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SERENDIBITE FROM PENRHYN GROUP MARBLE, MELVILLE PENINSULA DISTRICT OF FRANKLIN

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Abstract

Serendibite occurs in skarn which formed between Aphebian Penrhyn Group marble and granite on the Melville Peninsula, District of Franklin. The mineral is triclinic and the parameters of the reduced cell are *a* 9.513, *b* 10.001, *c* 8.622Å, α 95.85°, β 114.70°, γ 64.28°, V=668.27Å^3. Microprobe analysis gave (wt. %) SiO_2 20.85, Al_2O_3 40.20, FeO (total iron) 3.48, MgO 12.71, CaO 17.11 (B_2O_3 not determined). The optical properties of the mineral for Na_D are: $2V_Y$=81°, α 1.700 (pale blue-green), β 1.703 (pale yellow), γ 1.706 (moderate blue); axial $r>v$, inclined and horizontal dispersion. Serendibite is associated with fassaite, uvite-rich tourmaline, clinozoisite, spinel, and calcite. Comparison with other occurrences suggests that the stability field of serendibite may be restricted to silica-undersaturated bulk compositions.

Sommaire

La sérendibite se trouve dans le skarn qui s'est formé, entre le marbre du groupe Aphebian Penrhyn et le granite, sur la péninsule de Melville, dans le district de Franklin. Le minéral est triclinique, et les paramètres de la maille réduite sont: *a* 9.513, *b* 10.001, *c* 8.622Å, α 95.85°, β 114.70°, γ 64.28°, V 668.27Å^3. L'analyse à la microsonde donne en poids: SiO_2 20.85%, Al_2O_3 40.20%, FeO (fer total) 3.48%, MgO 12.71%, CaO 17.11% (B_2O_3 non déterminé). Les propriétés optiques de ce minéral pour Na_D sont: $2V_Y$=81°, α 1.700 (bleu-vert pâle), β 1.703 (jaune pâle), γ 1.706 (bleu moyen); dispersion des axes $r>v$; dispersion horizontale et inclinée. La sérendibite est associée à la fassaïte, la tourmaline riche en uvite, la clinozoïsite, le spinelle et la calcite. Par comparaison avec d'autres gîtes, on est amené à penser que le champ de stabilité de la sérendibite peut être limité aux compositions sous-saturées en silice.

(Traduit par la Rédaction)

Introduction

Serendibite was first described by Prior & Coomaraswamy (1903) from a contact zone between limestone and granulite near Kandy, Ceylon. Serendibite has subsequently been reported from remarkably similar occurrences near Johnsburg, New York (Larsen & Schaller 1932); Riverside, California (Richmond 1939); South Yakutia, Siberia (Shabynin & Pertsev 1956; Pertsev & Nikitina 1959); and northeast Tanzania (Bowden *et al.* 1969). This paper describes the first Canadian occurrence of serendibite.

Occurrence

A dark blue skarn mineral was identified as serendibite after the completion of a regional mapping project on the Melville Peninsula (Reesor *et al.* 1975). Detailed mapping and sampling of the occurrence will not be practical until new programs are undertaken in the region.

Serendibite was formed in a contact zone between coarse-grained calcite marble of the Aphebian Penrhyn Group and intrusive pink leucocratic granite (NTS 46 K 14; UTM Zone 16, 568840, 7427420). The marble is part of a narrow northeast-trending belt of Penrhyn Group metasediments infolded with granodiorite-granite gneiss. Numerous small bodies of granite and pegmatite intrude both metasediments and gneisses. Pelitic and calcium silicate assemblages throughout the area indicate regional upper amphibolite facies metamorphism.

Specimens containing serendibite are macroscopically zoned. A narrow 2-4 cm band made up of dark blue serendibite and green diopside separates coarse-grained white diopside-calcite marble from a black tourmaline-rich band.

Figure 1A is a sketch of mineral zones displayed in a thin section cut perpendicular to the zones. In the section, zone 1 is an equigranular mosaic of 2-5 mm pale blue-green tourmaline crystals with 5-10% interstitial colorless diopside. Tourmaline grains adjacent to zone 2 or zone 3 are embayed and surrounded by colorless clinozoisite (Fig. 1B) or pleochroic blue serendibite (Fig. 1C). Zone 2 is a discontinuous 3-6 mm wide clinozoisite-rich band. Clinozoisite grains poikiloblastically enclose tourmaline, serendibite, and diopside. Intricately zoned, twinned clinozoisite crystals display anomalous deep blue to maroon interference colors and a wide range of optical properties. Zone 3 is characterized by 0.5-10 mm serendibite grains which poikiloblastically enclose diopside (Fig. 1D). Accessory minerals are colorless spinel and calcite. Diopside is concentrated along the boun-

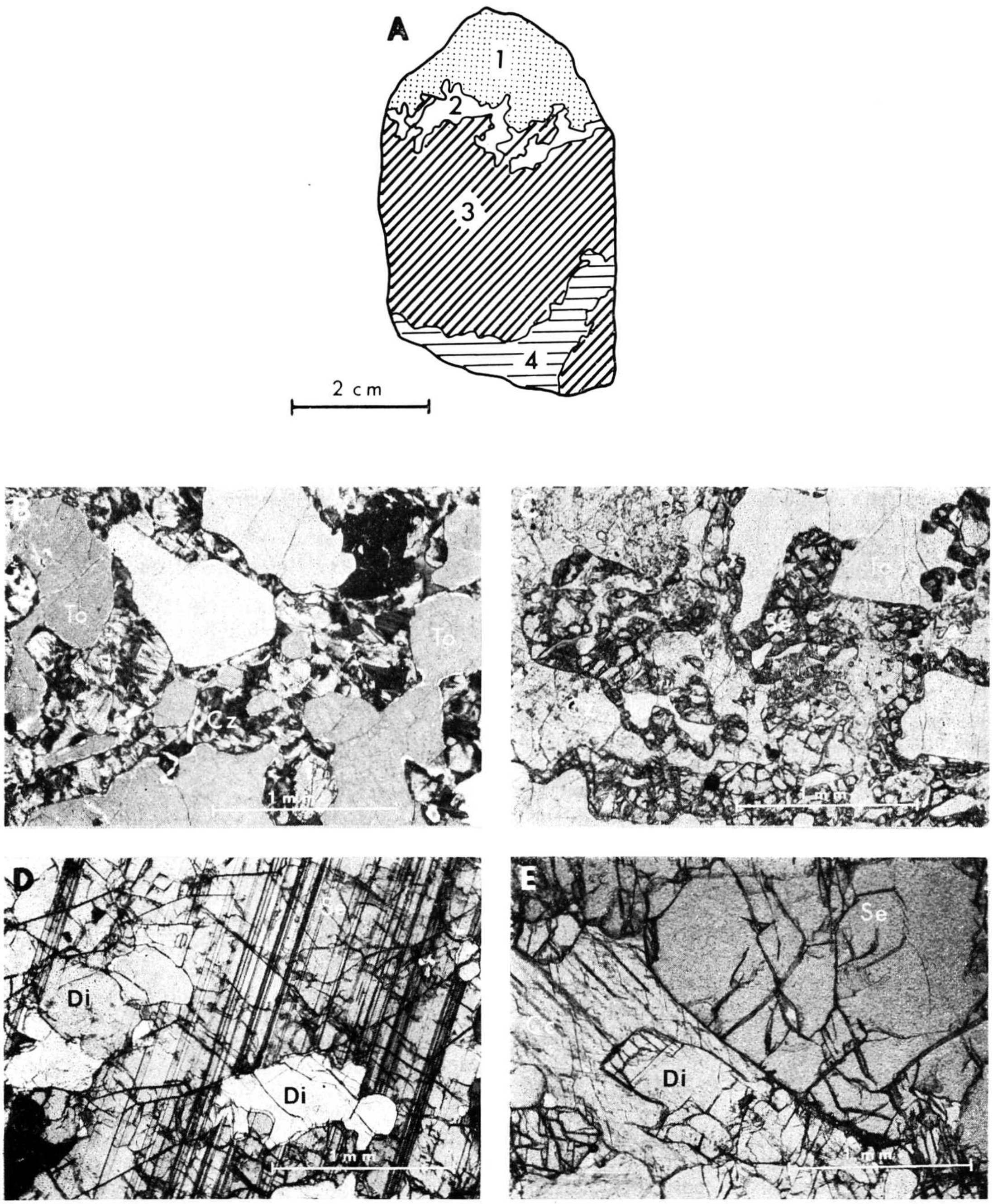

FIG. 1. (A) Sketch of mineral zones (lantern slide J272-2 RA 74): (1) tourmaline+diopside; (2) clinozoisite; (3) serendibite+diopside; (4) diopside+calcite. (B) Zones 1 and 2, crossed nicols: tourmaline (To) embayed and surrounded by zoned, twinned clinozoisite (Cz). (C) Zones 1, 2, and 3: serendibite (Se) enclosing tourmaline. (D) Zone 3, crossed nicols: polysynthetically twinned serendibite enclosing diopside (Di). (E) Boundary between zone 3 and 4: serendibite, diopside, calcite (Cc).

TABLE 1. X-RAY POWDER DIFFRACTION PATTERN OF SERENDIBITE FROM MELVILLE PENINSULA, N.W.T.*

hkl	d_{calc}Å	d_{obs}Å	I	hkl	d_{calc}Å	d_{obs}Å	I
100	7.7901	7.80	15	013	2.5635	2.565	1
$10\bar{1}$	7.2166	7.22	15	$32\bar{3}$	2.4633		
011	6.1884	6.19	5	$12\bar{3}$	2.4622	2.461	80
$01\bar{1}$	5.6200	5.61	5	$2\bar{2}\bar{2}$	2.4615		
101	4.6295	4.63	5	$2\bar{2}0$	2.4600		
021	4.0608	4.06	5	$01\bar{3}$	2.4338	2.439	1
$20\bar{2}$	3.6083	3.606	10	$30\bar{3}$	2.4055	2.408	5
$22\bar{2}$	3.3701	3.373	1	222	2.3858	2.385	10
$12\bar{2}$	3.3174	3.320	40	321	2.3854		
112	3.0975	3.095	1	023	2.3495		
102	3.0187	3.020	30	$1\bar{2}\bar{3}$	2.3489	2.347	25
$\bar{2}01$	3.0175			$42\bar{2}$	2.3487		
131	2.9741	2.974	5	340	2.2446		
031	2.8862	2.880	5	241	2.2445	2.243	10
$10\bar{3}$	2.8472			$24\bar{2}$	2.2430		
310	2.8451			$3\bar{1}\bar{3}$	2.1611		
301	2.8447	2.846	100	$42\bar{3}$	2.1608	2.162	15
122	2.8446			$02\bar{3}$	2.1594		
320	2.8438			$13\bar{3}$	2.1174		
$02\bar{2}$	2.8100	2.813	25	$10\bar{4}$	2.1092	2.108	20
$1\bar{2}1$	2.8089			$40\bar{1}$	2.1073		
$20\bar{3}$	2.7565	2.757	1	$22\bar{4}$	2.0342	2.038	70
$30\bar{2}$	2.7551			$3\bar{2}\bar{1}$	2.0321	2.032	70
$03\bar{1}$	2.7048	2.708	1	$44\bar{2}$	2.0311		
$1\bar{1}3$	2.6739	2.677	30	341	2.0202	2.018	50
$1\bar{1}2$	2.6714			133	1.9785	1.978	1
$13\bar{2}$	2.6154	2.623	5				
003	2.5988			+ 21 additional lines with d_{obs} less than 1.978			
300	2.5967						
223	2.5959	2.596	80				
330	2.5939						
$22\bar{1}$	2.5933						

*114.6mm camera, Cr$K\alpha$ radiation, Si internal standard, visual intensities.

dary separating zone 3 from zone 4 (Fig. 1E). Zone 4 is a coarse-grained diopside-calcite marble. Thin veinlets of clinozoisite, scapolite, calcite and rare prehnite cut all zones.

Two other specimens which do not contain serendibite are available from the skarn. A black, oxide-encrusted specimen is composed of 1-2 mm diopside crystals set in a very fine-grained intergrowth of prehnite and white mica. Several radiating or sheaf-like aggregates of prehnite up to 1 mm across are associated with zoned clinozoisite crystals. Dark red-brown sphene is a common accessory mineral. Pyrite and hematite occur in veins. The second specimen is a coarse-grained light grey scapolite-rich rock. The rock is made up of 80% scapolite, 15% diopside and accessory sphene, calcite, quartz, white mica, tremolite, and clinozoisite. X-ray measurement of $2\theta_{400}-2\theta_{112}$ (Cu$K\alpha$)=3.68° indicates that the scapolite is a calcium-rich mizzonite containing approximately 70% meionite (Burley *et al.* 1961).

Physical and Optical Properties

Serendibite occurs as irregular dark-blue grains up to 10 mm in length with no crystal terminations and an imperfect cleavage or fracture. On a microscopic scale, polysynthetic twinning is prominent with lamellae ranging in width from 0.003 mm to 0.5 mm (Fig. 1D). The optical orientation of individual twins is symmetric about the composition plane. The indices of refraction (Na light) and pleochroism are: α 1.700 (pale blue-green), β 1.703 (pale yellow), γ 1.706 (moderate to bright blue).

TABLE 2. CRYSTALLOGRAPHIC DATA FOR SERENDIBITE (esd in parentheses)

	Direct Cell	Reciprocal Cell	Buerger & Venkatakrishnan (1974)	Susse (1968)	Pertsev & Nikitina (1969)
a	9.513(2)Å	0.1284Å^{-1}	8.630Å	8.630Å	10.35Å
b	10.001(3)Å	0.1115Å^{-1}	9.532Å	9.826Å	9.2Å
c	8.622(2)Å	0.1283Å^{-1}	10.019Å	10.393Å	8.5Å
α	95.85(2)°	95.566°	64.17°	103.58°	65.5°
β	114.70(2)°	65.360°	83.94°	106.36°	86.°
γ	64.28(2)°	115.663°	65.29°	118.21°	65.°
V	668.27Å^3		670.9Å^3	670.9Å^3	

The cell of Buerger & Venkatakrishnan (1974) and Susse (1968) are related to the cell adopted in this study by the transformation matrices 001/100/010 and 001/101/$\bar{1}\bar{1}$0 respectively. The relationship between the present cell and the cell of Pertsev & Nikitina (1959) is uncertain.

$2V$ was determined on the universal stage using a Leitz high-power monochromator to set λ. For λ of 460, 546, and 660 nm, $2V_z$ is 78.5, 80, and 82°, respectively.

Serendibite has axial dispersion $r>v$, superimposed on a very strong inclined dispersion and weaker horizontal dispersion.

X-Ray Crystallography

Prior & Coomaraswamy (1903) and Larsen & Schaller (1932) suggested that serendibite was triclinic on the basis of its optical properties. Susse (1968) confirmed the triclinic symmetry and determined parameters of a non-reduced cell (Table 2). Machin & Susse (1974) assigned serendibite to the aenigmatite group. Buerger & Venkatakrishnan (1974) established the space group as $P1$, described the structure as similar to that of sapphirine-$1Tc$ and aenigmatite, and reported parameters of a tri-acute reduced cell (Table 2) calculated from the cell reported by Susse (1968).

Precession photographs of serendibite from Melville Peninsula were prepared from two twinned crystals using Mo$K\alpha$ radiation. The powder diffraction pattern given in Table 1 was indexed by comparison of observed and calculated d-values using the single-crystal photographs as a guide. The parameters of the reduced triclinic cell were obtained from the precession photographs and refined by a least-squares method using the powder diffraction data (Table 1). Cell parameters are compared in Table 2 with those given for serendibite from other localities.

The serendibite twin plane (101) is a pseudo mirror plane. The b-axis precession photographs show that reflections from individual II of the twin coincide with those of individual I when

TABLE 3. PARTIAL MICROPROBE ANALYSES OF SERENDIBITE, TOURMALINE, CLINOZOISITE, AND PYROXENE FROM THE MELVILLE PENINSULA. DATA OF OTHER AUTHORS INCLUDED FOR COMPARISON

wt.%	Tourmaline	Clinozoisite	Fassaite				Serendibite				
	1	1	1	2	3	4	1	5	6	7	8
SiO_2	32.93	38.70	48.49	49.55	48.09	49.81	20.85	25.33	26.30	22.08	24.98
Al_2O_3	30.62	33.37	8.19	7.05	7.61	6.42	40.20	34.96	34.05	30.68	32.46
B_2O_3	-	-	-	-	-	-	-	-	8.37	6.95	6.63
Fe_2O_3				0.79	3.09	1.25				5.05	2.39
FeO	1.99*	2.71*	2.40*	1.72	0.42	1.03	3.48*	4.17*	2.76*	6.06	4.02
MnO	-	-	-	-	0.03	0.06	-	-	-	0.16	0.16
MgO	11.97	0.37	14.15	15.57	15.11	15.22	12.71	14.91	15.44	12.92	12.56
CaO	4.58	22.94	26.89	24.08	25.34	25.92	17.11	14.56	13.30	14.93	15.08
Na_2O	0.30	0.00	0.08	0.12	0.00	-	0.02	0.51**	-	-	-
TiO_2	0.27	-	0.63	0.53	0.49	0.14	0.06	-	-	0.17	0.26
H_2O^+	-	-	-	0.92	0.41	0.13	-	-	-	0.75	1.11

* total iron as FeO
1. Melville Peninsula (J272 RA-2 74)
2. Tilley (1938): fassaite, Adhekanwela, Ceylon (fassaite-spinel rock)
3. Tilley (1938): fassaite, Monzoni, Tirol (fassaite-spinel rock)
4. Tilley (1951): green clinopyroxene, Kilbride, Scotland (zoned skarn)
5. Prior & Coomaraswamy (1903): serendibite, Gangapitiya, Ceylon (**$Na_2O+Li_2O=0.51$; $K_2O=0.22$)
6. Larsen & Schaller (1932): serendibite, Warren County, N.Y. (av. of 2 anal.)
7. Pertsev & Nikitina (1959): serendibite, Taezhny deposit, South Yakutia (3474)
8. Pertsev & Nikitina (1959): serendibite, Taezhny deposit, South Yakutia (5406 - av. of 2 anal.)

$k=2n$ and reflections from individual II fall halfway between those from individual I along the a^* direction when $k=2n+1$. Thus twinning has the effect of doubling the a axis.

Microprobe Analyses and Paragenesis

Tourmaline, clinozoisite, diopside, and serendibite from specimen J272 RA-2 74 were analyzed on the Cambridge Instruments Microscan 5 at Carleton University (accelerating voltage 15 kV, sample current 40 nanoamps). Standards were as close in composition to the analyzed minerals as possible. Standards for tourmaline, clinozoisite, and serendibite analyses were garnet (Si,Al), biotite (Fe, Ti, Na), and pyroxene (Ca, Mg). For the diopside analysis, standards were pyroxene (Ca, Mg, Si) and biotite (Fe, Al, Ti and Na). Corrections for absorption and fluorescence effects were computed using a revised version of EMPADR VII (Rucklidge & Gasparrini 1969). Li and B analyses of individual minerals by wet-chemical methods were precluded by sample limitations. Analyses are compared to published serendibite and diopside analyses in Table 3.

Aluminous diopside (fassaite, 8.19% Al_2O_3) coexists with alumina-rich serendibite (40.20% Al_2O_3) in the Melville assemblage. The fassaite is similar in composition to skarn pyroxenes from spinel-clinopyroxene associations (Table 3). No published analyses of clinopyroxenes from other serendibite occurrences are available, but the absence of quartz and the common association with spinel suggests that these clinopyroxenes are also fassaitic.

The high CaO content (4.58%) in the Melville tourmaline is typical of uvite-rich tourmalines from dolomite and limestone skarns (Shabynin 1974). Association of tourmaline with spinel-clinopyroxene rocks is uncommon except in rare parageneses which also contain serendibite. Textural evidence shows serendibite replaced tourmaline in the South Yakutia occurrence (Shabynin & Pertsev 1956) and in the Melville assemblage (Fig. 1C). The absence of quartz from all reported serendibite associations suggests that the stability field of serendibite may be restricted to silica-undersaturated bulk compositions.

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