THE AMERICAN MINERALOGIST, VOL. 51, SEPTEMBER-OCTOBER, 1966

PHYSICAL PROPERTIES OF ANORTHOCLASE FROM ANTARCTICA[1]

EUGENE L. BOUDETTE AND ARTHUR B. FORD,
U.S. Geological Survey, Washington, D. C. and Menlo Park, California.

ABSTRACT

The lattice parameters of anorthoclase [$Or_{15.7}Ab_{74.2}An_{10.1}$ (mol per cent)] from the Crary Mountains, and anorthoclase [$Or_{16.8}Ab_{64.8}An_{18.4}$ (mol per cent)] from Cape Royds, Ross Island, Antarctica, have been determined from *x*-ray diffractometer patterns by a least-squares cell refinement program. Chemical and spectrographic analyses and optical data are also furnished from the feldspar and Quaternary alkaline trachytes in which they occur. The Cape Royds feldspar is markedly higher in An content than any anorthoclase in which lattice parameters have been determined. Both suites of new data compare favorably with data from other modern work, considering that different methods of measurement are involved.

The antarctic anorthoclase is believed to be highly disordered and it differs optically from average anorthoclase by higher indices of refraction and 2V. The Cape Royds rock which bears the anorthoclase contains 7.4 per cent normative nepheline which is manifested by sodalite(?) in the mode. The partitioning of sodium to the sodalite is believed to be responsible for the unusually high An content of the Cape Royds feldspar, although the latter is not predicted in the norm.

INTRODUCTION

The composition, optical properties, and lattice parameters of anorthoclase from the Crary Mountains, West Antarctica (lat. 76°05′S.; long. 118°15′W.) and from Cape Royds, Ross Island, East Antarctica lat. 77°30′S.; long. 166°15′E.) (Fig. 1) have been determined as part of a study of Quaternary rhomb porphyry trachytes associated in an antarctic alkaline basalt-trachyte province. The crystals occur as conspicuous phenocrysts in trachyte flows that were first described in detail on Ross Island by Prior (1907) and subsequently aroused considerable interest for their comparison to kenyte of the African Rift. These phenocrysts have been classified variously as anorthoclase or plagioclase in antarctic literature (see for example David and Priestly, 1914; Jensen, 1916; Woolnough, 1916; Smith, 1954; and Treves, 1962).

The present work was undertaken to clarify the nature of these feldspars and to compare them to the ternary feldspars recently described by Carmichael and MacKenzie (1964).

Trachyte from the Crary Mountains was collected in 1959 by Boudette as a member of the 1950–60 U.S. Byrdland Oversnow Traverse. The Cape Royds trachyte was collected in 1961 by Ford and J. M. Aaron in conjunction with special field studies of the occurrence of the trachyte.

[1] Publication authorized by the Director, U.S. Geological Survey.

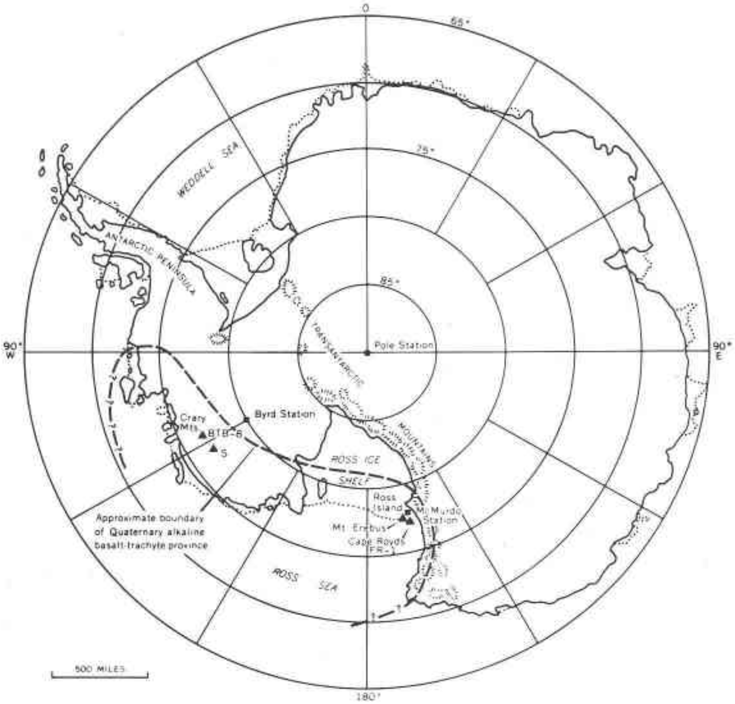

FIG. 1. Index map of Antarctica showing extent of Quaternary alkaline basalt-trachyte province and anorthoclase trachyte localities (▲). Anorthoclase from locality "S" (at Mt. Sidley, Executive Committee Range) is not specifically described.

METHODS AND SAMPLES

Neither of the samples has been previously analyzed chemically or studied structurally. However, Carmichael and MacKenzie (1964, p. 950–957, sample No. 8) describe anorthoclase from the summit of Mt. Erebus on Ross Island, Antarctica (Fig. 1, Table 1) that is comparable in occurrence. The occurrence, chemical analysis, texture and morphology of Mt. Erebus feldspar have been reported by Mountain (1925) and Jensen (1916); Carmichael and MacKenzie do not specify which sample was used in their work.

Calculations of the theoretical feldspar molecules from the analyses were made on the basis of 32 oxygens (Deer, *et al.* 1963, p. 106–107). We assumed that Ba substitutes for K, and Sr for Ca, but have not computed Cn and $Fs_{(Sr)}$ in the theoretical molecule (Table 1).

The chemical analyses, modes and norms of the rocks containing the feldspars described herein are given in Table 2. Crary Mountains sample

Table 1. Chemical Analyses in Weight Per Cent and Calculated Composition of Anorthoclase from Antarctica

	Crary Mts.[1] BTB-8	Cape Royds,[1] Ross Island FR-1	Summit Mt. Erebus, Ross Island			
			No. 8[2]	A[3]	B[4]	C[5]
SiO_2	65.4	62.8	65.23	62.79	62.49	60.83
Al_2O_3	21.3	22.2	20.68	22.12	21.86	23.92
Fe_2O_3	.10	.18	.20	.36	.30	.11
FeO	.10	.20	—	.41	1.31	2.14
MgO	.10	.05	—	.00	.16	.07
CaO	2.0	3.7	.87	3.76	3.74	3.39
BaO	.2*	.15*	.18	—	—	—
SrO	.07*	.15*	.22	—	—	—
Na_2O	8.2	7.2	8.45	7.35	7.20	6.11
K_2O	2.6	2.8	3.78	2.98	3.26	2.96
H_2O^+	.12	.28	.26	.19	.04	.07
H_2O^-	.00	.00	.06	.07	.00	.12
TiO_2	.05	.15	—	—	—	.36
P_2O_5	.07	.06	—	—	—	—
MnO	.00	.00	—	—	—	—
Total	100	99.6	99.93	100.03	100.36	100.08
		Number of ions on the basis of 32(0)[6]				
Si	11.5804	11.2771	11.6686	11.257	11.211	10.9289
Al	4.4409	4.6961	4.3583	4.675	4.623	5.0657
Fe^{+3}	.0213	.0215	.0215	0.048	0.041	0.0215
Ti	.0107	.0216	—	—	—	0.0539
Mg	.0319	.0107	—	—	0.043	0.0216
Fe^{+2}	.0106	.0323	—	0.061	0.196	0.3233
Na	2.8048	2.4988	2.9198	2.554	2.504	2.1340
Ca	.3825	.7109	.1718	.722	.719	.6575
Sr	—	—	.0215	—	—	—
K	.5950	.6462	.8588	.681	.746	.6682
Ba	—	—	.0107			
ΣZ	16.0533	16.0163	16.0484	15.98	16.07	16.07
ΣW	3.8248	3.8989	3.9826	4.02	4.01	3.80
Or (Mol%)	15.7	16.8	21.8	17.0	18.6	19.3
Ab (Mol%)	74.2	64.8	73.3	63.5	62.4	61.7
An (Mol%)	10.1	18.4	4.9	19.5	19.0	19.0
α	1.5308	1.5372	—	1.536	1.536	—
β	1.5364	1.5416	—	1.539	1.539	—
γ	1.5380	1.5430	—	1.541	1.541	—
$2V\alpha$[7]	55.9	59.3	—	61.6°	61.6°	—
$2V\alpha$[8]	53.2°	61.9	—	62°	62°	—
Ext. on {010}	6°–7°		—	4.7°	2.6°	—
Sp gr	2.54**	2.50**	—	2.620	2.620	

[1] Chemical analysis by Paul Elmore, Sam Botts, Gillison Chloe, Lowell Artis, and H. Smith by *x*-ray fluorescence methods supplemented by methods described by Shapiro and Brannock (1962).

[2] Specimen No. 8 of Carmichael and MacKenzie (1964, p. 950, Table 1).

[3] "Potash-oligoclase, Type 1" of Mountain (1925, p. 336); Analyst: E. D. Mountain. Theoretical molecule from Deer *et al.* (1963, p. 42).

[4] "Potash-oligoclase, Type 1" of Mountain (1925, p. 336); Analyst; E. D. Mountain. Theoretical molecule from Deer *et al.* (1963, p. 42).

[5] "Anorthoclase" of Jensen (1916, p. 122); Analysts: G. E. Burrows and A. B. Walkom.

[6] After the method of Deer, *et al.* (1963, p. 106–107).

[7] Calculated from refractive indices.

[8] Direct optical measurement methods. BTB-8 and FR-1 measured by universal stage techniques.

* Semiquantitative spectrographic analysis by J. L. Harris. Results are reported in percent to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, etc.; which represent approximate midpoints of group data on a geometric scale. The assigned group for semiquantitative results will include the quantitative value about 30% of the time. *Not included in analysis summation.*

** Determined with specific gravity bottle and toluene by Blanche Ingram. Precision ±0.05.

TABLE 2. CHEMICAL ANALYSES, NORMS, MODES, AND SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSES OF ANTARCTIC ANORTHOCLASE TRACHYTES

Field No.	BTB-8	FR-1
Lab. No.	159615	163086
Chemical analyses[1]		
SiO_2	57.6	55.9
Al_2O_3	18.3	19.8
Fe_2O_3	3.8	1.9
FeO	2.8	3.5
MgO	.77	1.2
CaO	1.9	3.0
Na_2O	7.3	7.4
K_2O	3.5	3.9
H_2O^-	.81	.13
H_2O^+	.96	.53
TiO_2	.74	1.2
P_2O_5	.30	1.3
MnO	.24	.14
CO_2	<.05	<.05
Sum	99	100
Powder density by air pycnometer	2.69	2.68
C.I.P.W. Norms		
Orthoclase	21.1	22.8
Albite	58.7	49.8
Anorthite	7.0	6.7
Nepheline	2.6	7.4
Corundum	—	1.0
Diopside Wo	0.4	
Diopside En	0.2 (0.7)	
Diopside Fs	0.1	
Olivine Fo	1.3 (2.1)	2.1 (4.3)
Olivine Fa	0.8	2.2
Magnetite	5.6	2.8
Ilmenite	1.5	2.3
Hematite	—	—
Apatite	0.7	3.0
Sum	100	100.1
Modes (volume per cent)[2]		
Anorthoclase*	31.0	33.3
Plagioclase*		0.7
Clinopyroxene*	<0.3	1.3
Olivine*	0.3	0.4
Ore minerals*	0.2	5.1
"K-feldspar"**	3.0	2.1
Plagioclase**	10.4	14.5
Orthopyroxene	Sp	—
Clinopyroxene**	—	Sp
Olivine**	Sp	Sp
Amphibole**	Sp	—
Apatite	Tr	Tr
Calcite	Tr	—
"Iddingsite"**	Tr	Tr
"Zeolites"	0.1	—
Glass**	A	Sp-A
Ore minerals**	Sp	Sp-A
(A+Sp+Tr)	54.7	42.6
Estimated % An in groundmass plagioclase	(25)	(25)
Sum	100	100

A = major component, Sp = sparse, Tr = trace amount.
* Reported as phenocryst, may also be in groundmass if indicated.
** Groundmass constituent.

Semiquantitative spectrographic analyses[3]	BTB-8	FR-1
B	.0007	.0007
Ba	.15	.1
Be	.0005	.0007
Ce	.07	.07
Co	—	.0007
Cu	.001	.0007
Ga	.003	.003
La	.02	.03
Mo	.0007	.001
Nb	.01	.015
Nd	.02	.03
Sc	.0005	.0005
Sr	.05	.15
V	—	.002
Y	.005	.005
Yb	.0005	.0005
Zr	.1	.15

Looked for, but not found: Ag, As, Au, Bi, Cd, Cr, Eu, Ge, Hf, Hg, In, Li, Ni, Pb, Pd, Pt, Pr, Re, Sb, Sm, Sn, Ta, Te, Th, Tl, U, W, Zn, Pr.

[1] BTB-8, Crary Mountains, West Antarctica; FR-1, Cape Royds, Ross Island, Ross Archipellago, Antarctica. Analysts: Paul Elmore, Samuel Botts, Gillison Chloe. Analyzed by methods similar to those described by Shapiro and Brannock (1962).

[2] The ratios of phenocrysts to groundmass in the trachyte were made by a macroscopic grid counting of sawed slabs; groundmass modes were point counted microscopically by the Chayes method and then combined with the macroscopic count and recalculated as the reported rock modes.

[3] Analyst: J. L. Harris. Results are reported, in per cent, to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, etc.; which represent approximate midpoints of group data on a geometric scale. The assigned group for semiquantitative results will include the quantitative value about 30% of the time.

(BTB-8) is from a moraine, but the location of the source can be inferred from the radial flow of ice from the mountain slopes and the abundance of the lithology in the moraine. The sample from Cape Royds, Ross Island, (Fr-1) is from the upper part of a flow about 50 feet thick. The similarity of the texture of the Crary Mountains specimen to that of the FR-1 trachyte (Fig. 2 a, b) leaves little doubt that the former is also from a similar flow.

The anorthoclase is optically homogenous but extremely poikilitic; the latter feature necessitates careful purification. The inclusions are olivine, pyroxene, apatite, ore minerals, and groundmass microlites and glass. BTB-8 is noticeably zoned in oscillatory habit; the zoning in FR-1 is not conspicuous (Fig. 2). The anorthoclase is partly glomeroporphyrytic and partly in mosaic aggregates which appear in hand specimen as single morphological euhedra (Fig. 2 a, b). Some individual crystals appear to be complexly twinned, in part on the Carlsbad law, but the most conspicuous twinning is close spaced (0.05 mm) lamellar albite twinning which is present in all individuals, and commonly a second, finer reticulated polysynthetic pericline(?) twinning is developed nearly at right angles which produces a fine cross-hatch (microcline-like) twinning pattern (Fig. 2 c, d). Textural evidence for "flow cataclasis" in the trachyte leaves the explanation of the second polysynthetic twinning open to reasonable doubt; it may be strain twinning and not truly pericline, although we favor the interpretation that it is pericline on the basis of its orientation.

Preliminary preparation of samples was done by gravity and magnetic purification of the 100–200 mesh fraction of crushed anorthoclase crystals handpicked from broken large sawed slabs of trachyte. We therefore consider the samples to be representive of the bulk specimens. Purified anorthoclase was first checked on the x-ray diffractometer for possible contamination and homogeneity by scanning between 7° and 60° 2θ; neither sample required further purification and both were reasonably homogeneous. Individual samples, after being ground in an agate mortar with fluorite ($a=5.4620$ Å) for 5–10 minutes, were made into a smear mount on a (0001) quartz plate and were traversed 3 times between 13° and 56° 2θ on a diffractometer using Ni filtered Cu radiation at 45KV and 20 ma. The diffractometer settings were: scale factor 2; multiplier 1; time constant 4, divergence and scatter slits 1°; receiving slit 0.006; scanning speed $\frac{1}{2}$° 2θ per minute; and chart speed $\frac{1}{2}$ inch per minute. All recognizable reflections were measured at the top of the peak, and the measurements were adjusted by the amount indicated by the internal standard. The average of the three measurements were used in the refinement, with Cu $K\alpha_1=1.5405$ Å. The feldspar patterns were refined using

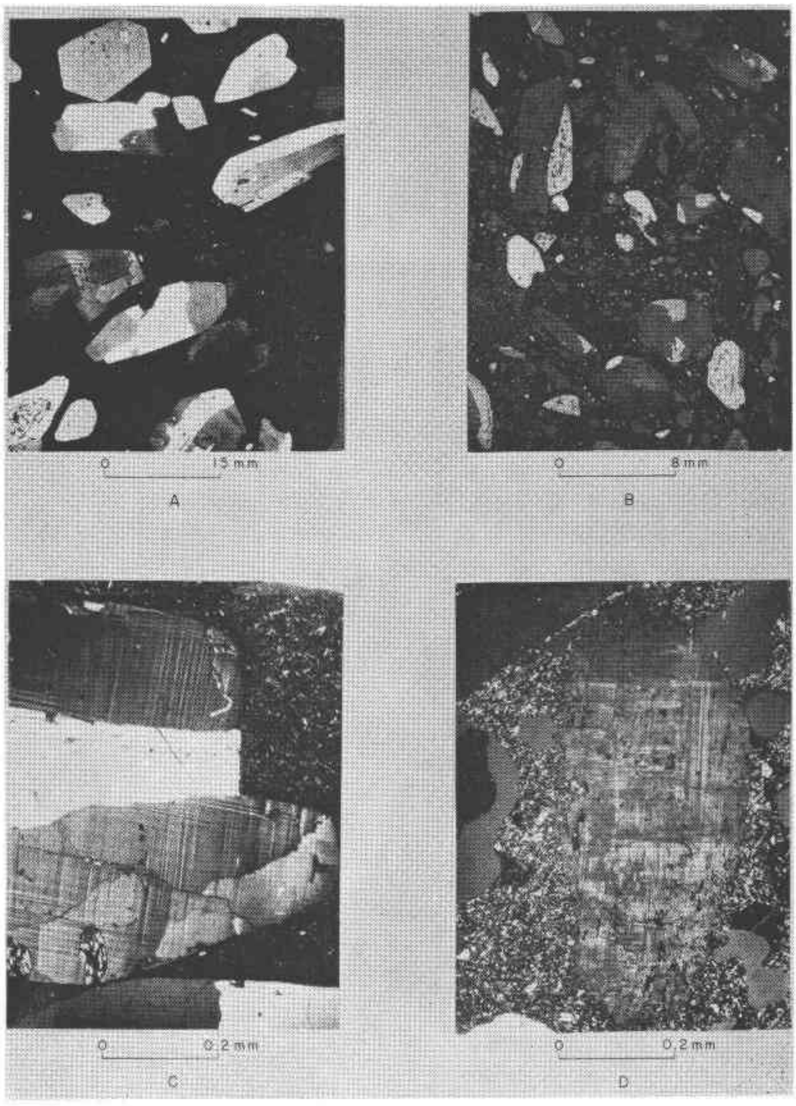

FIG. 2. Photomicrographs showing texture of anorthoclase trachyte BTB-8 (a) and FR-1 (b), and twinning in anorthoclase phenocrysts in BTB-8 (c), and FR-1 (d). crossed polars.

TABLE 3. LATTICE PARAMETERS OF HOMOGENEOUS ANORTHOCLASE FROM ANTARCTICA

	aÅ	bÅ	cÅ	α	β	γ	VÅ^3	a^*Å^{-1}	b^*Å^{-1}	c^*Å^{-1}	α^*	β^*	γ^*	Std. error unit Wt.	Number of observations
BTB-8	8.211	12.910	7.129	92°39.4′	116°21.9′	90°14.0′	676.1	.1360	0.0776	0.1569	86°55.2′	63°35.5′	88°25.3′		
±	.004	.002	.002	1.3′	1.9′	1.5′	~1.0	.0001	<.0001	<.0001	1.1′	1.9′	1.2′	0.0150	(22)
FR-1	8.228	12.915	7.127	92°35.6′	116°18.2′	90°16.9′	677.9	.1356	.0775	.1567	86°58.0′	63°39.1′	88°24.1′		
±	.003	.002	.001	1.4′	1.2′	1.5′	~1.0	.0001	<.0001	<.0001	1.1′	1.2′	1.3′	0.0099	(18
"8"[1]	8.263	12.935	7.138	92°15.6′	116°19.8′	90°10.8′	683.0	.1350	.0770	.1560	87.39°	63.64°	88.68°		

[1] From Carmichael and MacKenzie (1964, p. 956, Table 3).

TABLE 4. INDEXED POWDER PATTERNS OF ANORTHOCLASES FROM ANTARCTICA

hkl	BTB-8		FR-1	
	d_{calc}[1]	d_{obs}[2]	d_{calc}[1]	d_{obs}[2]
$\bar{1}10$	6.465		6.479	
020	6.446	6.449	6.448	6.453
001	6.378	6.388	6.380	
110	6.313		6.325	
$\bar{1}\bar{1}1$	5.832		5.832	
$\bar{1}11$	5.693		5.698	
$0\bar{2}1$	4.661		4.660	
021	4.417		4.420	
$\bar{2}01$	4.062	4.064	4.069	4.068
$1\bar{1}1$	3.888	3.889	3.893	3.894
111	3.781	3.781	3.787	3.787
$\bar{1}30$	3.775	3.757	3.760	3.760
200	3.677		3.686	
130	3.666	3.666	3.669	3.667
$\bar{1}\bar{3}1$	3.625	3.626	3.625	3.627
$\bar{1}31$	3.526		3.529	
$\bar{1}\bar{1}2$	3.474	3.473	3.472	3.471
$\bar{2}\bar{2}1$	3.442		3.446	
$\bar{2}21$	3.431		3.436	
$\bar{1}12$	3.392	3.391	3.392	3.391
$\bar{2}20$	3.232		3.240	
040	3.223	3.223	3.224	3.223
$\bar{2}02$	3.220		3.221	
002	3.189	3.190	3.190	3.191
220	3.157		3.163	
$1\bar{3}1$	3.008	3.008	3.011	3.010
$0\bar{4}1$	2.941	2.940	2.941	2.940
$0\bar{2}2$	2.922	2.921	2.922	2.921
$\bar{2}\bar{2}2$	2.916		2.916	
131	2.865	2.867	2.868	2.869
$\bar{2}22$	2.847		2.849	
041	2.816		2.818	
$\bar{1}\bar{3}2$	2.807	2.806	2.805	2.806
022	2.799		2.801	
201	2.707		2.713	
$\bar{1}32$	2.681	2.681	2.682	2.683
$\bar{3}11$	2.676		2.682	
$\bar{3}\bar{1}1$	2.667		2.673	
$2\bar{2}1$	2.535		2.540	
$\bar{3}\bar{1}2$	2.531		2.533	
$\bar{2}\bar{4}1$	2.529	2.525	2.531	2.527
$\bar{2}41$	2.520		2.523	
$1\bar{1}2$	2.519		2.522	
$\bar{3}12$	2.517		2.520	
112	2.470		2.473	
221	2.458		2.463	
$\bar{2}40$	2.457		2.461	
$\bar{1}50$	2.454		2.456	
$\bar{3}10$	2.421		2.427	
$\bar{1}\bar{5}1$	2.419		2.419	
150	2.412		2.414	
310	2.396		2.402	
240	2.391		2.394	
$\bar{1}51$	2.369		2.371	
$\bar{2}03$	2.348		2.348	
$0\bar{4}2$	2.330		2.330	
$\bar{1}\bar{1}3$	2.322		2.321	
$\bar{2}\bar{4}2$	2.313		2.317	
$\bar{3}31$	2.313		2.313	
$\bar{3}\bar{3}1$	2.297		2.300	
$\bar{1}13$	2.281		2.281	
$\bar{2}42$	2.2444		2.246	
$1\bar{3}2$	2.2399		2.242	
$\bar{2}\bar{2}3$	2.2363		2.2353	
$\bar{3}\bar{3}2$	2.2222		2.2234	
$1\bar{5}1$	2.2193		2.2207	
042	2.2083		2.2100	
$\bar{3}32$	2.1941		2.1971	
$\bar{2}23$	2.1770		2.1777	
$\bar{3}30$	2.1549		2.1597	
060	2.1485	2.1498	2.1494	2.1493
151	2.1228	2.1214	2.1247	
$2\bar{4}1$	2.1182		2.1212	2.1214
061	2.0038	2.0035	2.0051	
260	1.8332	1.8332	1.8347	
$0\bar{6}2$	1.8280	1.8280	1.8279	
$\bar{3}50$	1.8015	1.8010	1.8046	1.8027
$\bar{2}04$	1.7802	1.7804	1.7799	1.7800

[1] All calculated spacings are given for $d \geq 2.150$ Å; calculated spacings less than 2.150 Å are given only when they correspond to an indexed observed reflection.

[2] Average of three observations with annealed CaF_2 as internal standard, $a = 5.462$ Å at 25° C. Ni-filtered $CuK\alpha_1$ radiation ($\lambda = 1.5405$ Å). Lower limit of 2θ measured = 13° $CuK\alpha$ (6.809 Å). Pattern obtained at 26° C.

the variable index option of the least-squares refinement program devised by Evans, Appleman, and Handwerker (1963). Between 18 and 22 unambiguous reflections of the 25 or so present were used to calculate the lattice parameters in the 3rd or 4th cycle of the refinement. The standard deviation between observed and calculated 2θ for each sample was 0.0151 or less (Table 3). Observed and indexed lines are given in Table 4.

RESULTS

In the nomenclature of Smith and MacKenzie (1958) our samples are anorthoclase (Fig. 3). Comparison of the measured lattice parameters with those of the anorthoclase from Antarctica described by Carmichael and MacKenzie (1964) is given in Table 3. A graphical comparison of our

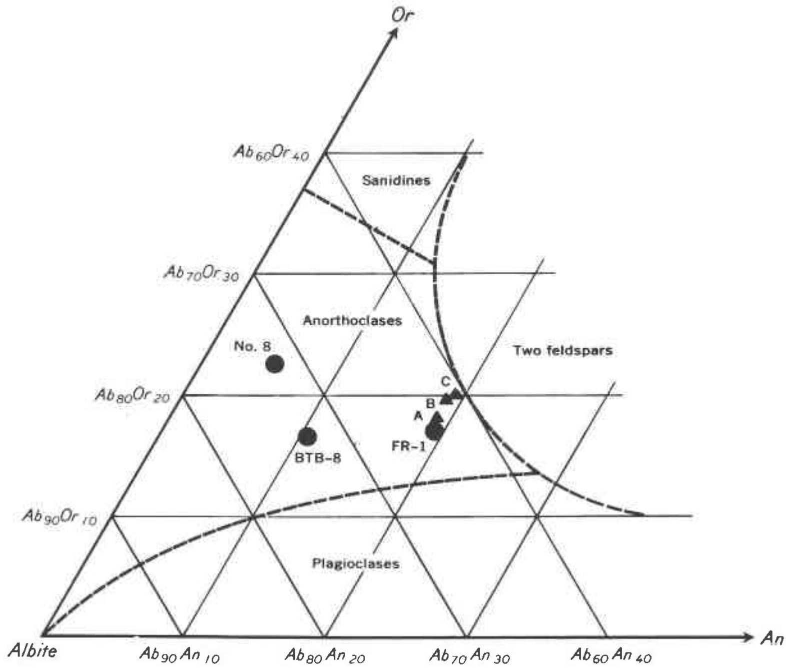

FIG. 3. Ternary diagram (after Smith and MacKenzie, 1958, p. 874) showing plots (weight percent) of analyzed anorthoclase from Antarctica. BTB-8 and FR-1, this report; No. 8, Carmichael and MacKenzie (1964); A and B, Mountain (1925, p. 336); and C., Jensen (1916, p. 122). Anorthoclase of this report and sample No. 8 of Carmichael and MacKenzie shown as circles; other Ross Island anorthoclases (Table 1) shown as triangles (lattice parameters *not* available).

anorthoclase with the anorthoclase described by Carmichael and MacKenzie (1964, figs. 1, 2, and 3) has been made on Figs. 4, 5, and 6 (Table 5). It is important to note that composite samples were used for the present study in contrast to the selected crystals used by Carmichael and MacKenzie, the Cn and $Fs_{(Sr)}$ components are not computed in the ternary composition calculations of BTB-8 and FR-1 (Tables 1 and 5), the samples were not heated, and a different method of measurement was used in the determination of the lattice parameters.

The chemical analysis of the Mt. Erebus summit sample given by Carmichael and MacKenzie (1964) differs markedly in CaO and K_2O content from the comparably occurring anorthoclase described herein, as well as from a previous analysis of anorthoclase from Mt. Erebus (Table 1, Fig. 3). The "Z" and "X" summations of both the old and the new

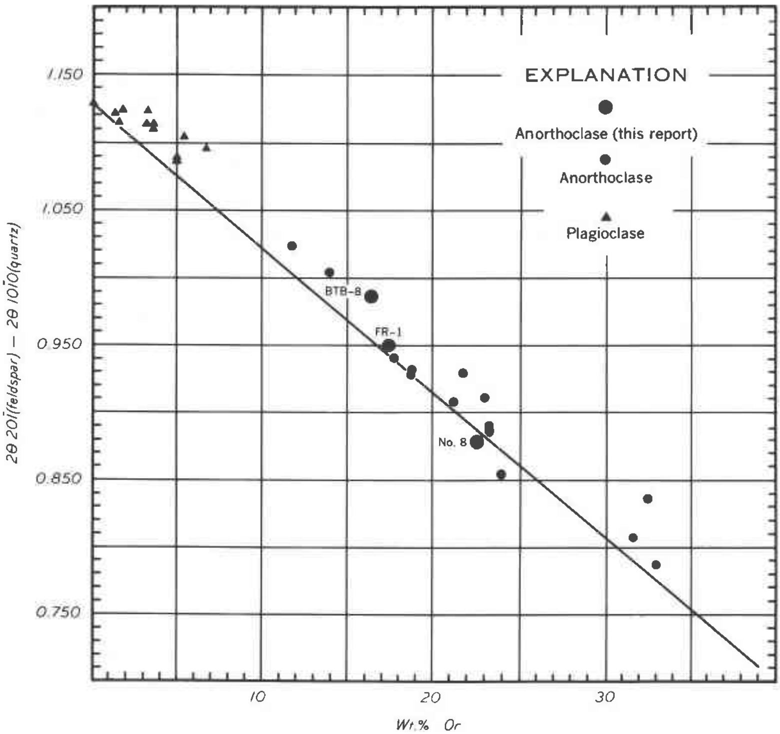

FIG. 4. $2\theta((\bar{2}01)-2\theta(10\bar{1}0)_{quartz}$ of anorthoclase and plagioclase plotted against Or content found by chemical analysis (after Carmichael and MacKenzie; 1964; p. 953, Fig. 1) showing comparison of anorthoclase of this report (Table 5).

analyses are good. Carmichael and MacKenzie (1964), however, worked on a selected crystal which when compared to the composite sample reported by Deer *et al.* (1963) may account for the difference in composition.

The $2\theta(\bar{2}01)_{Fs}-2\theta(10\bar{1}0)_{Qtz}$ separation plotted against weight per cent Or for BTB-8 shows the most divergence from the curve of Carmichael and McKenzie (1964, p. 953, Fig. 1), and its analysis is possibly suspect; however, it was made at the same time by the same analysts as FR-1

(Table 1) which is apparently a good analysis by the criteria of the 2θ separation used and ΣX and ΣZ (Table 1).

The determined lattice parameters α^* and cell volume are reasonably compatible with the findings of Carmichael and MacKenzie (Figs. 5 and 6). FR-1 plots outside the anorthoclase field erected by Carmichael and MacKenzie (1964, Figs. 2 and 3), but it may furnish valid data for ex-

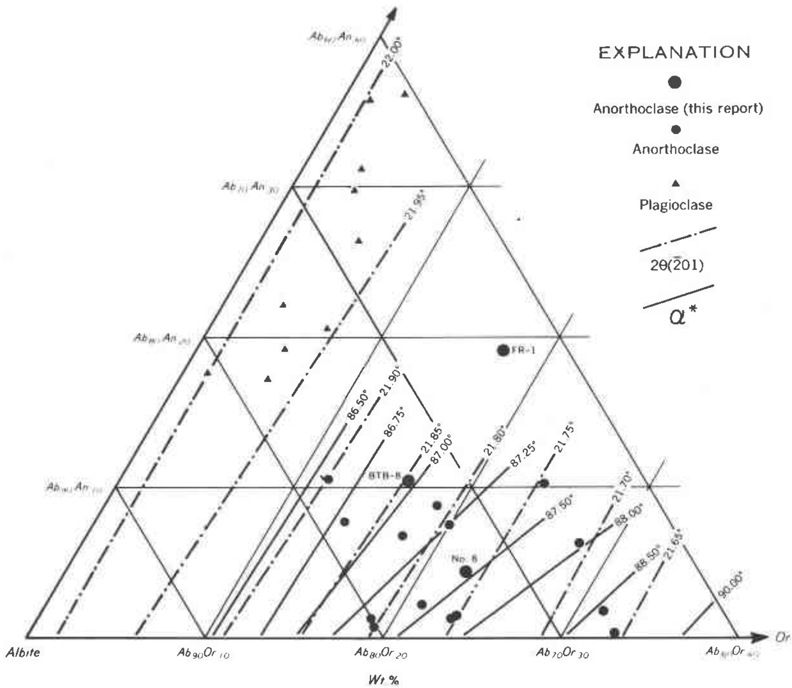

FIG. 5. Analyzed anorthoclase and plagioclase plotted in the Ab-rich portion of the ternary feldspar diagram (after Carmichael and MacKenzie; 1964, p. 954, Fig. 2) showing comparison of theoretical to measured $2\theta(\bar{2}01)$ and α* of anorthoclase from this report (Table 5).

tending the $2\theta(\bar{2}01)$, α^*, and cell volume curves in the direction of the tie line between $Or_{40}Ab_{60}$ and $An_{40}Ab_{60}$ because of the good agreement with the curve in Fig. 2, and it is anorthoclase of the highest An content for which the lattice parameters are known to us.

Carmichael and MacKenzie (1964, p. 960) believe that the curves of variation of α^* and $2\theta(\bar{2}01)_{Fs}-2\theta(10\bar{1}0)_{Qtz}$ when used in combination provide an x-ray method of determining ternary composition of feldspars more potassic than Or_{15}. Our determined parameters for BTB-8 and FR-1 would not, however, provide an accurate ternary composition (compared to the chemical analyses) using the curves (Figs. 4 and 5). FR-1 plots outside the data field, and although its Or content can be predicted quite accurately, the Ab-An ratio cannot be determined from the α^* curve intersection. If the α^* curves are extrapolated for FR-1, the feldspar would be estimated to be more sodic than its analysis shows. BTB-8

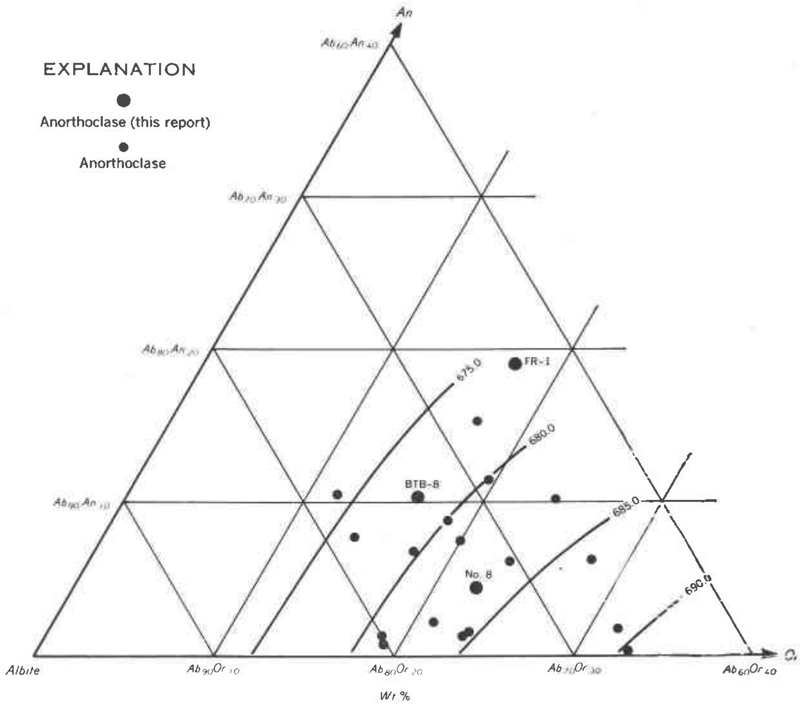

FIG. 6. Analyzed anorthoclase plotted in the Ab-rich corner of the ternary feldspar diagram showing variation in the cell volume (after Carmichael and MacKenzie; 1964, p. 955, Fig. 3). The comparison of anorthoclase of this report is shown (Table 5).

would be initially estimated to contain less than Or_{15} (Fig. 4), and hence the above curves would not be applicable.

The danger of rigidly comparing our lattice parameter determinations to the curves erected from the data of Carmichael and MacKenzie (1964) has been indicated above. Because of possible differences in the method of measurement it may not be possible to compare rigorously the results. It is obvious that duplicate samples should be run before a more quantitative comparison is made.

Simple criteria are not available to determine with confidence the structural state of each of the antarctic anorthoclases (*c.f.* Carmichael and MacKenzie, 1964, p. 961). Our graphic comparison (Figs. 4, 5, 6) with the homogeneous anorthoclases of Carmichael and MacKenzie (1964) indicates, however, that sample FR-1 is highly disordered and sample BTB-8 may be somewhat more ordered. It is possible that the divergence of the plot of BTB-8 from the $2\theta(\bar{2}01)_{Fs}-2\theta(10\bar{1}0)_{Qtz}$ curve (Fig. 4) is attributable to structural state. A general comparison of the optics reported herein and the optics reported in the literature for all anorthoclases indicates many similarities; refractive indices and 2V's of antarctic anorthoclases tend to be higher than usual. That the refractive

TABLE 5. SOME COMPARISIONS OF PARAMETERS FOR ANORTHOCLASE FROM ANTARCTICA

[Ternary composition is given for each sample as calculated from K_2O, Na_2O, and CaO by direct weight per cent molecular proportion. These values are given for comparison in Figs. 3, 4, 5 and 6, and differ somewhat from ternary composition (mol per cent) determined by the 32 oxygen method (see Table 1)]

	Weight per cent			$2\theta(\bar{2}01)$[1]	$2\theta(\bar{2}01)-2\theta(10\bar{1}0)_{Qtz}$[2]	$-\alpha_a*$	V Å^3
	Or	Ab	An				
BTB-8	(16.3)	(73.3)	(10.4)	21.8630°	0.987	86.92°	676.1
FR-1	(17.4)	(63.4)	(19.2)	21.8257°	.950	86.97°	677.9
No. 8[3]	(22.9)	(72.0)	(5.1)	21.7550°	.879	87.39°	683.0
A	(18.0)	(19.7)	(20.0)	Lattice parameters not available			
B	(63.1)	(61.5)	(60.3)	Lattice parameters not available			
C	(18.9)	(18.8)	(19.7)	Lattice parameters not available			

[1] Cu radiation, Ni filtered.
[2] $2\theta = 20.876°$.
[3] Specimen 8 of Carmichael and MacKenzie (1964, p. 950); includes Cn and $Fs_{(Sr)}$.

indices and optic angle of the Cape Royds anorthoclase (FR-1) is significantly higher than the rest is attributable to its notably higher An content.

The FR-1 rock is distinctly more silica undersaturated than rock BTB-8 to the extent that 7.4% normative nepheline is present (Table 2). The Or-Ab-An ratio in the normative feldspar in rocks FR-1 and BTB-8 are closely comparable (Table 2), and hence the partitioning of feldspar components, in particular Ab, is not accurately predicted in the norm as compared to the analyses. We have made a tentative identification of sodalite in rock FR-1. We believe that the sodium was partitioned into the sodalite, resulting in corresponding decrease in the relative Ab-An ratio.

ACKNOWLEDGMENTS

Thanks are particularly due to our colleague D. B. Stewart of the Geological Survey for guiding as through the preparation of data for computer least-squares refinement and for frequent consultation. We also acknowledge the kindness of John B. Lyons and Richard E. Stoiber of Dartmouth College in making the single variation system available for our use in determining refractive indices. The work was done in conjunction with a continuing study of alkali feldspars by Stewart and T. L. Wright, also of the Geological Survey. D. B. Stewart, D. R. Wones and D. W. Rankin read the manuscript and made many helpful suggestions which are gratefully acknowledged. The research on the minerals was supported by the U. S. Antarctic Research Program, National Science Foundation. Logistical support in Antarctica was supplied by the U. S. Navy.

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Manuscript received, January 14, 1966; accepted for publication, April 1, 1966.