In north-eastern England it seems worthy of inquiry whether the Purple and Hessle boulder-clays may not be in like manner the sub-glacial and englacial till of a single ice-sheet, its modified drift being the Hessle gravel and sand. If this view be admissible, the Hessle beds containing *Cyrena fluminalis* and mammalian remains, where they are overlain by the Hessle boulder-clay, mark an extensive recession and subsequent advance of the ice.¹ Again, in north-western England the Lower and Upper boulder-clays and Middle beds of gravel and sand have the same relationship. These groups of drift deposits, bounded wholly or in part by the terminal moraines traced by Lewis, probably belong, like the conspicuous terminal moraine of the United States, to the second or last glacial epoch; while the Chalky boulder-clay, like the southern portion of the glacial drift in the Mississippi basin, extends beyond these to the limits of an earlier glaciation.

IV.—ON SODA-MICROCLINE FROM KILIMANDSCHARO.²

By J. S. HYLAND, Ph.D., M.A.,
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THE material, in which this felspar occurs, was collected by Dr Hans Meyer during his visit in 1887 to the East-African "snow-mountain," the Kilimandscharo, and kindly entrusted to me for description by Prof. F. Zirkel of Leipzig, to whom I desire to express my indebtedness for assistance and advice supplied me whilst working in his laboratory.

The rocks which possess this mineral as feldspathic constituent are Nepheline- and Leucite-basanites,³ and were found *in situ* on the south and south-east flanks of the Kibo peak. As rock-constituent this felspar is presumably confined to the outflows from the higher peak—the Kibo⁴—as no trace of it is to be found in the large series of rock-specimens, which represent the materials of which the other and lower peak—the Kimawenzi—is formed.

It is remarkable that Gustav Rose,⁵ who described the collection of specimens brought back from the same locality by Baron von der Decken in 1861 and 1862, mentions the occurrence in a rock he terms "trachyte" of a curious porphyritic felspar "whose crystals are rhombic prisms, so that a transverse section parallel to the best cleavage face appears as a rhomb." From his description I hold this felspar to be identical with that which Dr. Meyer collected.

¹ Quart. Journ. Geol. Soc. vol. xvii. 1861, pp. 446-456, and 473-5; Great Ice Age, second ed. pp. 372-380.

² The orthography used by R. Andree and A. Scobel in their Map of Africa (Leipzig, 1884) is here employed.

³ Under "Basanite" Rosenbusch (Mikrosk. Phys. ii. p. 753) includes all Tertiary massive rocks, which possess as essential constituents plagioclase (usually a basic lime-soda-felspar), nepheline or leucite, augite, olivine and magnetite. The name was first employed by Alex. Brongniart (Classification et caractères minéralogiques des roches homogènes et hétérogènes, Paris et Strasbourg, 1827, pp. 102-105). This is the *first* occurrence of Leucite in Africa. For further particulars, see Hyland, "Ueber die Gesteine des Kilimandscharo und dessen Umgebung," Tschermak's Mitt. 1888, X. 203-267.

⁴ 6090 metres high.

⁵ Zeitschrift für allgemeine Erdkunde, Berlin, 1863, vol. xiv. p. 246.

In 1886 Mr. Miers¹ published an account of a felspar from the same locality, to which his attention had been called by Prof. Bonney, and concluded it to be an orthoclase, similar to that described by Brögger² in the Norwegian "Rhombenporphyr." A supplementary note³ was issued in 1887 with analyses by Mr. Fletcher.

Several loose crystals were included in Dr. Meyer's collection, and these, although not quite fresh, favoured a study and determination of their characters.

The felspar is, when fresh, of a pearl-grey colour, with a highly vitreous lustre on both cleavage faces, and possesses the usual cleavage parallel to P and M, with a maximum length of 29 millimetres.

The following combinations were observed :

1. OP (001), $\infty P \propto$ (010), ∞P (110), $2P \propto (\bar{2}01) : \infty P \propto$ and $2P \propto$ well developed.
2. OP, ∞P , $\infty P \propto : \infty P$ (T and l) predominating: $\infty P \propto$ is mostly very small and often almost disappears.

OP is sometimes represented by a cleavage face; the edges of the faces are mostly rounded off.

Mr. Miers has recorded these faces in the article already referred to. The presence observed by him of a macroscopic twinning according to the Carlsbad law with the striking peculiarity, that $\infty P \propto$ (100) appears both as plane of composition and of twinning I was able to confirm as regards the second combination only, for wherever I found the face y ($2P \propto$) developed, there was no trace—optically or crystallographically—of any such macroscopic structure. Hence such crystals are in this respect simple individuals.

Upon careful examination of these twin-crystals a peculiar anomaly becomes apparent. The occurrence of the twin-structure demands that the two halves of such a crystal be symmetrical as regards $\infty P \propto$; one is in fact led to expect at the one end a roof-like top, at the other a re-entering angle (einspringenden Winkel). The latter can at once be noticed on our felspar, but the roof-like top is wanting, its place being taken by one surface, the face OP.

By striking this surface a portion flies off, and we recognize the characteristic form. Further, a section cut parallel to M ($\infty P \propto$) from a crystal twinned after the Carlsbad type ought to be resolved under crossed Nicols into two fields optically different. In contradiction to this, such sections cut from the outermost portions of a crystal behave as if they were derived from un-twinned individuals. If, on the contrary, a section be cut parallel to the same surface, but from a point nearer the geometrical centre, one is able to observe the ordinary phenomenon and the inclination of the basal cleavages to each other can also be determined: this amounts to $42^{\circ} 15'$. That this curious anomaly does not owe its origin to any mistake in the directions of the sections, I was able to settle by measurement and comparison with the crystals from which the sections were

¹ Mineralogical Magazine, 1887, vii. pp. 10-11.

² Die silurischen Etagen 2 and 3, 1882.

³ Min. Mag. 1887, p. 131.

prepared.¹ This conclusion is further supported by mechanically removing the outer portions of the crystals till the twin junction (Zwillingsnaht) is observed. In fact, we have probably here to deal with a nucleus twinned after the Carlsbad type, surrounded by felspar-substance free from such a structure.

From a crystallographical standpoint it is interesting to note the angle between P and M. This I have determined on several cleavage pieces, and obtain as mean $90^{\circ} 3'$. The physical condition of the surfaces was not very favourable for such a determination, still the variation was always very small. Miers observed 90° , and mentions that the variation never exceeded $16'$. It is interesting to note, that Brögger determined $90^{\circ} 3'$ on the felspar from the dykes at Fredriksvärn.²

On examination under the microscope Mr. Miers³ observed that parts of the crystals viewed by polarized light exhibited a well-defined cross-hatching parallel to the pinacoidal faces, but could, however, discover no trace of striation on sections parallel to OP. On the contrary, all the crystals I examined—ten in number—were seen to be built up of fine triclinic lamellæ of variable breadth. The examination of numerous sections cut parallel to OP showed that the lamellæ mostly follow the albite law; in such sections the extinction is nearly parallel and perpendicular to the edge P:M.

The extinction of the very fine striæ on OP may be measured as 1° — 2° , the larger ones ascending to $3\frac{1}{2}^{\circ}$. The surface of such a striated section under crossed Nicols is therefore never dark. Certain portions however exhibit no striæ, in fact the lamellæ appear to taper off and finally disappear. Brögger has made a similar observation.

Sections parallel to M possess an extinction-angle of 5° — 6° and exhibit no striation.

One very thin section parallel to OP from the middle of a crystal showed at certain portions, in addition to the striæ of the albite type, a second system crossing these at right angles, thus producing a structure similar to though not perhaps identical with that of microcline. This microcline-structure is, however, to be seen best in sections cut at right angles to P and M. Such sections appear composed of very fine and distinct lamellæ crossed by another series perpendicular to the first and of irregular breadth. The extinction-angle is here 8° — 11° to their length, but others appear to possess a straight extinction.

The triclinic character of the felspar is well marked in the rock-sections. The felspars of the ground-mass are identical with their porphyritic representatives, although the former are mostly lath-shaped. Where, however, the felspar forms laths of very small breadth, there is certainly no striation to be recognized; but this is an observation already made by those writers who have examined the felspar of the "Rhombenporphyr," to which, as has been

¹ The sections were made by Fuess of Berlin, and Voigt and Hochgesang of Göttingen.

² Brögger, op. cit. p. 259.

³ l.c. p. 11.

stated, the felspar from Kilimandscharo bears a striking resemblance. I see nothing to lead one to conclude, that the ground-mass consists of felspar, which is partly monoclinic, partly triclinic, and as the result of my observations I must agree with Mügge,¹ when he accounts for the phenomenon by the fineness of the striæ combined with the small extinction-angle.

With regard to the chemical constitution the felspar was first analysed by Mr. Fletcher, who was unable to remove the numerous inclusions of glass and other material present. By means of a laborious method, which occupied nearly two weeks, I was enabled to separate these inclusions and to satisfy myself by microscopical examination of the powder that it was chemically pure.

The sp.g. was determined with aid of the Westphal balance to be 2.63 at a temperature of 18° C.

For comparison the composition of similar felspars from Svenör, Tyveholmen, and Pantelleria are given.

- I. Felspar from Kilimandscharo (mean of two analyses) *Fletcher.*
 II. do. do. do. *Hyland.*
 III. Felspar from the Augitesyenite of Svenör. *Vogt.*²
 IV. Felspar from the "Rhombenporphyr" of Tyveholmen. *Fischer.*³
 V. "Plagioclase" from Cuddia Mida, Pantelleria. *Förstner.*⁴

SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	H ₂ O etc.	Totals.	Oxygen ratios.	Sp.g.
60.78	2.32	23.0	2.84	trace	4.50	6.65	0.21	100.30	9.88 : 3.3 : 1	—
61.3	— ⁵	23.1	3.02	—	5.34	7.11	0.09	99.96	9.08 : 3.02 : 1	2.63
61.35	—	22.37	4.66	0.04	4.97	6.59	—	99.98	8.41 : 2.7 : 1	2.63
59.50	2.47	22.69	5.05	0.42	2.50	6.38	1.34	100.35	8.65 : 2.9 : 1	2.65
66.63	0.72	19.76	0.38	0.30	4.86	7.31	—	99.96	12.1 : 3.1 : 1	2.55

From a chemical standpoint the constitution of this felspar is remarkable inasmuch as there is present, in addition to a large amount of soda, a considerable quantity of potash. Further, that the 3.02 % of lime found cannot be accounted for by inclusions of apatite or other lime-bearing minerals is evident, when we remember the pure condition of the powder analysed and the fact that the removal of the inclusions increased the amount of lime found, as a comparison with the analysis made by Mr. Fletcher shows. We may therefore consider this mineral as an admixture of lime, soda, and potash felspars, distinguished, however, from all other such compounds by the fineness of the triclinic lamellæ. My analysis is therefore equivalent to a molecular relation of 1 Mol. Ca Al₂ Si₂ O₈ : 2.1 Mol. KAl Si₃ O₈ : 4.02 Mol. Na Al Si₃ O₈. There is therefore present 1 Mol. KAl Si₃ O₈ to 1.91 Mol. Na Al Si₃ O₈. Mr. Fletcher gives An₁ Or_{0.94} Ab_{2.11} and has therefore regarded the composition of anorthite as Ca₂ Al₄ Si₄ O₁₆. Förstner and others

¹ "Feldspath aus dem Rhombenporphyr von Christiania," Neues Jahrbuch, 1881, 2, p. 114.

² Brögger, op. cit. p. 261.

³ Mügge, l.c. p. 119.

⁴ "Ueber die Feldspathe von Pantelleria," Z. f. Kryst. viii. 2 u. 3, p. 182.

⁵ There was no trace of iron.

Locality.	Rock.	Molecular ratio.				Ratio of KAlSi_3O_8 to $\text{NaAlSi}_3\text{O}_8$		Sp. g.	Obliquity of Extinction.		Authors.
		$\text{CaAl}_2\text{Si}_2\text{O}_6$	KAlSi_3O_8	KAlSi_3O_8	$\text{NaAlSi}_3\text{O}_8$	KAlSi_3O_8	$\text{NaAlSi}_3\text{O}_8$		On P	On M	
Pico do Teyde, Tenerife	Vitreous Lava ...	1	1.96	4.94		1	2.52	2.59	3,80°	9,30°	Deville ¹ & Fürstner
Fréjus in the Esterelgebirge	Dacite	1	0.34	1.14		1	3.35	2.68	1°—3°	2—5	Rammelsberg, ² Desclouzeaux, ²
Lille Frognier, Christianiageb.	Rhombenporphyr	1	0.80	0.90		1	1.12	—	1—2	5½—6½	Brögger, Kjerulf,
Svenör	Augite-syenite ...	1	1.18	2.48		1	2.1	2.63	1—2	p	Brögger, Vogt.
Cuddia Mida Pantelleria ...	Vitreous Pantel- lerite	1	7.36	16.86		1	2.29	2.56	2,10	9,80	Fürstner. ³
Kilimandscharo	(Nepheline) Basanite (Leucite)	1	2.1	4.02		1	1.91	2.63	1—2	5—6	Hyland.

¹ Comptes rendus, 1844, 19, p. 46.² Rammelsberg, Min. Chem. 1875, p. 569, and Deville, Bull. géol. (2), 6, p. 410.³ *loc. cit.*

take, however, only one molecule, which course has also been followed in this paper. Considering the formula to be $\text{Ca Al}_2 \text{Si}_2 \text{O}_6$, Mr. Fletcher's ratio would be $\text{An}_1 \text{Or}_{1.88} \text{Ab}_{4.22}$.

The triclinic nature of the felspar having been shown, there remains only to add that according to Brögger's view the felspar should receive the name "soda-microcline."

Mügge¹ has described the occurrence of a "Natron-Mikroklin" in the younger igneous rocks from the neighbourhood of Naiwaseha Lake and (*in situ*) from the Kiwanganine Valley, two localities not far from the Kilimandscharo massif.² This felspar contains "along with Na and K some Ca." Unfortunately no quantitative analysis is given.

It is interesting to compare the Kilimandscharo felspar with others of a similar character from various districts. The following table will assist the comparison.

The interpositions are very numerous and may be recognized as olivine, augite-needles, apatite, particles of the ground-mass with its constituent minerals, and devitrified glass enclosures. The latter mostly possess a regularity in their relative positions to each other, and appear in sections cut at right angles to P and M rudely rectangular. At places grouped round the vesicles in the felspar occur very fine acicular crystals, which are brown and show a decided dichroism.

¹ N. Jahrbuch, 1886, Beilage-Band iv. p. 591.

² Kiwanganine lies 130 kilometres N.W. of Kilimandscharo.

These remind the observer of breislakite, although their presence in the felspar-substance instead of lining the vesicles may appear to contradict this diagnosis. If they be not breislakite they may possibly be cossyrite,¹ but their smallness does not permit of a more definite determination.

V.—ON SOME PHYSICAL CHANGES IN THE EARTH'S CRUST.

(Part III.)

By CHARLES RICKETTS, M.D., F.G.S.

(Concluded from p. 119.)

ON the western flanks of the Malverns, the Upper Silurians are folded in several great anticlinals and synclinals, formed parallel to the axis of the Hill itself. To the west of Ledbury and again near Woolhope these contorted strata dip beneath the Old Red Sandstone, which, as computed by Phillips, has a maximum thickness of 8000 feet,² that of the Upper Silurians being 2690 feet.

The thickness of the strata of which the Longmynd is formed has been estimated by the Government Surveyors at not less than 26,000 feet, as exposed in their highly inclined edges; the beds dipping at an average inclination of 60° to the W.N.W.³ They thus appear as if they had been tilted by pressure against the more ancient rocks of the Caer Caradoc Range.

In each of these instances the immense accumulations formed may have had effect in causing the great disturbance to which the strata have been subjected. Whether the ridges of the Malverns or of the Caradoc Range are recognized as having once formed the summits of ancient mountains, or the dividing ridges between valleys, there is abundant evidence that a great thickness of sediment has been laid down in their vicinity, burying the slopes on their sculptured sides; the deposit being greater at a moderate distance, where the slopes extend deeper, than near the summits.

An example affording more conclusive evidence of the nature of the causes by which contortions and cleavage are produced occurs in the neighbourhood of Llangollen. At three different periods during Palæozoic times, namely, the Lower Silurian, the Upper Silurian, and the Carboniferous periods, the area around Llangollen continuously sank below the sea-level whilst deposits were accumulating. Three times they were raised above that level, and at the same time these deposits underwent denudation; *i.e.* previous to the deposition of the Upper Silurians, the Limestone and later Carboniferous rocks, and again as we observe at present. During each of these periods valleys were excavated to a depth so great, that the summits so far presented a mountainous character that they were raised 1500 feet and more above the then sea-level.

Previous to the deposition of the Upper Silurian strata, a pre-Wenlock valley was excavated in those of the Bala formation to a

¹ H. Förstner, "Ueber Cossyrit, ein Mineral aus den Liparitlaven von Pantelleria," Zeits. f. Kryst. 1881, Y 348-362.

² Mem. Geol. Survey, vol. ii. pt. i. p. 102.

³ Siluria, 1859, p. 23.