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BYTOWNITE FROM CAPE PARRY, EAST GREENLAND

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The phenocrysts described originate from a porphyritic plagioclase-basalt dike in the syenitic intrusion of Cape Parry on Traill Island in East Greenland (72°25′ N, 22°05′ W). The intrusive center has suffered strong hydrothermal alteration; many of the dikes, however, are very fresh. The rocks belong to a volcanic association, to the well-known Brito Arctic province, and are of post-Campanian age (Donovan, 1954). The phenocrysts, which are up to an inch in size, and the dike-rock were sampled in 1957 on a short reconnaissance trip to Cape Parry by one of the authors (E. W.), who was a member of the Danish East Greenland Expeditions directed by Dr. Lauge Koch.

Clear, often idiomorphic crystals of plagioclase occur in a fine-grained doleritic matrix, composed of plagioclase An 60–90, augite $2V\gamma = 52°$, pseudomorphs after olivine, and ore. The rock is easily decomposed by the arctic weather and loose phenocrysts are scattered along the dike. All the following results were obtained from such crystals. They are twinned mainly according to the albite law, with a stepped, or curved composition "plane." In only a few cases do they consist of a single twin-group; large crystals containing smaller rounded grains are often intergrown, they both show a similar orientation. Typical for these rocks are imperfect twins. The positions of the indicatrices seldom fulfill the conditions of symmetry between the two parts of the twin, in spite of the uniform composition of the crystals, which latter condition facilitates the exact determination of the optical orientation. A wide variation of the optical-structural angle-relationships was ascertained and appears to be typical for this occurrence.

Chemical Composition

The spectrometric analysis of specimen Parry 1—adopting the methods described by Wenk *et al.*, (1963) gave the following results: SiO_2 47.2, Al_2O_3 33.5, Fe_2O_3 0.3, MgO <0.1, CaO 17.0, SrO 0.1, Na_2O 1.6, K_2O 0.1, TiO_2 <0.1, Total <100.0 weight percent; corresponding to Or 0.6, Ab 14.6, An 84.8, Mo 1%.

A second crystal (Parry 2), used for the optical study, was investigated by the electron microprobe and yielded values between 17.0 and 17.2% CaO. This crystal proved to be homogeneous in the area examined and served as a standard for other studies on plagioclase feldspars (Wenk *et al.*, 1965; Schwander and Wenk, 1967).

Optical Orientation

The most accurate determination was afforded by an albite-Carlsbad (Roc Tourné) twin in specimen Parry 2. The two individuals which form this twin, were measured three times, using different universal stages.

	ϕ	θ	ψ
Ind. 1	25°	37.5°	−4.25°
Ind. 2	25°	38°	−5.25°
Ind. 1	25°	38°	−4.5°
Ind. 2	24°	37.5°	−6.25°
Ind. 1	24.5°	36.5°	−4°
Ind. 2	24°	36.5°	−4.5°

If the third set of determinations, which was made in Na-light (strong dispersion) and which is the most accurate one, is regarded as twice as reliable as the other two, then the following averages for the three Euler-angles can be calculated:

$$\phi\ 24.5° \pm 0.5° \qquad \theta\ 37° \pm 1° \qquad \psi\ -4.5 \pm 1° \qquad 2V\gamma\ 97° \pm 2°$$

Dr. A. Glauser has investigated other specimens from Cape Parry with the universal stage in a more statistical way. His stereogram $\perp [n\ \beta]$ is composed of measurements of 27 crystals from 6 different slides. He graphically determined the center of the scattering projection points for the different planes and twin axes. From his composite stereogram the following Eulerian angles can be constructed:

$$\phi\ 25° \quad \theta\ 36.5° \quad \psi\ -4.5°; \quad 2V\gamma\ 98.5 \pm 4° \text{ (average of 14 readings of } 2V\text{)}.$$

These two series of data agree excellently with each other, although they were measured and calculated independently. They demonstrate the homogeneity of these bytownites, and prove that the average of the variations corresponds in this case to an exact, symmetrically-formed twin-group.

The strong individual scatter of, for example, the normals to (010) must be ascribed to the imperfect realization of the twin-law, and not to the joint occurrence of high- and low-temperature optics. It is internal scatter in the definition of Vogel (1964). Near the basic end of the plagioclase series, feldspars with different thermal histories do not differ much in optical orientation. This is well evidenced by the compilation of Burri, Parker, Wenk (1967), especially plates I to III. The optical-chemical data of the Parry bytownite—which refer partly to one single crysta- —should be more reliable than those of plagioclases of similar composil tion, listed in part 4 of the compilation cited.

From our Eulerian angles and from $2V\gamma=97°$ the following additional position angles were derived by computer:

Projection perpendicular to [001]

Eulerian angles II:

R 118.1° *I* 92.7° *Lα* 53.1° *LA* 11.6°

Eulerian angles III:

D 30.1° *N* 53.1° *Kα* 93.4°

Goldschmidt angles ϕ, ρ:

[α]	[β]	[γ]	*A*	*B*
204.5°/37.0°	298.1°/87.3°	30.1°/53.1°	207.5°/78.4°	58.6°/5.3°

Becke angles λ, ϕ^*:

[α]	[β]	[γ]	*A*	*B*
17.4°/-33.1°	86.9°/28.1°	−33.8°/43.8°	66.1°/−60.2°	−4.5°/2.8°

Projection perpendicular to [nβ], σ, τ

[001]	⊥[001] / (010)	[010]	[100]	[100] / (010)
126.9°/87.3°	31.9°/28.2°	222.3°/59.1°	80.2°/35.6°	319.6°/70.0°
(001)	(010)	(100)	(110)	(1$\bar{1}$0)
323.4°/72.1°	218.4°/61.9°	32.5°/31.3°	35.4°/60.2°	321.5°/2.8°
(021)	(0$\bar{2}$1)	($\bar{2}$01)		
179.0°/83.8°	274.1°/55.2°	90.4°/41.9°		

Köhler angles

		[αα]	[ββ]	[γγ]	*AA*	*BB*
Albite-Carlsbad law	*X*	151.1°	56.4°	132.6°	126.1°	170.9°
Albite law	*Y*	113.7°	123.8°	92.3°	59.5°	174.4°
Carlsbad law	*Z*	74.0°	174.6°	106.3°	156.9°	10.6°

Cleavage flakes of specimens Parry 2 gave $\alpha'=1.575$ and $\gamma'=1.580 \pm 0.001$. The index of refraction of the glass made from another crystal was 1.567. These data indicate the compositions An 87 (high)—89 (low), An 88 (high)—90 (low), and An 91 respectively, all values being higher than those determined by the microprobe and spectrochemical analysis. These conflicting results made us check the glass-curve of Schairer *et al.* (1955) with the aid of our chemical standards, and in all cases the glass method produced the correct result. We have no explanation for these deviations.

X-RAY DATA

From X-ray powder patterns (taken with Cu K_α radiation $\lambda=1.5418$ Å, calibrated with Si $a=5.4305$ Å as internal standard on a Norelco goniometer equipped with monochromator) the lattice constants were refined by least squares using a program written by C. W. Burnham (1962). The diagram was first indexed from theoretical reference values (Borg and Smith, 1967).

Bytownite Cap Parry ("transitional Anorthite") $Ab_{15}\ An_{85}$	Primitive Anorthite (low) (Kempster *et al.*, 1962) for comparison An_{100}
$a=9.191\pm0.005$ Å	8.177 ± 0.005 Å
$b=12.889$	12.877
$c=14.206$	14.169
$\alpha=93.38°\pm0.05$	$93.17°\pm0.03$
$\beta=115.96°$	115.85°
$\gamma=90.97$	91.22°
$V=1345\pm2$ Å^3	
$a^*=0.13594\pm0.00004$ Å^{-1}	
$b^*=0.07781$	
$c^*=0.07850$	
$\alpha^*=85.77°\pm0.04$	
$\beta^*=63.92°$	
$\gamma^*=87.27°$	

In the 2θ-difference functions, the bytownite is close to the value for plutonic plagioclase, although the differences between low- and high-plagioclase in that region are small, as is also true of the optical migration curves: Smith, J. R. and Yoder, H. S. (1956).

$$2\theta(132) - 2\theta(1\bar{3}2) = 2.265° \text{ obs.}$$
$$2.269° \text{ calc.}$$

Smith, J. V. and Gay, P. (1958)

$$2\theta(1\bar{1}2) - 2\theta(20\bar{2}) = 0.77° \text{ obs.}$$

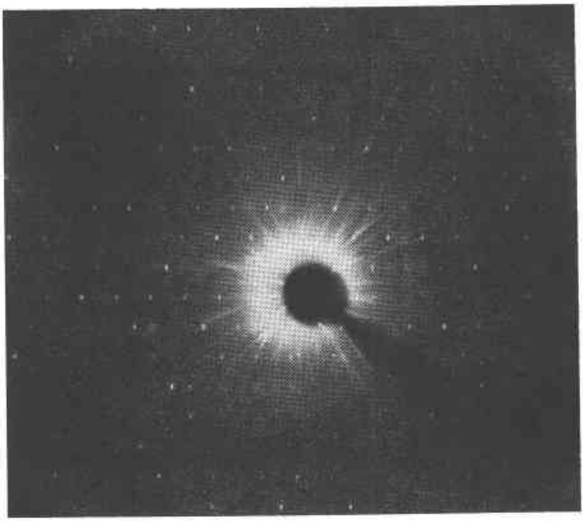

FIG. 1. *l*-layer precession *c* photograph of Cape Parry bytownite, *hkl*. Mo radiation, Zr filter. 150 hours exposed. b^*-axis horizontal. Note the weak but sharp *b*-type and the highly diffuse *c*-type reflections.

Single crystal precession photographs show weak, but sharp *b*-reflections and weak, highly diffuse *c*-type reflections (Fig. 1). These indicate transitional anorthite structure (Ribbe and Megaw, 1962) despite the fairly low anorthite content (85%). The sharpness of *b*-type reflections indicates high Al/Si order (Laves and Goldsmith, 1951a, b) which may best be achieved in a moderate to high temperature regimen (compare this with the fairly high-ordered labradorite phenocrysts from the Surtsey eruption; Wenk, 1966). The ordering of Ca (Laves and Goldsmith, 1954) and/or the anti-phase relationship of primitive anorthite domains (Ribbe and Megaw, 1962), contributes to the diffuse *c*-type reflections. Therefore the bytownite of Cape Parry, despite its subvolcanic origin, does not belong to the high-plagioclase series (Megaw, 1962). Quenching of volcanic material does not preserve high-temperature structures in basic plagioclase (Ribbe and Megaw, 1962; Stewart, 1967). The differentiation into volcanic and plutonic plagioclase near the calcic end of the series is structurally unsatisfactory. In the bytownite and anorthite range, the optical migration curves of Burri-Parker-Wenk are possibly based on crystals of different structures and this may be the reason for the fairly high scattering of the data. Synthetic crystals should not be used to characterize the volcanic series from 80 percent An upwards, since it seems that most of the rock-forming processes—including volcanic activity—produce highly-ordered material. Better understanding of the correlation between chemical composition and optical properties of plagioclase feldspars can only be achieved if crystals of the same structural state are compared, rather than those which have a similar geological origin.

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