (Me_{68}) scapolite phenocryst-bearing latite described by Goff *et al.* (1982), except that the latite is substantially more sodic (4.3% Na_2O) than the South Carolina pegmatite (1.43% Na_2O). Unlike the McKay Head pegmatite, both of these occurrences are peraluminous (A/CNK>1), and contain plagioclase. Significantly, however, the McKay Head scapolite is compositionally-similar to marialite ($EqAn_{12-37}$; Cl = 3–4 wt.%) in the Humboldt lopolith, Nevada where compositions have been taken to be indicative of contamination by evaporites (Vanko and Bishop, 1982).

It is reasonable to attribute the source of the Na to the ubiquitous evaporites which crop out in northern mainland Nova Scotia. Windsor Group evaporites have been identified as the source of S residing in a massive sulphide (Zn-Pb) deposit at Gays River (Ravenhurst *et al.*, 1987), some 150 km southwest of McKay Head. The evaporites north of the Minas fault include commercially important halite, so clearly represent an important potential source of Na and Cl, both of which characterize the scapolite pegmatite. Furthermore, underlying rocks of the largely clastic Horton Group also contain Na-rich evaporites (i.e. in the Gautreau Formation; Carter and Pickerill, 1985; Howie, 1988; St. Peter, 1992, 1993). It is therefore worth considering the significance of this unusual rock within the context of the regional geology.

The late Visean to early Namurian Windsor Group consists of marine evaporites, siltstones, limestone and dolomite deposited within a graben-basin system (e.g. Howie, 1988). The evaporites include commercially-important halite deposits (e.g. near Pugwash, some 65 km northeast of McKay Head), as well as anhydrite and gypsum. The Windsor Group overlies Eifelian to early Visean rocks of the Horton Group. Although predominantly consisting of fluviolacustrine clastic rocks, the upper part of the Horton Group contains evaporites, including halite, glauberite (Na-Ca sulphate) and anhydrite (Howie, 1988). Drilling in the Weldon-Gautreau area of southeastern New Brunswick, some 100 km WNW of McKay Head, indicates glauberite reserves exceeding 25 million tons, averaging 23% Na_2SO_4 (Webb, 1977). Halite-dominated evaporites of the Horton Group occur in a crescent-shaped belt some 60 km NE of McKay Head.

Two questions arise if the Na (and possibly Cl and affiliated components) in the pegmatite was indeed derived from nearby evaporites of early Carboniferous age. The first centres on possible magmatic heat (and fluid) sources, the second on whether the scapolite pegmatite is related to regional, Na-hydrothermal activity that occurred soon after (at *c.* 355 Ma; Nearing *et al.*, 1997) the emplacement of early Carboniferous (*c.* 358–363 Ma; Doig *et al.*, 1996) alkaline granitoid rocks that have been albitized and locally contain secondary riebeckite.

It is apparent from the bulk geochemical data (Table 3) that the McKay Head pegmatite has closer affinities to leucocratic mafic systems (e.g. anorthosites and their kindred rocks) than granitoid rocks *per se*. Unless scavenged from the chlorite schist host rock, the mafic characteristics of the pegmatite (i.e. elevated transition metal concentrations and low large-ion-lithophile elements) likely reflect the composition of magmatic source of the pegmatitic fluids, prior to being contaminated, as postulated here, by early Carboniferous evaporites.

Although nearly universally associated with Proterozoic and Archaean terranes, anorthositic rocks of Phanerozoic age have been identified (G. Pe-Piper, pers. comm., 1997) in the Cobequid highlands, to the north of the Minas fault. The Visean rocks of the Windsor Group host many Carboniferous and younger intrusive rocks ranging from granodiorite to lamprophyre (G. Pe-Piper, pers. comm., 1997).

Although not yet isotopically dated, the anorthosites are undeformed, and are seen to cross-cut early Carboniferous granitoid rocks. They appear to be some of the youngest intrusive rocks in the area, so therefore may be of suitable age (i.e. younger than the halite-bearing evaporites) to have acted as a heat source to drive brines from the evaporites. There are, however, two problems associated with a direct connection to the anorthosites. First, the flat *REE* patterns and negative Sm anomalies that characterize the scapolite pegmatite, contrast with typical *REE* signatures for anorthosites, which typically have higher *LREE* concentrations and negative Eu anomalies. This probably reflects the dominance of scapolite in influencing the *REE* pattern of the pegmatite; it also suggests that the pegmatite is not directly related to the anorthositic magma or its derivatives. Furthermore, the anorthosite is of very limited size, so is unlikely to have been an important heat source that could have either supplied (or activated) fluids to (or within) the evaporites. It therefore appears that the pegmatite is related, directly or indirectly, to some other, as yet unidentified suite of intrusive rocks, perhaps one that temporally correlates to gabbros (339 Ma; Barr *et al.*, 1994) emplaced near the base of the Windsor Group [i.e. near the contact between the Windsor and Horton groups] in southern Cape Breton Island. Obviously, dating of the pegmatite would greatly assist in identifying comagmatic rocks. It would also help to confirm or refute the possibility that the pegmatite is related to the regional, *c.* 355 Ma Na-metasomatic event that affected alkaline rocks in the area, as well as determine whether the Horton or Windsor group was the more likely source of halite components in the pegmatite.

Conclusions

Pegmatite at McKay Head contains chlorine-rich scapolite that is much more sodic ($EqAn_{17-32}$) than the igneous scapolites (typically $\sim EqAn_{70}$) described in the literature. It contains interstitial analcite, rutile and hematite, with minor amounts of chlorite and calcite. Analcite also occurs as a vug-lining phase along with pyrite and hematite. Some of the interstitial and vug-lining phases (notably analcite and hematite) might have crystallized from residual igneous fluids after (or overlapping the terminal stages of) the consolidation of the scapolite. The presence of rutile and hematite instead of ilmenite suggests that the pegmatitic fluid was oxygenated late (at $T\sim400°C$) in its crystallization history. Regional geological considerations suggest that the pegmatite was derived from hydrothermal fluids derived from (or affected by) halite-bearing Carboniferous evaporites. Isotopic dating of the pegmatite would help to determine whether or not it is related to the regional Na-metasomatism of early Carboniferous alkaline granitoid rocks in the area.

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