

*Potash-oligoclase from Mt. Erebus, Antarctic, and
anorthoclase from Mt. Kenya, East Africa.*

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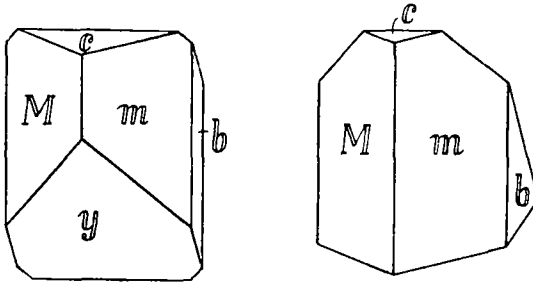
A FINE set of loose crystals of felspar from Mt. Erebus was collected by Mr. F. Debenham on the British Antarctic ('Terra Nova') Expedition in 1910, and was acquired by the British Museum (Natural History) with the collection of rocks obtained on that voyage. These crystals are found in great profusion on the crater slopes, and their occurrence has been briefly described by David and Priestley,¹ who referred to them as anorthoclase. On ascending the inclined floor of the second crater they saw 'that the covering of snow became thinner until it almost entirely disappeared, being replaced by a surface formed of crystals of anorthoclase felspar from half an inch to four inches in length'.

A cursory inspection of these crystals reveals the existence of two distinct types, distinguished by being of slightly different habit and more noticeably of different superficial colour. One type is rather stumpy and with a white surface (fig. 1), while the other is prismatic with rhombic cross-section and coated with a black vesicular lava (fig. 3). We shall refer to them as types 1 and 2 respectively, although intermediate examples do occur.

Crystals of type 1 are all very rounded and it is difficult to say whether the basal plane is a true face or merely a cleavage. This face, when carefully examined, is clearly composite, showing distinct albite-lamellation and also an unusual wavy structure perpendicular to it, possibly due to irregularities produced by pericline-twinning. Several minute

¹ T. W. E. David and R. E. Priestley, *British Antarctic Expedition, 1907-9. Reports on the Scientific Investigations, 1914*, vol. 1, p. 213 and pl. 65.

cleavage needles, scarcely visible to the unaided eye, were measured and gave the average result $(001):(010) = 87^\circ$; one or two of the faces (001) gave two sets of images inclined at about 6° , thus confirming the albite-twinning. These crystals then would appear to be plagioclase. These apparently simple crystals also twin according to the Manebach-law (fig. 5), so that fig. 2 may possibly represent a cleaved portion of such a twin rather than a distorted individual. The back of these twin-crystals consists of an almost flat surface and shows little sign of the salient angle of 20° at which respective y faces should be inclined. Goniometric measurements would suggest the face $(\bar{5}02)$, but since y is a common face it seems more probable that the convexity has been modified by corrosion. To test the effect of partial solution of



Feldspar crystals from Mt. Erebus, Antarctic.

FIG. 1. Type 1,
apparently simple.

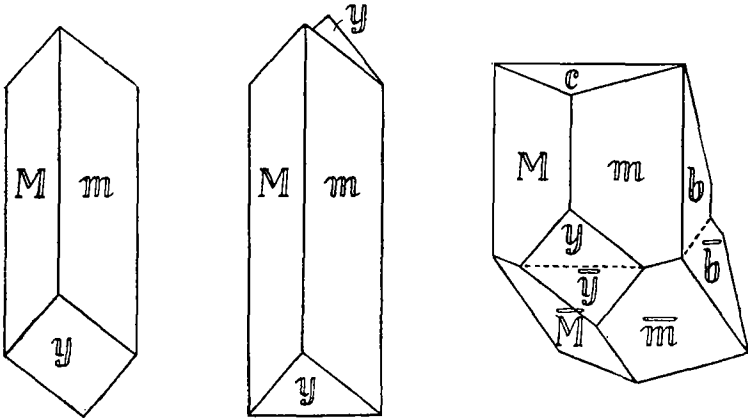
FIG. 2. Type 1,
distorted.

similar feldspars on their morphological characters, orthoclase crystals of typical adularia habit from St. Gotthard were etched for 2-3 days in dilute hydrofluoric acid. During this treatment a very rough surface was produced approximately perpendicular to the basal plane, while the prism-faces remained fairly plane. The angle between the prism-faces of the Erebus crystals, moreover, is more frequently about 55° than 61° , also due, no doubt, to corrosion. Carlsbad-twins (fig. 4) also occur, resembling those which will be described under type 2, among which they are more common.

The specific gravity of one of these crystals was measured by the suspension method, employing small pure cleavage-fragments, in cadmium borotungstate solution. Fragments sank in solutions of density varying from 2.615 to 2.625, but mostly at 2.620. These crystals of type 1 all show a fairly fresh appearance, with inclusions of augite and more

obvious inclusions of brown glass, the latter frequently being of rectilinear shape, similar to those described in feldspars from Kilima-njaro by Hyland.¹

Thin sections were ground parallel to the cleavages and also perpendicular to both cleavages. The basal section shows characteristic albite-twinning with lamellae of an average width of 0.02 mm. giving symmetrical extinction. The clinopinakoid section appears, near the extinction-position, as a mosaic of diamond-shaped individuals with the respective cleavage-traces belonging to two systems mutually inclined



Feldspar crystals from Mt. Erebus, Antarctic.

FIG. 3. Type 2, apparently simple.

FIG. 4. Type 2, Carlsbad-twin.

FIG. 5. Type 1, Manebach-twin.

at 2°, while the extinction-angle is fairly constant. This variation is the same as that seen on the cleavage-face. The extinction-angles (measured with a Calderon eyepiece with parallel nicols) are :

	Min.	Max.	Average.
(001) . . .	2.3°	4.5°	3.4°
(010) . . .	3.4	5.9	4.7

The third section cut perpendicular to both cleavages shows between crossed nicols the combined albite- and pericline-twinning characteristic of microcline. In convergent light it shows an optic picture, the section being perpendicular to the acute negative bisectrix with the

¹ J. S. Hyland, *Tschermaks Min. Petr. Mitt.*, 1888, vol. 10, pl. 7, fig. 8.

optic axial plane approximately parallel to (001). $2V = 62^\circ$, by Mallard's method. The refractive indices were measured by total reflection (i) and by the immersion method (ii) and gave respectively:

$$\begin{array}{lll} \text{(i)} & \alpha = 1.536 & \beta = 1.540 & \gamma = 1.542 \\ \text{(ii)} & \alpha = 1.536 & \beta = 1.539 & \gamma = 1.541. \end{array}$$

The chemical composition of this felspar crystal, the mean of two analyses made on portions of the same crystal on which the physical properties were determined, is given in col. 1, p. 336. Heavy liquids proved incapable of separating the glass inclusions, although the augite could be removed by this means, so that a selection of the sample had to be made by hand-picking under the microscope.

A simple crystal of type 2 is shown in fig. 3. This corresponds with the well-known lozenge-shaped crystals of the 'rhomb-porphyr' and is usually considered characteristic of anorthoclase felspars. On cleaving the crystal parallel to the base, the interior appears much darker than crystals of type 1, due no doubt to inclusions. The cleaved surface, however, is unlike that of crystals of the other habit and appears as a uniform surface except for inclusions of glass. Cleavage needles were measured on the goniometer and gave measurements from $89^\circ 24'$ to 90° between the cleavages, the average result being $89^\circ 45'$.

Crystals of this second type usually consist of two or three individuals twinned on the Carlsbad-law with (100) as composition-plane, as shown in fig. 4. Such a twin of two individuals was examined in detail, sections being ground with orientations as before. The section parallel to the base of one individual is in part homogeneous with straight extinction, but mostly shows very fine albite-lamellae with an average width of 0.0013 mm. and with extinction about 2.7° . The clinopinakoidal section shows the two individuals, with cleavages inclined at $127^\circ 42'$ (corresponding to $\beta = 63^\circ 51'$), separated by a lenticular inclusion of brown glass. In fact these sections both show a greater quantity of included augite and also of brown glass than those of the type 1 crystals. The extinction on (010) varies from 1.8° to 3.2° with an average of 2.6° . The section perpendicular to the zone [100] also shows very fine cross-hatching of the microcline type, another feature usually considered characteristic of anorthoclase. The optic axial angle measured as before gives almost the same value, viz. $2V = 61^\circ$, and with the same orientation.

Determinations of the refractive indices also gave results exactly identical with those of the previously examined crystal.

The chemical composition, moreover, was also found to be almost identical, and is shown in column 2 (p. 336). The extra potash may possibly be explained by the greater quantity of included glass, which could not be completely separated.

Specially oriented sections of a Carlsbad-twin of type 1 were further examined, but yielded results somewhat intermediate between the two sets already recorded. These are tabulated later under Erebus 3 (p. 336).

The rocks of Ross Island, on which Mt. Erebus is situated, were first described in detail by G. T. Prior in the Report of the Antarctic Expedition (1901-4).¹ I have re-examined the sections of these rocks and find the anorthoclase of the leucite-kenyte of Cape Royds² to be identical with the type 2 crystals. In spite of a careful search, however, I could find nothing exactly corresponding with the type 1 crystals. The felspar of some of the lavas has broad albite-lamellation comparable with that of the type 1 crystals, but these all have a much greater extinction-angle corresponding with andesine or labradorite. In accordance with the generally accepted theory that the 'monoclinic' are the unstable forms of the 'triclinic' crystals, one would perhaps not expect to find the latter among the volcanic ejectamenta. From their size they have evidently taken considerable time to grow and have probably grown in a magma which has had an opportunity to cool relatively slowly. The appearance of the surface of these crystals, moreover, points to weathering as their immediate origin, whereas the other type have obviously been blown out directly from a lava, portions of which still adhere to the crystals.

The occurrence of 'anorthoclase' in the leucite-kenytes at Ross Island was compared by Dr. Prior with that of the anorthoclases of Mt. Kenya and Kilima-njaro³; and in view of this, these latter anorthoclases were also examined.

The Kenya anorthoclases also occur in tuffs on the slopes of the crater, as mentioned by J. W. Gregory.⁴ A few of these crystals were presented by him to the British Museum in 1900, and show the characteristic stout habit ($Mm\ bcy$) of type 1 crystals with well-developed clinopinakoids (fig. 1), sometimes composite due to parallel growth on (010) and frequently twinned on the Carlsbad-law with (100) as

¹ G. T. Prior, National Antarctic Expedition, 1901-4, Natural History, 1907, vol. 1, p. 101.

² G. T. Prior, *ibid.*, p. 112.

³ G. T. Prior, *ibid.*, p. 118.

⁴ J. W. Gregory, Quart. Journ. Geol. Soc. London, 1900, vol. 56, p. 216.

composition-plane. Basal cleavage surfaces show little evidence of albite-twinning, and the cleavage-angle measured on acicular fragments measures from $89^{\circ} 30'$ to 90° . Sections parallel to the cleavages and perpendicular to the zone [100], however, resemble those of type 2 Erebus feldspar, the measurement made on them being given below. The crystal which was sectioned gave on analysis the results shown in col. 3 below.

The Kilima-njaro feldspars have already been described by Fletcher and Miers¹ and later by Hyland.² Their results are now mainly substantiated, although there is evidence of very fine albite-twinning on basal sections, and the specific gravity of clear fragments is 2.605 and not 2.63. The new results are appended for comparison.

An analysis of a feldspar from Allemont,³ Oisans, France, has been added, since, in chemical composition, it closely agrees with the Mt. Erebus feldspar; it was referred to andesine and occurs in diabase.

Physical Properties.

	(001):(010).	ext. (001).	ext. (010).	α .	β .	γ .	2V.	Sp. gr.
Erebus, 1 ...	87°	3.4°	4.7°	1.536	1.539	1.541	62°	2.620
" 2 ...	89° 45'	2.7	2.6	1.536	1.539	1.541	62	2.620
" 3 ...	88	2.6	3.7	1.536	1.539	1.541	62	2.620
Kenya ...	89 30	2.9	7.8	1.526	1.530	1.532	51	2.602
Kilima-njaro	89 52	0.5	5.1	1.533	1.537	1.539	60	2.605

Chemical Analyses.

	1. Erebus, type 1. (E.D.M.)	2. Erebus, type 2. (E.D.M.)	3. Kenya. (E.D.M.)	4. Allemont. (C. Lory, 1850.)
SiO ₂ ...	62.79	62.49	64.33	59.40
Al ₂ O ₃ ...	22.12	21.86	20.94	24.20
Fe ₂ O ₃ ...	0.36	0.30	0.20	0.60
FeO ...	0.41	1.31	0.58	—
CaO ...	3.76	3.74	2.01	3.70
MgO ...	—	0.16	—	—
Na ₂ O ...	7.35	7.20	7.22	7.00
K ₂ O ...	2.98	3.26	4.71	3.40
H ₂ O 110°+	0.19	0.04	0.27	} 1.48
H ₂ O 110°-	0.07	—	0.10	
	100.03	100.36	100.36	99.78
Or: Ab: An	18: 64: 18	19: 64: 17	27: 63: 10	19: 62: 19

If, now, these two types of crystals from Mt. Erebus are to be referred to the same name, some modification of the usual methods

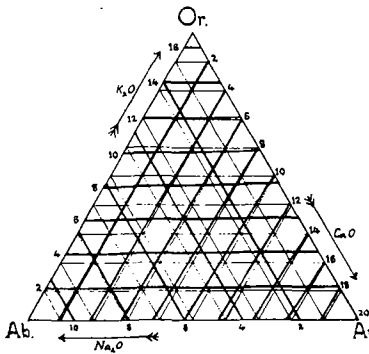
¹ L. Fletcher and H. A. Miers, *Min. Mag.*, 1887, vol. 7, p. 131.

² J. S. Hyland, *Tschermaks Min. Petr. Mitt.*, 1888, vol. 10, p. 256.

³ C. Lory, *Bull. Soc. Géol. France*, 1850, ser. 2, vol. 7, p. 542.

of discrimination must be instituted. In the first place, are we justified in considering type 2 as anorthoclase, the name employed for them by Dr. Prior? To answer this question it is necessary briefly to review the application of this term anorthoclase.

The term anorthoclase was introduced by Rosenbusch in the second edition of his 'Mikroskopische Physiographie'¹ of 1885 to include 'triclinic potash-soda feldspars having a cleavage-angle which appears scarcely, or not at all, to differ from a right angle'. These feldspars had already been grouped together by H. Foerstner² as 'anorthic potash-feldspars', but evidently they did not agree in having a cleavage-angle of nearly 90°, unless 2 or so is a discrepancy conformable with such



Nets correlating percentages of Ab, Or, An with Na₂O, K₂O, CaO in the feldspars
 FIG. 6. Molecular percentages.

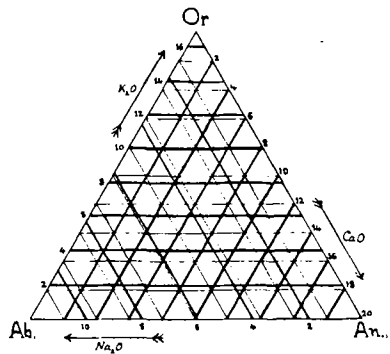


FIG. 7. Weight percentages.

a definition. Accordingly, this distinction from plagioclase breaks down. More recently H. L. Alling³ has given a more quantitative definition to the term. He says that 'many anorthoclase specimens are supersaturated, undercooled, metastable, solid solutions potentially perthite' and its range is delimited to Or₇₀Ab₃₀-Or₂₀Ab₈₀, while an arbitrary content of anorthite separates it from potash-oligoclase. Consequently it was thought desirable to seek for some more suitable criterion for distinguishing anorthoclase from plagioclase, if any such exist.

With this object in view, the detailed physical properties of 68 examples of such feldspars, of which the analyses were available, were

¹ H. Rosenbusch, Mikroskopische Physiographie, 1885, vol. 1, p. 550.

² H. Foerstner, Zeits. Kryst. Min., 1884, vol. 8, p. 193.

³ H. L. Alling, Journ. Geol., 1921, vol. 29, p. 291.

collected from the literature. It is perhaps unnecessary to point out that very few chemical and physical data have been determined on the same specimens, for these 68 include all the available data on the subject. The chemical compositions were first plotted on the usual triangular diagram, recasting being rendered unnecessary by drawing first the loci of points corresponding to the different percentages of alkalis and lime (see figs. 6-8). It is evident that if the actual

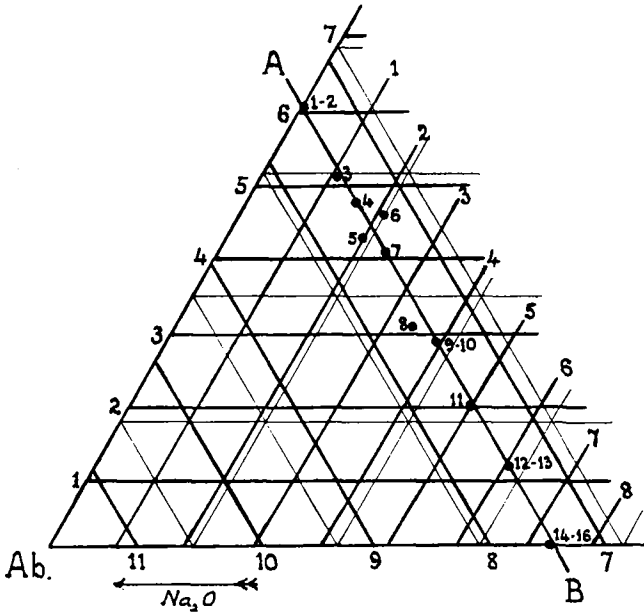


FIG. 8. Plot of the composition (molecular percentages) of feldspars of the series $Ab_{65}Or_{35} - Ab_{65}An_{35}$.

composition is low in these constituents compared with the theoretical composition of the corresponding pure feldspar, owing to impurities or imperfect analyses, the composition will be represented by a triangle with sides parallel to the axes of reference. The recast values will be obtained by joining corresponding corners of this triangle and the axial triangle and producing them to meet in a point.

Under exceptional circumstances, however, the composition triangle will be inverted owing to a predominance of the alkalis and lime. If the analysis is trustworthy the only explanation of this excess is based

upon the assumption of nepheline or soda-anorthite (carnegieite)¹ in solid solution. Bowen² has found that pure anorthite can only hold 2% of nepheline in solid solution, while Washington and Wright in their Linosa feldspar, corresponding to Ab_4An_6 , found 5.5% of nepheline. Bancroft and Howard³ have recently described labradorite from Mount Royal, Montreal, containing as much as 10.5%. There is no doubt that the presence of nepheline affects the physical properties of the feldspar, but so far these properties have not been sufficiently accurately investigated to detect anything anomalous suggestive of the presence of the nepheline. If, then, the presence of nepheline is a vital factor in rock nomenclature, this phenomenon would appear to give rise to a certain amount of confusion.

Of the 68 points located on the diagram to represent the feldspars mentioned, 9 happen to lie on or near the line *AB* (fig. 8) joining the points representing the Erebus and Kenya feldspars. These are included in the following list:

Locality.	Author and reference.
1. Porto Scuso, Sardinia	F. Fouqué, Bull. Soc. Franç. Min., 1894, vol. 17, p. 409.
2. (By interpolation)	D. Byelyankin, Bull. Petrograd Polytech. Inst., 1916, vol. 24 (for 1915), p. 437. [Min. Abstr., vol. 1, p. 89.]
3. San Marco, Pantelleria	H. Foerstner, Zeits. Kryst. Min., 1884, vol. 8, p. 187.
4. Sidori, Pantelleria	H. Foerstner, <i>ibid.</i> , p. 179.
5. Pic, Teneriffe	St. Claire Deville, Voyage Géol. aux Antilles, 1848, vol. 1, p. 130.
6. Mt. Kenya	E. D. Mountain, see p. 336.
7. R. Zichidi, Pantelleria	H. Foerstner, Zeits. Kryst. Min., 1884, p. 165.
8. Mt. Vesuvius, Italy	G. vom Rath, Pogg. Annalen, 1869, vol. 138, p. 466.
9. Mt. Erebus	E. D. Mountain, see p. 336.
10. "	" " " p. 336.
11. Rispond, Sutherland	M. F. Heddle, Min. Mag., 1881, vol. 4, p. 224.
12. (By interpolation)	J. P. Iddings, Rock Minerals, 1906, p. 221.
13. " "	N. H. and A. N. Winchell, Optical Mineralogy, 1909, p. 224.
14. (Artificial)	A. L. Day and E. T. Allen, Amer. Journ. Sci., 1905, ser. 4, vol. 19, p. 141.

¹ H. S. Washington and F. E. Wright, Amer. Journ. Sci., 1910, ser. 4, vol. 24, p. 52.

² N. L. Bowen, Amer. Journ. Sci., 1912, ser. 4, vol. 63, p. 571.

³ J. A. Bancroft and W. V. Howard, Trans. Roy. Soc. Canada, 1923, ser. 3, vol. 17, sect. 4, p. 23. [Min. Abstr., vol. 2, p. 401.]

Locality.	Author and reference.
15. Orjjarvi, Finland	H. Gylling, Öfvers. Finska Vet. Soc. Förh., 1883, vol. 25, p. 101.
16. Hohenstein, Kremstal, Austria	O. Grosspietsch, Sitzungsber. Akad. Wiss. Wien, 1918, Math. naturw. Kl. Abt. 1, vol. 127, pp. 439. [Min. Abstr., vol. 1, p. 281.]

These, then, were selected and their properties plotted by the usual two-component methods on a base corresponding to *AB* (fig. 9). I have

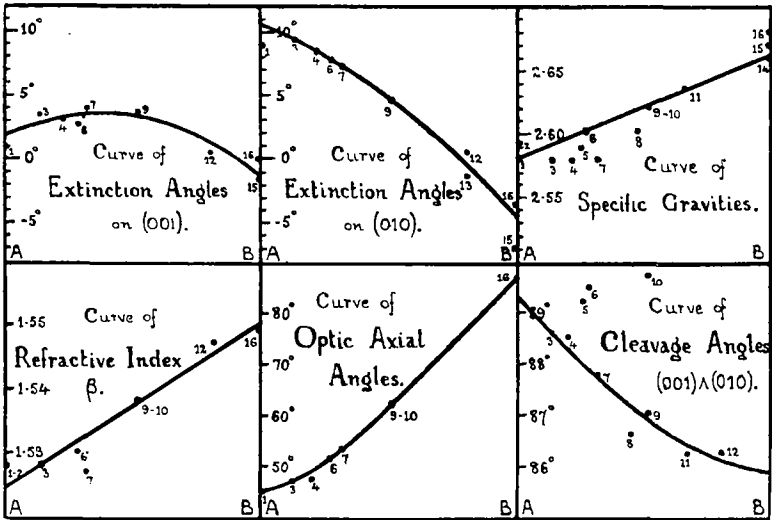


FIG. 9. Curves of the physical properties of feldspars of the series $Ab_{65}Or_{35}-Ab_{65}Al_{35}$. (Base-line *AB* of Fig. 8.)

also inserted the values for the naturally-occurring plagioclase feldspar falling in this series, according to H. L. Alling,¹ obtained from the curves of these properties for the natural plagioclase series (12 and 13). Apart from the cleavage-angle, these points lie very reasonably on single curves, and in no two cases would the adoption of two curves divide the points in the same way. This would indicate, then, that so-called 'monoclinic' and 'triclinic' modifications of the same chemical composition are not dimorphic (allotropic) modifications, but that they differ only in the coarseness of their twinning, sub-microscopic or very fine twinning giving rise to an apparent cleavage-angle of about 90°.

¹ H. L. Alling, Journ. Geol., 1921, vol. 29, p. 250, fig. 5.

This is, of course, the same conclusion as that to which Mallard¹ and Michel Lévy² came with regard to the identity of microcline and orthoclase. The effect of this twinning, however, on the extinction-angles still remains somewhat obscure.

In itself this is not a 3-component problem, but it might be solved by a study of the K-Na-felspars alone. Byelyankin,³ by plotting certain properties (sp. gr. and ref. index) of this series, also came to the conclusion that only one series exists, while Alling⁴ strongly believes in the two series. It would appear, then, that unless Alling has merely over-estimated the disparity between the properties of his two series, the three components, or 'minerals' as he calls them, are completely mutually soluble at their melting-points, at least within the area considered, giving rise to a single series of solid solutions of any composition. Alling's results, however, would appear to confirm the existence of two series in other areas of the system.

It is generally agreed that a eutectic line separates the fields of the orthoclases and plagioclases. The well-known diagram of Vogt (developed by Warren), however, applies to pegmatitic felspars and must be considerably modified to meet the requirements of porphyritic felspars. The diagram for these felspars would appear to be a complete series of solid solutions with a minimum (at $Ab_{68}Or_{32}$) as propounded by Dittler.⁵ The felspars in question are presumably undercooled solid solutions due to crystallization in a very viscous magma in the presence of mineralizers and to relatively rapid cooling precluding diffusion and exsolution.

How, then, are they to be differentiated? The problem is precisely the same as that of the nomenclature of the plagioclases. The divisions between the different species must be purely arbitrary, and the method of Calkins, as being the simplest, commends itself most favourably. Alling⁶ has extended this classification into the 3-component system and in consequence I have employed the divisions suggested by him, but retained the 'popular' nomenclature.

The Mount Erebus felspar falls in the potash-oligoclase area, while that from Mt. Kenya is anorthoclase. In this connexion it should be

¹ E. Mallard, *Ann. des Mines*, 1876, ser. 7, vol. 10, p. 10.

² A. Michel Lévy, *Bull. Soc. Min. France*, 1879, vol. 2, p. 135.

³ D. Byelyankin, *loc. cit.*

⁴ H. L. Alling, *Journ. Geol.*, 1923, vol. 31, p. 296.

⁵ E. Dittler, *Tschermaks Min. Petr. Mitt.*, 1912, vol. 31, p. 513.

⁶ H. L. Alling, *Journ. Geol.*, 1921, vol. 29, p. 253, fig. 13.

noted that the term potash-oligoclase was first used by Iddings¹ to include anorthoclase feldspars containing from about 3-5% of lime, but no limit was set to distinguish it from the corresponding plagioclase.

Since, now, the lozenge-shaped habit and the very fine cross-hatched twinning are purely relative criteria and depend not only on the molecular structure or composition, but also on the conditions of crystallization, further physical properties must be determined before an approximate estimate of the chemical composition of any feldspar in general can be made. Moreover, since we are dealing with a 3-component system, at least two factors must be considered, and, before they can be interpreted, data must be at hand for the whole system on the lines along which Alling has worked. The data collected here only refer to a single section of such a system.

The application of this classification in the description of rocks chiefly affects the volcanic series, or at least those rocks which have cooled under conditions which preclude exsolution and the consequent formation of intergrowths. As the present petrological nomenclature is dependent upon recognizing feldspars only as 2-component systems (and it is a matter of experience that most feldspars do tend to agree with this definition), feldspars falling very far from these limited ranges in composition must give rise to intermediate types. As an example, we will consider the rocks from which the series of feldspars discussed in this paper are derived.

Locality.	Names given by authors.	Rock.
1. Porto Scuso, Sardinia ...	... Anorthose ...	Trachyte-tuff.
3. San Marco, Pantelleria ...	... Plagioclase ...	Pantellerite (cryst.).
4. Sidori, Pantelleria ...	... Plagioclase ...	Pantellerite (glassy).
5. Pic, Teneriffe ...	... Oligoclase ...	Trachyte.
6. Mt. Kenya ...	... Anorthoclase ...	Kenyte.
7. R. Zichidi, Pantelleria ...	... Plagioclase ...	Augite-andesite.
8. Mt. Vesuvius, Italy ...	... Oligoclase ...	(drusy) in ejected block.
9. Mt. Erebus ...	... Anorthoclase ...	Leucite-kenyte.
11. Rispond, Sutherland ...	... Oligoclase ...	Pegmatite.
13. Orijärvi, Finland ...	... Andesine ...	(drusy).
16. Hohenstein, Kremstal, Austria	Andesine ...	Pegmatite.

The above table shows the confusion that has been allowed to permeate the nomenclature of feldspars containing both lime and potash in appreciable quantities and also the names of the rocks in which they occur. Even Dana gives crystallographic constants for oligoclase

¹ J. P. Iddings, *Rock Minerals*, 1906, p. 232.

determined on crystals containing almost as much potash as lime. And if the rocks in which they occur are named, other things being equal, from these feldspars, the confusion is bound to be increased. In the case of the Mt. Erebus, Mt. Kenya, and Kilima-njaro feldspars, the phenocrysts occupy a large percentage of the rocks¹ in which they occur and are consequently largely instrumental in determining the rock type; in the percentage of lime and alkalis they consequently show a marked similarity.

	Mt. Erebus.			Mt. Kenya.		Kilima-njaro.	
	Leucite-kenyte.	Pumice. ²	Pheno-cryst.	Kenyte.	Pheno-cryst.	Rhomb-porphry.	Pheno-cryst. ³
CaO ...	3.18	3.21	3.74	2.04	2.01	2.13	2.84
Na ₂ O ...	7.33	7.42	7.20	8.81	7.22	8.76	6.65
K ₂ O ...	3.91	3.97	3.26	5.27	4.71	5.75	4.50

With an increase of lime relatively to the alkalis, the feldspar would pass into a plagioclase near andesine, and, according to the accepted rock definitions, the rock would change from a soda-rich trachyte to an andesite. But where shall we draw the line? G. T. Prior has classified the rocks according to the strong resemblance existing in mineral composition and texture to the original kenyte from Mt. Kenya described by J. W. Gregory, and is accordingly justified in calling them kenytes. But it is useful, in classification, to assign them to one or other of the main divisions of the volcanic intermediates. H. O. Lang⁴ attempted a purely chemical classification of volcanic rocks, based on the total lime and alkalis in the rock, but it is obvious from his results that the divisions are quite artificial. H. S. Washington⁵ also developed this method in conjunction with the mineral associations and in consequence suggested new intermediate general groups.

The Cross-Iddings-Pirsson-Washington classification would appear to be equally at variance with the mineralogical classification, which is the basis of our usual nomenclature. Trachyte, for example, is defined as containing a predominant alkali-feldspar, even, in a more limited sense, to the exclusion of plagioclase. In the 'C. I. P. W.' classification, however, the rang is defined by the ratio of both alkalis to lime in all the 'salic' minerals, including nepheline and leucite, but this is modified by

¹ G. T. Prior, loc. cit., p. 113.

² H. I. Jensen, Brit. Antarctic Exped. 1907-9, 1916, vol. 2, p. 98.

³ L. Fletcher, Min. Mag., 1887, vol. 7, p. 131.

⁴ H. O. Lang, Tschermaks Min. Petr. Mitt., 1891, vol. 12, p. 199.

⁵ H. S. Washington, Journ. Geol., 1897, vol. 5, p. 368.

the subrang, and in any case an appreciable quantity of felspathoid will give rise to a distinct group of rocks.

Even if we accept the mineralogical definition, what is an alkali-felspar? If it were confined to pure orthoclase we should have no difficulties in considering our potash-oligoclase as a potential mixture of orthoclase and plagioclase. But in any case orthoclase is never free from soda, and, moreover, the albite molecule occurs both in anorthoclase and plagioclase, and according to its distribution affects the rock type.

In this instance, the 'C. I. P. W.' classification at least affords us an opportunity of finding rocks with a similar composition, but it only serves to bring out the remarkable similarity or identity of these rocks with certain of the rhomb-porphyrines of the Christiania district. The rhomb-porphry felspars also contain lime up to 5% and lie near the Erebus felspar on the triangular diagrams.

In connexion with the kenyte series developed by G. T. Prior, more calcic rocks are found, but the typical porphyritic character disappears, and the rocks are referred to trachydolerites or trachybasalts. Other porphyritic rocks, however, occur on Ross Island in which the felspar-phenocrysts are of two types, anorthoclase and oligoclase, and to these rocks H. I. Jensen has given the name 'basic kenyte'. The latter phenocrysts are of the tabular habit characteristic of those of andesites, and this introduction of a plagioclase, especially in addition to the anorthoclase, might serve to distinguish this type from kenyte. If, however, the two types grade into each other, and this requires further investigation, this occurrence of the plagioclase as phenocrysts should extend the kenyte division into the group of trachyandesites according to the chemical composition.

Finally, then, we are left with the apparent identity of kenyte (as used by G. T. Prior) with rhomb-porphry. The original kenyte of Gregory contains, as I have shown, felspars with well-developed clinopinakoids, and consequently can be described neither as containing rhomb-shaped phenocrysts nor as a porphyry. Kenyte might, however, well be extended to designate the lava analogues of laurvikite conformable with the definition given by Gregory (*loc. cit.*, p. 214), with the alternative that the phenocrysts may be anorthoclase or potash-oligoclase (or both anorthoclase and oligoclase) irrespective of their crystal-habit.

From these considerations, one may conclude that felspars intermediate between anorthoclase and plagioclase are only of local and rare occurrence, and in consequence play no appreciable part in systematic

petrology. In any case the arbitrary division of the 3-component feldspars into different types should find no parallel in rock nomenclature, since we are, in the case of rocks, also concerned with their mode of origin and associations.

In conclusion, I should like to thank my colleague Mr. W. Campbell Smith for much help and encouragement during this work.
