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ON THE
CANCRINITE-SYENITE

FROM

KUOLAJÄRVI AND A RELATED DIKE ROCK

BY

I. G. SUNDELL

HELSINGFORS

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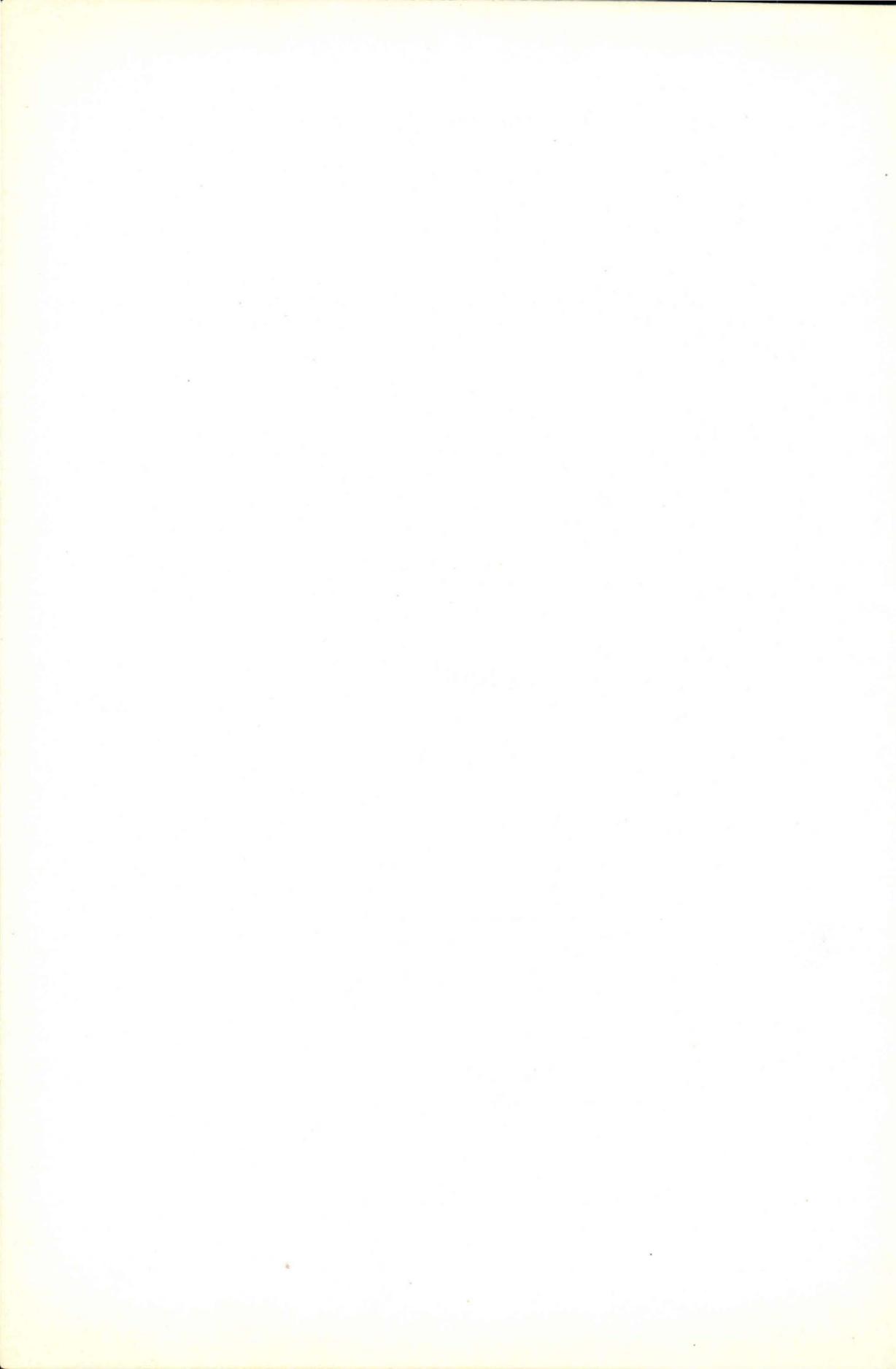
I. G. SUNDELL

WITH ONE PLATE OF FIGURES

HELSINGFORS

FRENCKELLSKA TRYCKERI-AKTIEBOLAGET

1905



ON THE CANCRINITE-SYENITE
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1. Cancrinite-Syenite.

In the deep valley of Pyhäkuru, in the parish of Kuolajärvi, the North of Finland, a new representative of the cancrinite-syenite was discovered in 1891. This rare rock was first identified by Törnebohm in his account on the Phonolite from Elfdalen in Särna, Dalarne, Sweden ¹⁾, which on a closer examination proved to be a nepheline-syenite, containing a considerable amount of primary cancrinite, as an essential constituent.

An account of the petrographical character of the cancrinite-syenite from Pyhäkuru is given in the Bulletin de la Commission géologique de Finlande, N:o 1 ²⁾, by W. Ramsay and E. T. Nyholm, who have studied the rock under the microscope and fixed its close relationship to the nepheline-syenites. They prove on good evidence, that the cancrinite in this rock must originate from the molten magma, from which the rock has solidified.

The chemical composition of this rock being of great interest, towards completing our knowledge of it, an analysis of it was made by myself in 1904, the results of which are given below. At this work the methods of Hillebrand ³⁾ were followed, which are, with regard to the different determinations as well as to the convenient manner,

¹⁾ Geologiska Föreningens i Stockholm Förhandlingar. N:o 80 Vol. VI, p. 383. A. E. Törnebohm: Om den s. k. Fonoliten från Elfdalen, dess klyftort och förekomstsätt. Mars 1883.

²⁾ Bull. Comm. géol. de Finlande, N:o 1, Mai 1895, pp. 1—5.

³⁾ Hillebrand: Some Principles and Methods of Rock Analysis. Bull. Geol. Surv. U. S. A. N:o 176.

in which the whole system is built up, superior to all other methods in use. Referring to Hillebrand, *op. cit.*, I shall not iterate the description of the methods; it will suffice to mention a few circumstances in reference to certain details of the work.

Material for the analysis was obtained from the same hand specimen¹⁾, which forms the basis of the microscopical examination, mentioned above. The rock powder used was practically air-dry, the sample of the rock having been kept in the collections of the University for more than ten years. Furthermore the powdered rock was exposed to the air for several days before bottling. The hygroscopic moisture, determined in an air bath at 110 °C did not amount to more than 0.08 p. c. Total water was determined by the Penfield tube. For the estimation of TiO₂ the colorimetric method was used, which has first been applied by Weller and afterwards modified by Hillebrand and Dunnington. Alkalis were, of course, determined by the Lawrence Smith method.

Naturally special care was paid to the CO₂ determination, the carbon dioxide being a main factor at the calculation of the amount of cancrinite present. The apparatus used for this purpose was built upon the same principles as the one described by Hillebrand²⁾, and was carefully tried in order to controll, its proper working before as well as after the decisive experiments. The carbon dioxide was retained by an absorption apparatus of the Geissler type, connected with a potash tube.

1) This hand specimen is taken from a loose stone, not bigger than a fist, which is the only authentic piece of the rock, that has ever been found. The first informations as to the occurrence of the rock have afterwards proved not to be correct, and to this day the locality from whence it derives, has not been discovered.

2) Hillebrand, *op. cit.* p. 101.

To avoid every error, the analysis was made double and as the table shows, the results agree very well with each other, the differences not being wider than allowable.

	I	II	Special determinations		Mean
SiO ₂	52.13	52.36	—	—	52.25
TiO ₂	0.32	0.32	—	—	0.32
ZrO ₂	—	—	trace	—	trace
Al ₂ O ₃	20.40	20.53	—	—	20.46
Fe ₂ O ₃	3.87	3.76	—	—	3.82
FeO	—	—	0.68	0.68	0.68
NiO	0.06	0.04	—	—	0.05
MnO	0.09	0.09	—	—	0.09
CaO	2.40	2.38	—	—	2.39
SrO	0.09	0.09	—	—	0.09
BaO	—	—	0.06	—	0.06
MgO	0.11	0.17	—	—	0.14
K ₂ O	—	—	6.18	6.18	6.18
Na ₂ O	—	—	10.10	10.01	10.05
H ₂ O below 110° C	—	—	0.08	—	0.08
H ₂ O above 110° C	—	—	1.75	—	1.75
P ₂ O ₅	—	—	0.05	0.05	0.05
CO ₂	—	—	1.70	1.68	1.69
SO ₃	—	—	trace	—	trace
S	—	—	trace	—	trace
	—	—	—	—	100.15

Evidently the analysis, high in alkalis and alumina and low in iron oxides, lime and magnesia, shows an alkali rock, most typical in composition, while the low percentage of silica includes it with the nepheline-syenites of a more basic character. The chemical features of the rock correspond fairly well to the mineralogical composition of it, as given by Ramsay und Nyholm¹⁾. According to the high alkalis and alumina and rather low silica the feldspathoid molecule is very abundant, giving rise to the main constituent of the rock, the cancrinite, and some nepheline. On account of the considerable amount of potash, orthoclase is common, while the pyroxene recedes before the other components because of the small amounts of oxides of the bivalent metals.

1) Bull. Comm. géol. de Finlande, *loc. cit.* p. 3 *et seq.*

As has been already shown, by Ramsay and Nyholm¹⁾ there exists a close relationship between the Pyhäkuru and Särna rocks with regard to their mineralogical and petrographical character, and even their chemical composition is nearly the same. In the table below the analyses are compared to each other, the analysis of the cancrinite-syenite from Särna, made by Dr. Mann²⁾, being put in column II. The small numbers refer to the molecular amounts of the different oxides.

	I	II		I	II
SiO ₂	52.25 .865	51.04 .851	MgO	0.14 .004	0.97 .024
TiO ₂	0.32 .004	0.29 .004	K ₂ O	6.18 .066	3.52 .037
ZrO ₂	trace	—	Na ₂ O	10.05 .162	11.62 .187
Al ₂ O ₃	20.46 .200	20.47 .201 (3.11) ³⁾	H ₂ O below 110° C	0.08 —	} 5.85
Fe ₂ O ₃	3.82 .024	1.89 ? .012 (1.08)	H ₂ O above 110° C	1.75 .098	
FeO	0.68 .010	2.19 ? .031	P ₂ O ₅	0.05 .000	0.27 .002
NiO	0.05 .000	—	CO ₂	1.69 .038	1.64 ⁴⁾ .037
MnO	0.09 .001	—	SO ₃	trace	—
			S	trace	—
CaO	2.39 .043	2.62 .046		100.15	102.37
SrO	0.09 .000	—	Spec. grav.	2.64	2.65 ⁵⁾
BaO	0.06 .000	—			

1) *Ibid.* p. 5.

2) Neues Jahrbuch für Mineralogie, 1884 II p. 193.

3) See note 2 p. 7.

4) In the place of the CO₂ determination by Dr. Mann, 0.62 p. c., of which the correctness must be doubted, is put the more reliable CO₂ percentage, 1.64, obtained by E. Schoult and quoted by Törnebohm, *op. cit.* p. 397, note.

5) By Dr. Mann 2.46 (Neues Jahrbuch, *loc. cit.*). As this determination seemed somewhat doubtful, I determined the spec. gravity of several fragments of a typical sample of the cancrinite-syenite from Särna, with the result mentioned above.

It is evident that the main features of the analyses are very much the same. Certain differences refer to differences in their mineralogical composition. This concerns especially the ratio of Na_2O to K_2O , which is in the Pyhäkuru rock, $2\frac{1}{2}:1$, but in the cancrinite-syenite from Särna amounts to $5:1$. This is due to the difference between the feldspars of the two rocks, the feldspar in the former being a pure orthoclase, while in the latter the albite prevails.

Considering the fact, that these two rocks are practically free from magnetite and sulphides, a good statement as to the relation of their pyroxene minerals to each other can be obtained by examining the ratio FeO to Fe_2O_3 , which may here express the proportion of the diopside molecule to the acmite molecule ¹⁾. This ratio comes in the cancrinite-syenite from Pyhäkuru only to 0.46, showing that the pyroxene of this rock is an almost pure acmite, which is in full accordance with its appearance under the microscope, the extinction angle being about $3\frac{1}{2}^\circ$, no zonal structure visible. In the Särna rock this ratio amounts to 0.76 ²⁾, and consequently the pyroxene must be here regarded as being a little more diopsidic. The microscopical investigation of the mineral points in the same direction, its extinction angle sometimes reaching up to $8-10^\circ$, while zonal structure is common ³⁾.

Since the chemical composition of the pyroxene in the cancri-

¹⁾ Strictly the MgO , which together with the FeO forms the diopside molecule, ought to be considered here at the same time. In any case, as the Särna rock is the richer one in MgO as well as in FeO , it will be to the same effect, if the FeO is considered alone.

²⁾ This ratio is calculated from the amounts of FeO and Fe_2O_3 given in the analysis of the pyroxene of the cancrinite-syenite from Särna by Dr. Mann. (Neues Jahrbuch für Mineralogie 1884 II p. 196). As there is no other iron-bearing mineral in this rock except the pyroxene, the $\frac{\text{FeO}}{\text{Fe}_2\text{O}_3}$ ratios, obtained from the analysis of the rock itself and from the analysis of the separated pyroxene mineral should correspond with each other. Yet they differ beyond every reason, and as the ratio obtained from the pyroxene analysis seems far more reliable, it has been preferred to the other one, the rather as I have myself determined the relative amounts of FeO and Fe_2O_3 in a typical specimen of the Särna rock, and obtained a ratio of 0.69. — If the total amount of iron in the analysis of the Särna rock is distributed upon the oxides corresponding to the ratio 0.76, the percentage weights for Fe_2O_3 and FeO would be resp. 3.11 and 1.08.

³⁾ Törnebohm, *op. cit.* p. 395.

nite-syenite from Pyhäkuru is not known — for lack of material there was no possibility of separating and analyzing it — the actual mineral composition of the rock cannot be calculated. But with regard to the near chemical and mineralogical relationship of the cancrinite-syenites from Pyhäkuru and Särna to each other, a good parallel between both can be obtained by calculating their norms in accordance to the rules given by Cross, Iddings, Pirsson and Washington¹⁾).

For this purpose I would suggest in this special case to adopt the cancrinite as a salic standard mineral among the lenads because of its great importance as a very abundant and doubtless primary constituent of these rocks. It does not seem reasonable to distribute the different components of this mineral, which in the present case and according to the scheme of calculation, given by the authors, would be nepheline and calcite, upon the opposite — salic and femic — groups of standard minerals. Further, the authors have omitted the cancrinite from the list of standard minerals only on account of its great rarity as a primary component of igneous rocks, and naturally they would not charge their system by, in most cases, unnecessary factors.

The chemical composition of the cancrinite is hereby expressed by the formula of Dana²⁾, which is based upon a series of valuable analyses of the cancrinite from different localities. The analysis of the cancrinite from Särna corresponds very nearly with this formula.

The results of the calculations are given in Tables I and II³⁾). The close relationship of both rocks is here fully stated, both take the same position in the new system, and their norms are nearly the same. As the colored minerals in both rocks are rather subordinate, the standard mineral composition, calculated with the modi-

1) Cross, Iddings, Pirsson and Washington: Quantitative Classification of Igneous Rocks. 1903. The University of Chicago Press.

2) Dana: A System of Mineralogy. London 1892. P. 427.

3) This calculation of the cancrinite-syenite from Pyhäkuru has been already performed by Hackman in his recent work: „Die chemische Beschaffenheit von Eruptivgesteinen Finlands und der Halbinsel Kola im Lichte des neuen amerikanischen Systemes. Bull. Comm. géol. de Finl. N:o 15, 1905, p. 79. The cancrinite-syenite from Särna is calculated by H. S. Washington in his: Chemical Analyses of Igneous Rocks, Washington 1903, p. 303. Though my calculations differ with regard to the treatment of the cancrinite the subrang arrived at has not been influenced by the different proceeding of mine.

fication suggested above, may be, with certain modifications, assumed to coincide with the actual mineral composition rather closely. If the total amount of femic minerals, except the apatite, is supposed to represent the amount of pyroxene present in the rocks, and all percentage weights of the minerals are recalculated to 100 p. c., the probable actual mineral composition of the rocks, given in percentage weights, would thus be:

	Pyhäkuru.		Särna.
orthoclase	37.13	} 43.50	21.09
albite	6.37		22.03
nepheline	13.21	} 40.01	14.28
cancrinite	26.80		26.44
aegyrte	16.49		15.53
apatite	—		0.63
	<u>100.00</u>		<u>100.00</u>

The identity of both rocks in mineral composition is striking. The only difference worth mentioning occurs in the relative amounts of the feldspars. The sums of the feldspars, as well as of the feldspathoids, are nearly the same in both rocks, and also the percentage weights of the aegyrte. As to the albite molecule, which appears at the calculation, it has been mentioned above, that, as far as the Pyhäkuru rock is concerned, no albite nor plagioclase of any kind has been observed at the microscopical investigation of this rock. This circumstance indicates, that the orthoclase in the cancrinite-syenite from Pyhäkuru should contain a considerable amount of Na_2O . The amount of Na_2O of this mineral would have been found to be still higher, if the amount of K_2O of the nepheline had been considered at the calculation.

2. Nepheline-Porphyr.

Among the rock samples, collected in Pyhäkuru, there are several which have, though not closely examined, been characterised as cancrinite-syenite-porphyr because of their porphyric structure and macroscopic resemblance to the cancrinite-syenite. Naturally, I, being once occupied with the chemical analysis of the cancrinite-

syenite from Kuolajärvi, would turn my attention to the said rock, which was believed to be a mere variety of the former.

According to the notes, made by the geological surveyors ¹⁾ of these regions, the rock occurs upon a system of dikes and veins, penetrating the old archean crystalline rocks, granite-gneiss etc., which cover this part of the country. The dikes and veins, varying in thickness from less than an inch to as much as ten feet and perhaps more, break across the heavily ruptured rocks, but sometimes appear very much in the shape of intrusive sheets, the molten material having followed the planes of cleavage of the rocks, if such a path offered less resistance, than the fissures in them.

The rock when fresh looking, is of a dark grayish-green color. It is rather tough and breaks with an uneven, somewhat conchoidal fracture. On the surface it is thoroughly weathered and is then yellowish-brown. The groundmass is megascopically perfectly aphanitic, the only constituents of the rock distinguishable to the unassisted eye being phenocrysts of nepheline and pyroxene, and, very occasionally, biotite. The nepheline forms rectangular or hexagonal individuals not larger than 2 or 3 mm, while the pyroxene occurs as dark slender needles and stout prismatic crystals, sometimes 4 mm in length.

In thin section the rock is observed to be more or less altered by weathering. This is particularly the case with the nepheline, which has changed, often almost completely, into a radiating mass of slender transparent fibers and patches of a doubly refracting mineral, the alteration beginning on the outside, the patches and fibers standing normally to the outline of the crystals. Only in the center of the larger crystals some fresh substance remains. It has not been possible, because of its extraordinarily finegrained condition and indefinite forms, to identify with accuracy this decomposition product of the nepheline with any certain mineral. It shows white to yellow interference colors, thickness of section being about 0.025 mm. The extinction is often parallel to the fibers. When treated with acid, the mineral gelatinizes. No doubt a zeolite or a mixture of zeolites is at hand. Brögger has shown, that this alteration product of the nepheline consists principally of hydro-

¹⁾ Mr. E. T. Nyholm, 1899. No further examination of this rather complicated case has taken place.

nepheline, with some natrolite, etc.¹⁾ Where the decomposition has been more complete, minute crystals of calcite are scattered through the mass, discernible from their characteristic form and high birefringence. Primary inclusions of pyroxene and apatite are common.

In contrast to the nepheline, the pyroxene is perfectly fresh in color and appearance under the microscope. It is quite auto-morphic and shows a good development in the prismatic zone, where observed forms are (110), (100) and (010). The crystals are stout prismatic, or tabular \parallel (100), or usually long and slender, with pointed forms. Twins are formed \parallel (100). Generally distinct terminations are rare, and the ends of the crystals are rather fringing. To the long and slender individuals terminations by very acute pyramids are characteristic. The pyroxene is present in three different varieties, all in zonal growth with each other²⁾. The interior of the larger crystals consists of an almost colorless augite, which is non-pleochroic. It is surrounded by several zones of a light green aegyrite-augite, that shows a distinct pleochroism, the colors varying in the following manner:

a	>	b	>	c
green		light green		yellowish-green

A narrow border of dark green aegyrite forms the outline of the crystals. The aegyrite substance is chiefly concentrated at the ends of the crystals. It is strong pleochroic and the colors observed are:

a	>	b	>	c
dark green		lighter green		yellow

The extinction, measured between a and c is varying. In the augitic center of the crystals extinction angles of 52° have been noted, while the zones of aegyrite-augite range from 36° to 28°, the angle of extinction decreasing towards the outside, as the relative amount of the aegyrite molecule increases. In the border of aegyrite the extinction is nearly parallel, a : c amounting to a few degrees

¹⁾ Brögger: Mineralien der südnorwegischen Augitsyenite, Zeitschr. f. Kryst. Vol. 16, 1890, pp. 232—236.

²⁾ See Ramsay and Nyholm: Bull. Comm. géol. de Finlande N:o 1, p. 6 fig. 2.

only, a falling in the pointed angle between a and c . Sometimes a recurrence in the zonal growth appears, when around the zones of aegyrte-augite follows a zone of the same substance, which forms the center of the crystal, in its turn surrounded by new zones of aegyrte-augite, with decreasing angles of extinction. It is to be noted also, that the pyroxene of this rock shows the characteristic dispersion of the axes of elasticity, which, as far as the augitic center is concerned, points to a considerable amount of titanium, but in the case of the aegyrte-augite may be partly due to the influence of the aegyrte molecule.

Biotite is very rarely present in thin sections. It shows rounded contours and is pleochroic in brown to yellow tints. Judging from the percussion figure, the plane of the optic axes is $\parallel (010)$. The biotites are surrounded by a border of fine needles of pyroxene in tangential position and would look like included fragments of extraneous origin, were not inclusions of the same biotite sometimes at hand in the larger crystals of pyroxene. In one of the sections small biotites occur rather abundantly, showing that the presence of this mineral is not quite accidental, though not very characteristic to the rock.

The groundmass of the rock is under the microscope found to be chiefly an aggregate of the same alteration products, which originate from the decomposition of the phenocrysts of nepheline. Needles of pyroxene are present abundantly, without showing any sign of flow-structure. Small rhombohedrons of calcite are seen everywhere, and microscopical fissures of the rock are filled with the same mineral. Apatite, sometimes reaching in size the dimensions of phenocrysts, is a common accessory, together with small, usually twinned crystals of titanite. Feldspar occurs, but quite rarely, in diminutive lamellae and seems to be a more basic plagioclase.

The zeolitic aggregate of the groundmass shows no marked structure, and the dots and patches are more rounded or irregular in shape. Sections parallel to the fibers are rare. Consequently the double refraction is generally less intense here, and the interference colors range from white to gray in different shades.

As to the original state of the groundmass it is difficult to decide anything with certainty. But from the fact, that phenocrysts of nepheline have developed abundantly, and as the alteration products of the groundmass are similar to those of the phenocrysts

of nepheline, it seems perfectly justified to conclude, that the chief component of the groundmass must have been originally nepheline. In fact small remains of nepheline substance can be identified in the groundmass, as an affirmative of this supposition. The rock thus seems to have been, when undecomposed, a porphyry with phenocrysts of nepheline, pyroxene and occasionally biotite, in a groundmass consisting chiefly of nepheline and pyroxene. Feldspar is quite subordinate. Apatite and titanite occur as accessories.

Near the contact the mesostasis is glass-like, but devitrificated to a certain extent. The nephelines are here less altered and usually contain much fresh substance in the center. The presence in the contact zone of numerous amygdales filled with calcite is remarkable. The contact is quite sharp and appears as a dark line, often running almost straight. As to the effect of the contact upon the surrounding rock, which in the only thin section of the contact, that has been studied, is a rather coarse grained gneiss, we find that it is penetrated by a network of fissures, filled with a mass of micro-litic crystals of some green mineral, probably aegyrine, which has evaporated from the intruding molten magma.

Considering the present altered state of the rock, the chemical analysis of it is given only with reservation. The analysis was accomplished in the same way, as that of the cancrinite-syenite, so there is no need of giving any further account of the methods, which were here followed. The results are seen in the accompanying table, under column I.

How far the alteration of the rock has affected its chemical composition, is difficult to discern. The high amount of lime seems suspicious and probably some of it has been deposited from infiltrating water, though another part no doubt is due to some decomposed mineral of the rock, which originally contained lime (cancrinite?).

	I	II
SiO ₂	45.48	48.28
TiO ₂	1.18	—
Al ₂ O ₃	18.75	20.72
Fe ₂ O ₃	3.99	6.24
FeO	1.57	3.58
MnO	0.15	0.22
CaO	7.22	2.88
BaO	0.13	—
MgO	1.50	2.32
K ₂ O	3.80	4.43
Na ₂ O	10.69	11.00
H ₂ O below 110° C	0.10	} 1.50
H ₂ O above 110° C	2.00	
P ₂ O ₅	0.46	0.18
Cl	0.14	—
CO ₂	2.77	—
SO ₃	0.24	—
	<u>100.17</u>	<u>101.35</u>
Spec. grav.	2.76	2.76

From the microscopical investigation as well as from the chemical analysis of the rock it is obvious, that it is not identical with the cancrinite-syenite from Kuolajärvi and cannot be regarded as a mere apophysis of the latter. On the other hand the analysis shows all the signs, characteristic to the foyaitic magma, and the occurrence of the rock in the vicinity of the cancrinite-syenite makes it probable, that it is genetically connected with it without having solidified from a magma of exactly the same composition.

The affinity of this rock to the cancrinite-syenite is furthermore stated by its position in the American system of igneous rocks. The calculation of the norm ¹⁾ from the chemical composition shows, that the rock belongs to the same subrang as the former. (See

¹⁾ This calculation has already been performed by Hackman, *op. cit.* p. 80. But since the analysis has afterwards been completed by determination of Cl and SO₃, the present calculation differs slightly from Hackman's with regard to the sodalite and noselite molecules, which appear in consequence of the amounts of Cl and SO₃. In any case the difference is of no consequence, and of course does not influence the position of the rock in the system.

Table III). This fully proves the close relationship of both rocks in chemical respect.

As a dike rock of foyaitic character it naturally ranges among the tinguaite, at the basic end of this series, according to the predominance of the nepheline molecule. In a general way it resembles chemically the tinguaite-porphyr from Katzenbuckel, Odenwald¹⁾ (column II, of the table above), the main difference, if the lime is left aside, being the higher amounts of Fe_2O_3 and FeO of the latter. Both rocks fall in the same subrang of the American system¹⁾.

Probably a whole system of dike rocks of tinguaite type accompanying the supposed cancrinite-syenite massive of Kuolajärvi will be discovered at a further geological exploration of this region.

As to the name of the said rock Hackman³⁾ has previously called it nepheline-porphyr, owing to the prevalence of phenocrysts of nepheline in it, and it seems, as if this name were the most natural at least until a closer knowledge of the rock has been obtained by studying it in unweathered samples and in the field. To characterise it plainly as a tinguaite, would be less exact, with regard to the extraordinary petrographical features of it, which are rather extreme compared to the tinguaite in general.

At the microscopical investigation of the nepheline-porphyr, which was followed with great interest by Professor Ramsay, it became evident, that this rock is identical with the melilite-basalt from Kuolajärvi, which has been described by Ramsay and Nyholm in the Bull. Comm. géol. de Finlande N:o 1, 1895. At the time being only a single specimen of the rock was at hand which had been obtained from a loose stone of small size, and was weathered to such a degree, as to allow no exact identification of its original state.

¹⁾ Rosenbusch: Elemente der Gesteinslehre, 1898 p. 215.

²⁾ The norm of the rock from Katzenbuckel, calculated by me, is: or 26.13 ab 1.05 ne 43.74 ac 9.70 di 11.16 ol 3.63 mt 4.18 ap 0.34. Class II: *Dosalanite*; Order 7: *Italare*; Rang 1: *Chibinase*; Subrang 4: *Chibinose*. — See note Tab. I.

³⁾ Hackman: *op. cit.* p. 80 and 124.

No wonder, that the nepheline, which was almost entirely changed into a zeolitic mass, in the way described above, was mistaken for melilite. The fibrous structure of the decomposition products was considered as indicating a former „Plockstruktur“ of the mineral in its unaltered condition, which is regarded as typical for the melilite, when seen under the microscope.

The Mineralogical Institute of the University.

Helsingfors in August 1905.

Table I.
Cancrinite-syenite from Pyhäkuru, Kuolajärvi.

	Per cent.	Mol.	Il.	Or.	Ab.	Ne.	Cr.	Ac.	Di.	Wo.	Ns.
SiO ₂	52.25	.865		396	72	92	171	96	22	13	4
TiO ₂	0.32	.004	4								
ZrO ₂	trace	—									
Al ₂ O ₃	20.46	.200		66	12	46	76				
Fe ₂ O ₃	3.82	.024						24			
FeO	0.68	} .011									
NiO	0.05		4						7		
MnO	0.09										
CaO	2.39	} .043									
SrO	0.09						19		11	13	
BaO	0.06		.000								
MgO	0.14	.004							4		
Na ₂ O	10.05	.162			12	46	76	24			4
K ₂ O	6.18	.066		66							
H ₂ O —	0.08	.004									
H ₂ O +	1.75	.098					57				
P ₂ O ₅	0.05	.000									
CO ₂	1.69	.038					38				
SO ₃	trace	—									
S	trace	—									
	100.15										

Formula.	Mol. Wt.		Norm.		
K ₂ O. Al ₂ O ₃ . 6SiO ₂	66 × 556 = orthoclase		= 36.70	} F 42.99	} Sal 82.54
Na ₂ O. Al ₂ O ₃ . 6SiO ₂	12 × 524 = albite		= 6.29		
Na ₂ O. Al ₂ O ₃ . 2SiO ₂	46 × 284 = nepheline		= 13.06		
4Na ₂ O. 4Al ₂ O ₃ . CaO.				} L 39.55	
9SiO ₂ . 2CO ₂ . 3H ₂ O	38 × 697 = cancrinite		= 26.49		
Na ₂ O. Fe ₂ O ₃ . 4SiO ₂	24 × 462 = acmite		= 11.09	} P 15.69	} Fem 16.30
Na ₂ O. SiO ₂	4 × 122 = sodium metasilicate		= 0.49		
CaO. SiO ₂	11 × 116 = diopside		= 2.60		
MgO. SiO ₂	4 × 100 = diopside		= 2.60	} P 15.69	} Fem 16.30
FeO. SiO ₂	7 × 132 = diopside		= 2.60		
CaO. SiO ₂	13 × 116 = wollastonite		= 1.51	} M 0.61	
FeO. TiO ₂	4 × 152 = ilmenite		= 0.61		
	45 × 18 = H ₂ O (rest)		= 0.81		
			99.65		

Class II:	Order 7:	Rang 1:	Subrang 4:
Sal = $\frac{82.54}{16.30} < \frac{7}{1} > \frac{5}{3}$	F = $\frac{42.99}{39.55} < \frac{5}{3} > \frac{3}{5}$	$\frac{K_2O + Na_2O}{CaO} = \frac{200}{19} > \frac{7}{1}$	$\frac{K_2O}{Na_2O} = \frac{66}{134} < \frac{3}{5} > \frac{1}{7}$
<i>Dosalane.</i>	<i>Italare.</i>	<i>Chibinase</i> ¹⁾ .	<i>Chibinose</i> ¹⁾ .

¹⁾ See Hackman *op. cit.* p. 124, notes 65 and 66; further p. 139.

Table II.

Cancrinite-syenite from Särna, Dalarne.

	Per cent.	Mol.	Ap.	Il.	Or.	Ab.	Ne.	Cr.	Ac.	Di.	Ol.	Ns.
SiO ₂	51.04	.851			222	246	98	167	48	44	15	11
TiO ₂	0.29	.004		4								
Al ₂ O ₃	20.47	.201			37	41	49	74				
Fe ₂ O ₃	1.89	.012							12			
FeO	2.19	.031		4						12	15	
CaO	2.62	.046	6					18		22		
MgO	0.97	.024								10	14	
Na ₂ O	11.62	.187				41	49	74	12			11
K ₂ O	3.52	.037			37							
H ₂ O	5.85	.325						55				
P ₂ O ₅	0.27	.002	2									
CO ₂	1.64	.037						37				
	102.37											

Formula.	Mol. Wt.	Norm.	
K ₂ O. Al ₂ O ₃ . 6SiO ₂	37 × 556 = orthoclase	= 20.57	F 42.05
Na ₂ O. Al ₂ O ₃ . 6SiO ₂	41 × 524 = albite	= 21.48	
Na ₂ O. Al ₂ O ₃ . 2SiO ₂	49 × 284 = nepheline	= 13.92	
4Na ₂ O. 4Al ₂ O ₃ . CaO.			L 39.70
9SiO ₂ . 2CO ₂ . 3H ₂ O	37 × 697 = cancrinite	= 25.78	
Na ₂ O. Fe ₂ O ₃ . 4SiO ₂	12 × 462 = acmite	= 5.54	P 12.02
Na ₂ O. SiO ₂	11 × 122 = sodium metasilicate	= 1.34	
CaO. SiO ₂	22 × 116	= 5.14	Fem 15.76
MgO. SiO ₂	10 × 100 = diopside		
FeO. SiO ₂	12 × 132		
2MgO. SiO ₂	14 × 70 = olivine	= 2.51	
2FeO. SiO ₂	15 × 102		O 2.51
FeO. TiO ₂	4 × 152 = ilmenite	= 0.61	M 0.61
3CaO. P ₂ O ₅	2 × 310 = apatite	= 0.62	A 0.62
	270 × 18 = H ₂ O (rest)	= 4.86	
		102.37	

Class II:	Order 7:	Rang 1:	Subrang 4:
$\frac{\text{Sal}}{\text{Fem}} = \frac{81.75}{15.76} < \frac{7}{1} > \frac{5}{3}$	$\frac{\text{F}}{\text{L}} = \frac{42.05}{39.70} < \frac{5}{3} > \frac{3}{5}$	$\frac{\text{K}_2\text{O} + \text{Na}_2\text{O}}{\text{CaO}} = \frac{201}{18} > \frac{7}{1}$	$\frac{\text{K}_2\text{O}}{\text{Na}_2\text{O}} = \frac{37}{164} < \frac{3}{5} > \frac{1}{7}$
<i>Dosalane.</i>	<i>Italare.</i>	<i>Chibinase.</i>	<i>Chibinose.</i>

Table III.

Nepheline-porphry from Pyhäkuru, Kuolajärvi.

	Per cent.	Mol.	Ap.	Il.	NaCl	Na ₂ SO ₄	Cc.	Or.	Ab.	Ne ¹⁾	Ac.	Di.	Wo.
SiO ₂	45.48	.758						246	36	274	100	94	7
TiO ₂	1.18	.015		15									
Al ₂ O ₃	18.75	.184						41	6	137			
Fe ₂ O ₃	3.99	.025									25		
FeO	1.57	.022		15								7	
MnO	0.15	.002										2	
CaO	7.22	.129	12				64					46	7
BaO	0.13	.001										1	
MgO	1.50	.038										38	
Na ₂ O	10.69	.173			2	3			6	137	25		
K ₂ O	3.80	.041						41					
H ₂ O	2.10	—											
P ₂ O ₅	0.46	.004	4										
Cl	0.14	.004			4								
CO ₂	2.77	.064					64						
SO ₃	0.24	.003				3							
	100.17												

Formula.

Mol. Wt.

Norm.

K ₂ O. Al ₂ O ₃ . 6SiO ₂	41 × 556 = orthoclase	= 22.80	} F 25.94	} Sal 65.48
Na ₂ O. Al ₂ O ₃ . 6SiO ₂	6 × 524 = albite	= 3.14		
Na ₂ O. Al ₂ O ₃ . 2SiO ₂	125 × 284 = nepheline	= 35.50		
3(Na ₂ O. Al ₂ O ₃ . 2SiO ₂)			} L 39.54	
2(NaCl)	2 × 969 = sodalite	= 1.94		
2(Na ₂ O. Al ₂ O ₃ . 2SiO ₂)				
Na ₂ . SO ₄	3 × 699 = noselite	= 2.10		
Na ₂ O. Fe ₂ O ₃ . 4SiO ₂	25 × 462 = acmite	= 11.55		
CaO. SiO ₂	47 × 116	} = diopside	} P 22.80	} Fem 26.32
MgO. SiO ₂	38 × 100			
FeO. SiO ₂	9 × 132			
CaO. SiO ₂	7 × 116 = wollastonite	= 0.81		
FeO. TiO ₂	15 × 152 = ilmenite	= 2.28	M 2.28	
3CaO. P ₂ O ₅	4 × 310 = apatite	= 1.24	A 1.24	
CaO. CO ₂	64 × 100 = calcite	= 6.40		
	H ₂ O	= 2.10		
		100.30		

Class II:

Order 7:

Rang 1:

Subrang 4:

$$\frac{\text{Sal}}{\text{Fem}} = \frac{65.48}{26.32} < \frac{7}{1} > \frac{5}{3} \quad \frac{\text{F}}{\text{L}} = \frac{25.94}{39.54} < \frac{5}{3} > \frac{3}{5} \quad \frac{\text{K}_2\text{O} + \text{Na}_2\text{O}}{\text{CaO}} = \frac{189}{0} > \frac{7}{1} \quad \frac{\text{K}_2\text{O}}{\text{Na}_2\text{O}} = \frac{41}{148} < \frac{3}{5} > \frac{1}{7}$$

Dosalene.

Italare.

Chibinase.

Chibinose.

1) For nepheline, sodalite, noselite.

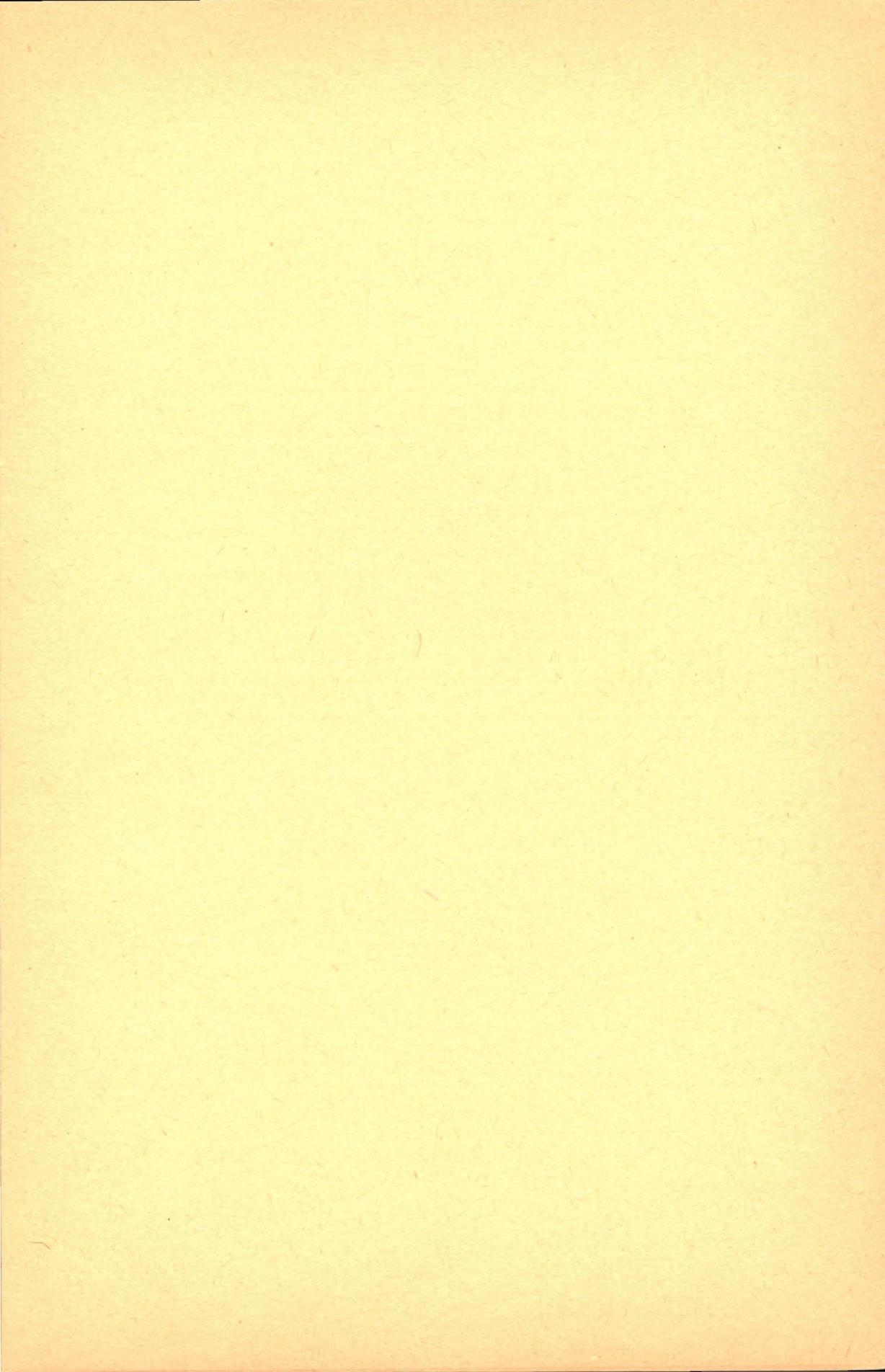
The figures.

Fig. 1 and 2 show the cancrinite-syenite from Pyhäkuru between parallel nicols and between nicols crossed 72° , and magnified 24 diameters. The flow-structure and semi-porphyratic character of the rock is easily recognized as well as the different mineral constituents of it. The aegyrine appears in the shape of black needles, and tabular crystals of orthoclase, usually Carlsbad twins, are present abundantly. Some large individuals of nepheline are distinguished by their basal cleavage. The cancrinite fills up the space between the other minerals and shows rather white in the second figure.

Fig. 3 and 4 represent a type of the cancrinite-syenite from Särna, which closely resembles the Pyhäkuru rock. The rock is here seen under the same conditions as the former and magnified on the above scale. The porphyritic structure of it shows clearly. A couple of large, lamelled phenocrysts of plagioclase occur; the cancrinite shows in the same way, as in the former rock.

Fig. 5 and 6 show a typical section of the nepheline-porphyrity, magnified 24 diameters, between parallel and crossed nicols. The large crystal of nepheline presents no sharp outline and disappears almost completely, when nicols are crossed, mixing up with the groundmass. Numerous crystals of apatite, of various size, are easily seen. A fissure filled with calcite occurs in the upper border of the figures, cutting in from the right and lowering slightly to the left. Between parallel nicols it shows like a white zone, but is dark when nicols are crossed.





Fascicules parus du Bulletin de la Commission géologique de Finlande (en vente dans les librairies d'Helsingfors et chez MAX WEG, Leplaystrasse 1, Leipzig).

- N:o 1. Cancrinitenyt und einige verwandte Gesteine aus Kuolajärvi, von WILHELM RAMSAY und E. T. NYHOLM. Mit 4 Figuren im Text. Mai 1895 0 M. 50.
- N:o 2. Ueber einen metamorphosirten präcambrischen Quarzporphyr von Karvia in der Provinz Åbo, von J. J. SEDERHOLM. Mit 12 Figuren im Text. Dec. 1895 0 M. 75.
- N:o 3. Till frågan om det senglaciala hafvets utbredning i södra Finland, af WILHELM RAMSAY, jemte Bihang 1 och 2 af VICTOR HACKMAN och 3 af J. J. SEDERHOLM. Med en karta. Resumé en français: La transgression de l'ancienne mer glaciaire sur la Finlande méridionale. Févr. 1896 1 M. 25.
- N:o 4. Ueber einen neuen Kugelgranit von Kangasniemi in Finland, von BENJ. FROSTERUS. Mit 2 Tafeln und 11 Figuren im Text. April 1896 1 M. 25.
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- N:o 15. Die chemische Beschaffenheit von Eruptivgesteinen Finlands und der Halbinsel Kola im Lichte des neuen amerikanischen Systemes, von VICTOR HACKMAN. Mit 3 Tabellen. April 1905 . 2 M. 50.
- N:o 16. On the Cancrinite-Syenite from Kuolajärvi and a Related Dike Rock by I. G. SUNDELL. With one plate of figures. August 1905 1 M. —