

Narsarsukite: a new occurrence in peralkaline trachyte, south Greenland

B. G. J. UPTON, R. MACDONALD*, P. G. HILL, B. JEFFERIES,
AND C. E. FORD

Department of Geology, Edinburgh, EH9 3JW

*Department of Environmental Sciences, Lancaster, LA1 4YR

SUMMARY. A flinty, spherulitic dyke of peralkaline trachyte in a Precambrian dyke-swarm consists mainly of albite and aegirine. Within this, euhedral crystals of narsarsukite, $\text{Na}_2(\text{Ti,Fe})\text{Si}_4\text{O}_{10}(\text{F})$, occur as short prisms elongate parallel to *c*. This distinguishes them from all previously described narsarsukites, which have tabular habits. Minor phases present include micas, apatite, quartz, pectolite, nordite, and a thorium silicate. Probe analyses are presented for narsarsukite, aegirine, albite, biotite, apatite, pectolite, nordite, and the thorium silicate.

On mineralogical and geochemical grounds it is unlikely that the narsarsukite-bearing dyke is a differentiate of supposedly mantle-derived basalt-trachyte-comendite magmas in the region. The dyke is colinear with a comendite dyke exposed at lower altitude and it is suggested that the narsarsukite-bearing dyke developed as a rheomorphic fenite generated by reaction between quartz diorite basement and fugitive alkaline solutions from the subjacent comendite.

NARSARSUKITE is a rare titanosilicate known only in close association with highly alkaline igneous intrusions and is generally confined to silica-oversaturated granites, syenites, and fenites. It is a chain silicate with tetragonal symmetry and a composition of approximately $\text{Na}_2(\text{Ti,Fe})\text{Si}_4\text{O}_{11}$ with four formula units per unit cell (Warren and Amberg, 1934; Pyatenko and Pudovkina, 1961). It may, however, contain some hydroxy and/or halide ions and the formula is quoted by Vlasov *et al.* (1966) as $\text{Na}_2(\text{Ti,Fe})\text{Si}_4\text{O}_{10}(\text{OH,F})$ and by Semenov (1969) as $\text{Na}_8\text{Ti}_3\text{FeSi}_{15}\text{O}_{43}\text{F}$.

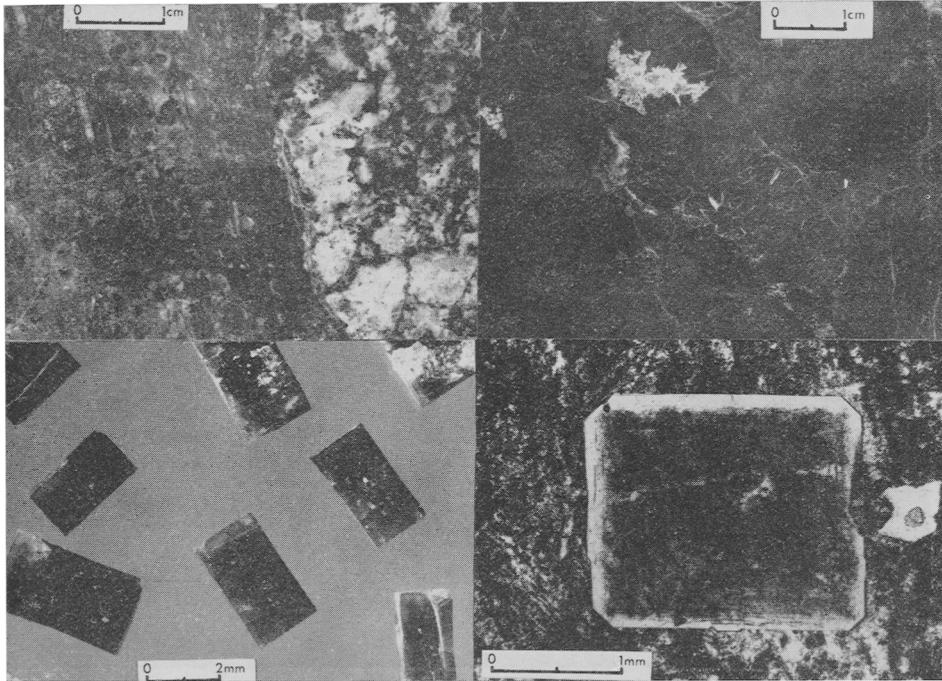
The localities from which it has hitherto been recorded include the type locality at Narssarsuk, South Greenland (Flink, 1901; Bøggild, 1953), Ilfmaussaq, South Greenland (Semenov, 1969), Montana (Graham, 1935; Stewart, 1959), Sudan (Jérémine and Christophe-Michel-Lévy, 1961), Oslofjord (Saebø, 1966), Quebec (Rajasekaran, 1966), Kola Peninsula (Vlasov *et al.*, 1966), and East Greenland (Bearth, 1959).

This account concerns a previously undescribed locality on the island of Igdlutalik some 45 km west of the type locality and approximately 12 km west of the Ilfmaussaq complex, in which the mineral occurs as euhedral crystals within a dyke of peralkaline trachyte.

Field occurrence. The narsarsukite-bearing dyke occurs among a prominent swarm of ENE.-WSW. trending alkaline dykes that extends through the Ilfmaussaq peninsula and the Tugtutôq district (Upton, 1974). The swarm involves dykes of alkali olivine basaltic and trachybasaltic composition together with trachytes, phonolites,

quartz trachytes, and comendites. All are part of the Gardar alkaline province and are believed to have been intruded between 1150 and 1200 Myr ago.

The narsarsukite-bearing dyke crops out within a gully at a height of approximately 220 m. The dyke is some 20 m wide and the outcrop can be traced not more than 50 m



FIGS. 1 to 4: FIG. 1 (top left). Polished surface showing contact of the peralkaline dyke (left) and the country-rock (right). Ovoid spherulites can be seen in the dyke as well as small (<1 mm) dark aggregates of biotite apparently pseudomorphous after a mineral with approximately square cross-section. FIG. 2 (top-right). Polished surface of dyke-rock showing spherulites. The light-coloured area within the larger spherulite in the upper part of the plate consists of pectolite. Narsarsukite crystals (with light-coloured rims) may be seen as square/rectangular sections at top left, centre, and lower right. FIG. 3 (bottom left). Separated narsarsukite crystals showing elongation parallel to the *c*-axis and slight curvature of the prism faces. FIG. 4 (bottom right). Photomicrograph of a narsarsukite crystal viewed (approximately) along the *c*-axis, showing the clouded interior and clear rims.

along the length of the dyke. The southern contact, against the country-rock quartz diorite, is well exposed and shows a reddish-brown fine-grained flow-banded marginal dyke facies (fig. 1). The interior of the dyke is heterogeneous but composed mainly of dull greenish-grey flinty rock. Spherulitic structures up to 2 cm diameter are common (fig. 2). Narsarsukite crystals are abundant in the dyke interior, occurring as deep-green square-sectioned prisms up to 6 mm long. The prism faces exhibit slight concavity (fig. 3).

The narsarsukite-bearing dyke lies on strike with a comendite dyke that is seen at lower altitude (*c.* 50m), to the ENE. The alignment of these two dykes suggests that

they may be intimately connected and that possibly the narsarsukite-bearing rock represents a higher-level facies of a dyke that either grades down or is abruptly underlain by comendite.

Analytical techniques. Microprobe analyses were performed on a Cambridge Scientific Instruments Microscan 5 Electron Probe Microanalyser. The more common elements were measured against well-established standards of simple composition. The rare earths were determined against synthetic glass standards described by Drake and Weill (1972). Corrections for atomic number, absorption, and characteristic fluorescence differences between standard and unknown are essentially those described by Sweatman and Long (1969). A correction for 'dead-time' counting losses was also made.

Probe-analyses of albite, aegirine, apatite, biotite, and nordite are presented in Table II. Light-brown veinlets and patches developed within some of the aegirine-rich spherulites consist of acicular pectolite, apatite, and interstitial quartz. Analyses of the apatite and pectolite are also given in Table II.

The habit of the Igdlutalik narsarsukite appears to be unique (fig. 3). The crystals occur as stumpy prisms approximately twice as long as they are broad, while narsarsukites described from other localities are invariably tabular parallel to {001}. Some crystals exhibit geniculate twinning. The forms {100} and {001} are dominant, with slender prism faces of the form {110}; {210} and {111} forms, common at Narssarsuk and elsewhere, are not developed. The simple, nearly rectangular habit is shared by those at Mont St. Hilaire (Rajasekaran, 1966), although the latter retain the usual tabularity. The deep-green colour is a further unusual feature, narsarsukite being typically a pale-yellow mineral. {100} cleavage is well developed.

The crystal cores are cloudy and contain an abundance of small inclusions (mainly aegirine and albite), while the crystal rims are clear (fig. 4). This zonation is abrupt and not gradational from core to margin. The presence of some 30 wt. % of inclusions consisting of a 3:2 (approximate) ratio of albite and aegirine would account for the bulk compositional differences between the clear rims and the inclusion-rich central parts shown in Table I. In thin-section the narsarsukite is colourless and the colour exhibited by the crystals as a whole is probably governed by the high content of included aegirine. The narsarsukite is uniaxial positive: ω 1.604 ± 0.002 , ϵ 1.657 ± 0.002 .

Probe-analyses of the narsarsukites show them to be essentially homogeneous, the compositional differences between cores and rims being wholly attributable to the inclusions in the former. Niobium is a significant minor component of the narsarsukites. Separated crystals (with contained inclusions) were analysed for H₂O, Cl, and F. Whereas H₂O and Cl were so low as to be indeterminable, 0.73 % F was determined. Since the inclusions are essentially albite and aegirine, this figure is clearly a minimum value for F in the narsarsukite.

An accelerating potential of 20 kV and a probe current of 30 nA measured by a Faraday Cage were the general operating conditions and ensured reasonable counting statistics for all the elements.

With the exception of narsarsukite, stability of the minerals examined under the

electron beam was not a problem. Sodium volatilization in the narsarsukite was overcome by the use of a de-focused beam.

Rock-sample¹ GGU 50176 was analysed using the wet-chemical methods described by Upton *et al.* (1971, p. 165), except that F and Cl were determined by the spectrophotometric method of Peck and Smith (1964). In GGU 50177, SiO₂ was determined

TABLE I

Narsarsukite analysis			Atomic Ratios based on 11 Oxygens + Fluorine		
	1	2		1	2
SiO ₂	62.01	61.89	Si	4.00	4.05
TiO ₂	15.59	10.87	Ti	0.76	0.53
Nb ₂ O ₅	1.31	1.00	Nb	0.04	0.03
Al ₂ O ₃	0.43	4.18	Al	0.03	0.32
FeO	3.20*	5.07*	Fe	0.17	0.28
MnO	0.11	0.10	Mn	0.01	0.01
MgO	0.20	0.14	Mg	0.02	0.01
CaO	0.01	0.13	Ca	0.00	0.01
Na ₂ O	16.04	15.35	Na	2.01	1.95
K ₂ O	0.06	0.06	K	0.01	0.01
F	1.0†	n.d.‡	F	0.20	—
	99.96	98.79			
O ≡ F	0.44				
	99.52				

1. Mean of seven analyses of clear rims in GGU 86012, Igdlutalik.

2. Mean of six analyses of inclusion-rich cores in GGU 86012, Igdlutalik.

* Total iron as FeO.

† Adjusted for 0.73 % F in separated narsarsukite crystals containing *c.* 30 % (wt.) of albite and aegirine inclusions. H₂O⁺ and Cl in specimen not detected. F and Cl analyses by S. Rizzello using method of Huang and Johns (1967).

‡ n.d. not detected.

gravimetrically, Al₂O₃ by the method of Mercy and Saunders (1966), total iron, CaO, MgO, and MnO by atomic absorption spectrometry, TiO₂ and P₂O₅ spectrophotometrically, F by the method of Peck and Smith (1964), FeO and H₂O as for GGU 50176, and Na₂O and K₂O by flame-photometry.

Petrography and mineralogy. The flow-banded selvage of the narsarsukite-bearing dyke consists of finely disseminated albite, aegirine, hematite, (green) biotite, and opaque oxides. The flow-banding is defined by modal variation within these components on a mm scale.

The quartz diorite within a few cm of the dyke possess a granoblastic texture and consists of quartz, andesine, and micropertthite. The crystals are strained and fractured. Fine-grained aggregates of aegirine, green biotite, and blue-green amphibole, patchily distributed along the crystal boundaries, imply some degree of metasomatic recrystallization and introduction of Fe and Na.

Samples from the dyke interior display textural and modal inhomogeneity. They

¹ Sample numbers refer to the Geological Survey of Greenland collection.

are typically fine-grained rocks composed principally of aegirine and albite. Typically the albite is anhedral and less than 100 μm across. However, albite crystals up to 1 cm occur in some coarser more leucocratic facies. Aegirine generally occurs as short prisms 50 to 100 μm long but is seen as longer acicular prisms within spherulites. Other components include green biotite, white mica, riebeckite, opaque oxides, calcite, apatite, zircon, and nordite.

TABLE II. *Electron-probe analyses of accompanying minerals*

	1	2	3	4	5	6	7	8	9	10	11	12
SiO ₂	68.51	68.50	52.51	52.88	52.50	35.60	36.55	0.06	0.52	53.65	46.48	43.47
TiO ₂	n.d.	n.d.	2.03	0.77	1.70	0.93	1.20	n.d.	n.d.	n.d.	n.d.	n.d.
Al ₂ O ₃	19.05	19.30	1.24	1.65	1.00	13.16	16.35	n.d.	n.d.	0.02	n.d.	0.29
FeO*	0.06	0.08	26.41	27.12	25.52	29.28	10.00	n.d.	0.22	0.05	0.22	1.29
MnO	n.d.	n.d.	0.10	0.02	0.13	0.47	0.69	n.d.	0.02	n.d.	n.d.	3.16
MgO	0.02	0.02	0.62	0.68	1.40	4.89	9.26	n.d.	0.02	0.56	0.13	0.50
CaO	0.01	0.03	1.01	3.12	3.36	0.08	0.03	45.27	54.91	31.93	1.48	n.d.
Na ₂ O	11.83	11.72	13.73	12.32	12.00	0.05	0.02	1.35	n.d.	9.79	11.15	n.d.
K ₂ O	n.d.	0.13	n.d.	n.d.	n.d.	9.60	9.57	n.d.	n.d.	n.d.	n.d.	n.d.
	99.48	99.78	97.65	98.56	97.61	94.06	92.67	96.48	96.64	96.00	101.12	90.37

1. Albite in GGU 101201.
2. Albite in GGU 101204: Mean of 2 analyses.
3. Aegirine in GGU 101201: Mean of 3 analyses.
4. Aegirine in GGU 101202: Mean of 3 analyses.
5. Aegirine in GGU 101204: Mean of 5 analyses.
6. Biotite in GGU 101202: Mean of 3 analyses.
7. Biotite in GGU 101204.
8. Apatite in GGU 101201: Total includes: P₂O₅ = 40.89; SrO = 3.74; La₂O₃ = 1.03; CeO₂ = 3.04; Pr₂O₃ = 0.18; Nd₂O₃ = 0.92; Mean of 2 analyses.
9. Apatite in GGU 101204: Total includes: P₂O₅ = 40.95; Mean of 4 analyses.
10. Pectolite in GGU 101201: Mean of 4 analyses.
11. Nordite in GGU 86012: Total includes BaO = 8.99; SrO = 9.73; ZnO = 9.74; La₂O₃ = 8.48; CeO₂ = 11.37; Nd₂O₃ = 1.35; Mean of 8 analyses.
12. Unknown thorium mineral in GGU 86012: Total includes: ZnO = 0.63; ThO₂ = 35.12; Mean of 10 analyses.

* Total iron as FeO.

n.d. = not detected.

The Igdlutalik narsarsukite has a distinctly high Ti/Fe ratio compared with those from Ilfmausaq and Narssarsuk, and falls into the category of titanian narsarsukite (Semenov, 1969). In this respect it most closely resembles the Sweet Grass, Montana narsarsukites (Stewart, 1959).

Small euhedral crystals (< 0.5 mm), occurring in rectilinear, square-sectioned prisms, occur both within the narsarsukite crystals and the groundmass. These are brown (with conspicuous colour zonation) isotropic and, where included in narsarsukite, surrounded by radiating fractures. Probe-analyses show these to contain approximately 35 % ThO₂ (Table II). Their composition, form and isotropy suggest that they are an alteration product, probably hydrated, of thorite.

A further accessory mineral sparsely distributed through the groundmass is a member of the nordite group. It occurs as colourless prismatic euhedra with pyramidal terminations, up to 0.4 mm long. These are biaxial negative, with a small 2V and are length slow with extinction onto prism edges of *c.* 36°. They show shadowy zonation, a prismatic cleavage and birefringence of 0.020 ± 0.002 (γ 1.646 ± 0.002 ; α 1.628 ± 0.002). The refractive indices are slightly higher than those quoted for nordite from

the type locality in Lovozero (Vlasov *et al.*, 1966) and the birefringence of the Igdlutalik material is marginally lower. The composition of nordite according to Bakakin *et al.* (1970) is $\text{Na}_3\text{Ce}(\text{Sr}, \text{Ca})(\text{Mn}, \text{Mg}, \text{Fe}, \text{Zn})_2\text{Si}_6\text{O}_{18}$. While Bakakin *et al.* report ZnO up to 3.9 % in nordite from Lovozero, the Igdlutalik material contains over 9 % of this component.

TABLE III. *Whole-rock analyses*

Major elements (Wt %)	CIPW Norms		Trace elements (ppm)				
	50176	50177	50176	50177			
SiO ₂	62.4	62.3	qz	3.92	4.60	Rb	560
TiO ₂	1.01	1.05	or	24.18	11.82	Zn	445
Al ₂ O ₃	12.54	12.73	ab	42.07	55.22	Yt	70
Fe ₂ O ₃	7.67	5.29	ac	22.31	15.51	Ce	970
FeO	0.30	0.37	hy	1.34	3.44	Zr	500
MnO	0.13	0.18	di	1.33	2.96	Sr	585
MgO	0.78	1.91	il	0.92	1.17	Ba	15
CaO	1.36	2.50	ap	0.83	1.44	Nb	940
Na ₂ O	8.46	9.35	tn	1.31	1.09	K/Rb	60.4
K ₂ O	4.07	1.98	hl	0.01	—		
H ₂ O ⁺	0.19	0.18	ns	1.42	1.70		
P ₂ O ₅	0.35	0.61	fr	0.36	0.88		
F	0.19	0.42					
Cl	<0.01						
	99.45	98.87					
O ≡ F	0.08	0.18					
	99.37	98.69					

Analysts: 50176, S. A. Malik and R. Macdonald; 50177, Sheila Rizzello and R. Macdonald.

Apatite is a ubiquitous minor accessory throughout the dyke. Analyses of apatite prisms occurring in sample GGU 101204 (Table II), an albite-aegirine-calcite-rich facies, show no unusual features while the apatite from GGU 101201, associated with late pectolite-rich veins and patches, has a significant content of Sr, Na, and rare-earth elements.

Whole rock composition. Analyses of two samples of the narsarsukite-bearing rock are presented in Table III. These, and the accompanying norm, show the rocks to be silica-oversaturated trachyte containing *c.* 1–2.5 % of normative Na_2SiO_3 (ns). The analyses do not differ greatly from those of fourteen trachytic (or microsyenitic) dyke-rocks occurring within the Tugtutôq swarm, (Macdonald, 1969). These contain 59 to 66 % SiO₂ and 6.5–9.3 % FeO+Fe₂O₃ while the dyke under consideration has some 62 % SiO₂ and 5.5–8 % total iron oxides. An excess of wt. % Na₂O over K₂O is a feature the dyke has in common with all but three of the other fourteen trachytic analyses but the narsarsukite-bearing dyke is exceptionally sodic, containing *c.* 9 % Na₂O as compared to a range of 5.1–7.4 % in the other analysed (narsarsukite-free) dykes. Furthermore, with >1 % TiO₂, the narsarsukite-bearing dyke is among the most titaniferous of the analysed dykes. The iron is predominantly in the ferric state and is mainly contained within the aegirine component.

While eleven of the fourteen trachytes possess normative acmite, none has a molecular excess of alkalis over alumina leading to normative 'ns'. Upton *et al.* (1971) proposed that many of the salic dykes in the Tugtutôq swarm may initially have been strongly persodic but lost alkalis during magmatic crystallization or subsequent devitrification. Despite the evidence for some metasomatic sodium loss to wall-rocks the Igdlutalik dyke retained a peralkaline character as a result of its modal content of such persodic minerals as narsarsukite and nordite.

In comparison with the other analysed dykes the narsarsukite-bearing dyke also shows anomalously high contents of Sr, Zn, Ce, La, and Nb. The Sr, Zn, and rare-earth elements are accommodated principally within the nordite. Nb and Ti are contained mainly within the narsarsukite; the associated analysed aegirines contain less than 4 % TiO₂.

Melting relations. Melting experiments were carried out on two samples of the dyke. One of these, sample GGU 101201, is from a narsarsukite-rich sample from the dyke interior, texturally similar to the analysed sample GGU 50176. The other, GGU 101202, is from chilled marginal-facies material.

This, though free of narsarsukite, contains small rectangular biotite aggregates, which are conceivably pseudomorphous after narsarsukite. The experiments were carried out at 1 kb P_{H_2O} in sealed Ag₇₀Pd₃₀ alloy tubes, with oxygen fugacity buffered by the Fe₂O₃+Fe₃O₄+H₂O assemblage. Approximately 10 wt. % of water was added to the samples.

Crystallization of GGU 101201 commences with appearance of aegirine somewhat above 950 °C. Magnetite crystallizes with aegirine between 950 and 900 °C. Between 850 and 800° albite begins to crystallize while magnetite is resorbed. From 750 to 700°, nepheline crystallizes together with aegirine and albite. At 700° there is only a trace of liquid (glass) remaining. Magnetite appears as the liquidus phase of GGU 101202 at over 950 °C, with albite and aegirine crystallizing between 900 and 850 °C. From 750 to 700° magnetite is replaced by ilmenite and nepheline commences crystallization.

Narsarsukite crystallized from neither composition; it is consequently thought unlikely that narsarsukite could have crystallized from any liquid with a composition similar to GGU 101201, above 700 °C. However, GGU 101201 could conceivably represent a residual composition after the loss of some considerable quantity of fugitive components (H₂O, Na₂O, SiO₂ ?).

The occurrence of nepheline (identified optically and by X-ray diffraction), is difficult to reconcile with the quartz-normative character of the trachyte and known phase relations in the system NaAlSiO₄-SiO₂-H₂O. It may suggest either that the primary phase volume of nepheline extends into quartz-normative regions under conditions of excessive peralkalinity, or that in these experiments the water-vapour phase dissolved sufficient silica to shift the remaining bulk composition into the nepheline-normative region.

Paragenesis of narsarsukite. Growth of narsarsukite, according to Stewart (1959), requires an excess of silica, high partial pressure of oxygen, and an abundance of Ti and Na. Stewart considered that at lower P_{O_2} neptunite, Na₂FeTiSi₄O₁₂, would be

generated. However, Rajasekaran (1966) demonstrated the apparently stable co-existence of narsarsukite and neptunite at St. Hilaire, Quebec. All known occurrences of narsarsukite are in silica-oversaturated environments in close association with alkaline intrusive rocks that have crystallized at relative low pressures (<2 kb).

Flink (1901) gave the first precise description of the mineral, which occurs abundantly as one of the earliest phases in an assemblage including quartz, microcline, albite, aegirine, and taeniolite at the type locality of Narssarsuk, in a marginal facies of the Igdlertfigssalik alkaline complex (Emeleus and Harry, 1970). An extensive list of minerals from this locality was presented by Gordon (1924). At Ilímaussaq (Semenov, 1969), narsarsukite occurs in a quartz-bearing contact zone between naujaite and alkaline granite. Narsarsukite is also known from quartz-bearing pegmatites in the Werner Bjerge alkaline complex, East Greenland (Bearth, 1959) and, according to Gerasimovskii (in Vlasov *et al.*, 1966), narsarsukite occurs along metasomatized (albitized) zones between alkali syenite and plagioclase gneiss, at the margin of the Lovozero complex (Kola, U.S.S.R.). The mineral is also well known from quartz veins cutting a syenitic stock in the Sweetgrass Hills, Montana (Graham, 1935). In a fuller description of a second occurrence (Sage Creek) in the Sweetgrass area, Stewart (1959) wrote of narsarsukite occurring in close-spaced veinlets within highly brecciated metamorphosed rocks, intimately intruded by syenite. This hybrid host rock is composed of orthoclase, albite, aegirine, quartz, biotite, apatite, calcite, and pectolite and is, like the Igdlutalik host rock, a greenish-grey flinty material. The veinlets comprise both manganpectolite and narsarsukite, with later galena, calcite, and quartz. Pectolite is also associated with narsarsukite in the Lovozero occurrence (Vlasov *et al.*, 1966).

The Mont St. Hilaire (Quebec) occurrence appears closely comparable to that of Sage Creek. Rajasekaran (1966) described narsarsukite forming euhedral prisms within a greenish-grey metasomatized hornfels in the aureole of the Mont St. Hilaire alkaline stock, and concluded that the narsarsukite had grown as porphyroblasts in a matrix of albite, aegirine, apatite, and opaque oxides. The Mont St. Hilaire narsarsukites, like those from Igdlutalik, have cores crowded with inclusions (albite and an unidentified green mineral) and clear rims devoid of inclusions.

Brief descriptions have been furnished by Saebø (1966) and Jérémie and Christophe-Michel-Lévy (1961) of accessory narsarsukite in peralkaline granites at Gjerdingen (Oslo District) and Gouré (Sudan) respectively. The Gjerdingen occurrence is of particular interest in that the narsarsukite is accompanied by ramsayite ($\text{Na}_2\text{Ti}_2\text{Si}_2\text{O}_9$). An illustration of the Gouré material shows that, like the Igdlutalik crystals, inclusion-rich cores are surrounded by clear narsarsukite margins.

At Igdlutalik the flow-banding and spherulitic structure, together with the sharp and apparently chilled margin, seemingly provide clear evidence that the body is a magmatic dyke that congealed as a glass of extreme and unusual composition which later devitrified. The high values for Zn, Zr, Rb, Nb, and rare earths, together with high $(\text{Na} + \text{K})/\text{Al}$ and strikingly low K/Rb could have arisen from extreme fractionation of feldspar from more basic magmas. One sample of the dyke was analysed for strontium isotopes by Mr. A. B. Blaxland. On the assumption that the dyke is older than 1144 Myr (which would be the case if the dyke is coeval with the main ENE.-WSW.

alkaline dyke swarm) the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio was less than 0.7040. This too is compatible with an origin by crystal fractionation of (mantle-derived) basaltic parental magma.

The relatively low Si and high Ca and Sr values are, however, less readily explicable on a crystal fractionation basis. Furthermore if the narsarsukite euhedra in an (originally) glassy matrix are interpreted as phenocrysts, the absence of any feldspar (or other) phenocryst minerals is a further feature difficult to explain by a fractionation hypothesis. Thus, from both petrochemical and mineralogical viewpoints it appears improbable that such a magma could have arisen by crystal fractionation from any of the trachytic, comenditic, or other magma types represented in the Tugtutôq-Ilímaussaq dyke swarm.

Stewart (1959) pointed out that the requisite conditions for narsarsukite growth may be obtained where emanations from alkaline magmas react with siliceous wall-rocks. The origin of the Igdlutalik dyke-rock may well be bound up with reaction between emanations from the comendite dyke seen outcropping to the ENE. and the country-rock quartz-diorites. We suggest that a peralkaline acid magma was injected into a dyke fissure during the development of the regional dyke swarm. As it ascended, a fugitive volatile phase preceded it, rich in Na, Fe, Ti and in Sr, Zn, and rare-earth elements, reacting with the quartz diorite to create a zone of fenite above the acid magma. With rising temperature and lowering of melting-point as metasomatism proceeded, a rheomorphic fenite was generated and driven ahead of the (comenditic) magma. This, in turn, was responsible for some metasomatism of wall-rocks with which it came into contact. The bulk composition of the rheomorphic fenite magma was similar to that of the metasomatized hornfels described by Rajasekaran (1966) from the Mont St. Hilaire aureole.

While the Mont St. Hilaire narsarsukites are clearly porphyroblasts, this is less obviously so on Igdlutalik. The spherulitic flow-banded matrix must have been largely or wholly molten and it is improbable that porphyroblasts grown at sub-solidus temperatures during a temperature rise would have survived extensive melting.

Whereas aenigmatite ($\text{Na}_4(\text{Fe}_{10}\text{Ti}_2)\text{Si}_{12}\text{O}_{40}$) is well known as a phenocryst phase in peralkaline magmas (pantellerites), other NaFeTi silicates such as titanian acmite, ramsayite, neptunite, and narsarsukite have not been recorded as phenocrysts in fast-chilled eruptives or intrusives and it seems improbable that the Igdlutalik narsarsukites are true phenocrysts grown from an unusual Fe-Ti-rich peraluminous magma. However, on textural evidence it is not possible to decide whether the narsarsukite euhedra crystallized from the magma or from a glass at sub-solidus temperatures, although it appears certain that the crystals grew before the devitrification leading to spherulite formation. Failure to grow narsarsukite in the experimental runs may be due to lack of correspondence between the starting materials used and the original magma (or glass) composition, arising from loss of fugitive components during cooling and devitrification.

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