SVERIGES GEOLOGISKA UNDERSÖKNING

SER. C. Avhandlingar och uppsatser. N:o 430.

ÅRSBOK 33 (1939) N:o 10.

SOME POST-SILURIAN DYKES IN SCANIA AND PROBLEMS SUGGESTED BY THEM

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SVEN HJELMQVIST

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Contents.

Introduction.

In the small isolated Archaean horst, Torpa Klint, east of the lake Vombsjön in Scania, which rises as a narrow ridge above the surrounding Cambro-Silurian strata, there is a series of younger dykes of varied composition which are of particular petrographic interest. They are exposed in a quarry in the northern part of the horst about one km E.N.E. of the Torp farm. Especially one of these dykes attracts immediate attention, *viz.* a bright red, syenitic dyke of a type not earlier known of in Scania. The other dykes are more or less basic and are closely related to the Tolånga melaphyres. The area in the vicinity of Tolånga church where the last-mentioned dykes are most frequent is only about 8 km from the quarry at Torpa Klint.

Like most post-Silurian dolerite dykes in Scania these dykes run practically W.N.W.—E.S.E. Their location in relation to each other will be seen from the attached sketch map of the quarry at Torpa Klint (Fig. 1). Fig. 2, a schematized geological survey map of Scania, shows the location of the quarry.

This paper is founded on material collected by the author, partly as early as 1930, when I visited the locality the first time and was attracted by the unusual appearance of the above-mentioned syenitic dyke. I have subsequently paid several visits to the place and have supplemented my earlier observations. Due to intervening, more important and urgent work, however, I have not been able to publish the results of my investigations earlier. I take this opportunity of expressing to Professor Assar Hadding my gratitude for his kindness in lending me material for comparison from the collections of the geological-

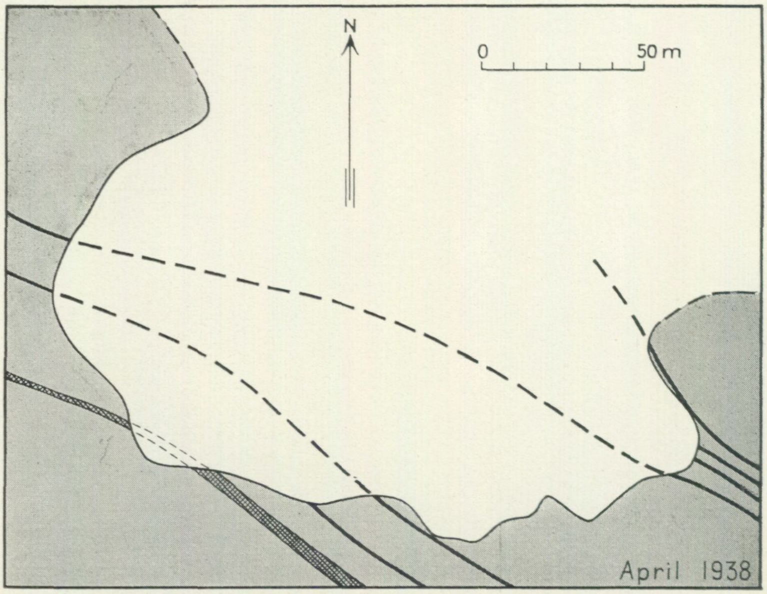

Fig. 1. Sketch of the quarry at Torpa Klint. Grey = granite-gneiss, black = melaphyre, chequered = syenite porphyry.

mineralogical institution of Lund. At the same time I wish to thank the geologist, Mr. Josef Eklund, of the Geological Survey of Sweden for valuable literary references.

Description of the Rocks.

The Archaean.

The rock prevailing in Torpa Klint consists of a fine-grained, salic granite-gneiss of a type fairly common in the Archaean rocks of south-western Sweden. It is of a faint reddish colour and of homogeneous, massive development, with a characteristic gneissic texture. Close to the basic dykes this type often develops into a deeper red, somewhat coarser and more granitic rock with reflecting feldspar faces, whose relationship to the normal gneiss, however, is quite evident. Pegmatitic segregations are also found in the granite-gneiss.

Normal granite-gneiss. Under the microscope the normal granite-gneiss presents a massive, granoblastic texture with irregular grains and a variation in the size of the predominating minerals (Fig. 4). — A geometric analysis of a sample gave the following result:

	Vol. %
Quartz	28.3
Microcline-perthite	33.6
Albite	35.2
Biotite, magnetite, apatite	2.9
	100.0

The quartz is faintly undulating, the larger grains often granulated. Albite as well as microcline-perthite are fairly clear and not very disintegrated. The latter is a rather coarse perthite with regularly interlaminated albite intergrowths. The independent albite grains have thin, often faintly curved twin lamellae. The composition is $Ab_{94}An_6$—$Ab_{92}An_8$. The biotite forms small, compact scales of a faint olive-brown colour. Magnetite and apatite are fairly prominent accessories in the rock. Besides the minerals mentioned there are also quite inconsiderable quantities of titanite and zircon. In rare instances garnet has been observed.

Altered granite-gneiss. The boundary in the field between the normal and the altered granite-gneiss, which occurs close to the basic dykes, is not very sharp. Under the microscope the altered granite-gneiss also discloses a granoblastic texture. The grains, however, are definitely more rounded than in the unaltered rock. The quartz grains are smaller and the quartz content lower. A remarkable change from a mineralogical point of view is occasioned by the fact that anorthoclase occurs as an important component of the rock. — A geometric analysis of an altered granite-gneiss shows the following composition:

	Vol. %
Quartz	23.6
Microcline	24.3
Anorthoclase and albite	48.0
Biotite, magnetite, apatite	4.1
	100.0

It is difficult to establish definitely the mutual proportions between anorthoclase and albite, as it is not always possible to distinguish these minerals in every position in thin sections. However, the anorthoclase is quite predominant. Compared with the unaltered granite-gneiss, the analysis shows — apart from the somewhat lower quartz content — a noticeably lower microcline and albite content, which partly have been replaced by the new mineral, anorthoclase.

The quartz in the altered rock displays the same faint undulatory extinction as in the normal granite-gneiss. The larger grains are usually granulated. The microcline is generally fairly clear but changes into more highly pigmented types. Grains of a dirty grey appearance are also seen with still recognizable perthite texture. These evidently represent an intermediate stage towards anorthoclase. The latter mineral has a deeper red pigment than the microcline and forms larger individuals of a mottled appearance. The extinction is decidedly irregular. The optic properties vary in different parts of the same grain, evidently due to variations in the potash-soda proportion. Between crossed nicols there is observed a characteristic net-like pattern (Figs. 5 and 6). $2\ V_\alpha$ varies from about 50° to 75°. Also the index of refraction varies. Usually n_β is greater than the refractive index of Canada balsam and n_α lower. In parts richer in potash, however, the refractive index is considerably lower than that of Canada balsam. Thin albite lamellae may sometimes be observed, but usually only in part of the mineral grain.

The albite is greatly disintegrated. The refractive index n_β is lower than that of Canada balsam, n_γ greater. $2\ V_\alpha = 80°—82°$. The maximum extinction angle in the zone normal to (010) is 14°—15°. Optically the mineral thus deviates noticeably from ordinary albite, particularly with regard to the optic angle. The deviation is no doubt primarily due to a certain content of potash.

The remaining minerals differ but slightly from the corresponding minerals in the normal granite-gneiss. Apart from the above-mentioned constituents, titanite and zircon are also found among the accessories.

To a certain extent the rock described brings to mind an altered, though not identical, type of an acid, aplitic gneiss observed near a kullaite dyke at the Dalby quarry in Scania (*12*). In this instance, too, the result is a coarser, more deeply red rock. The perthitic potash feldspar of the unaltered gneiss has been replaced by a deeper red pigmented form. The quartz content is reduced and the margins of the mineral grains have become corroded. Nearest to the kullaite the alteration has advanced still further, and the original gneiss has there, in a narrow zone, been replaced by a comparatively coarse, calcite-bearing syenite. This zone, too, has its parallel in Torpa Klint, *viz.* in the syenitized gneiss fragments occurring in the basic dykes and which are described further on.

The Basic Dykes.

In the quarry at Torpa Klint there are in all six basic dykes of varying composition and thickness (see sketch map, fig. 1). The strike of the dykes averages W.N.W.—E.S.E., but varies from N. 20° W. to N. 80° W. The dip is fairly steep, about 65° towards S. W., but may also be flatter. In two of the dykes the width exceeds one metre, but in the narrowest ones it is only a couple of dm. All six dykes are visible in the southern and eastern wall, but only two of them recur in the western wall, which is due to the fact that at least three of the dykes pinch out towards the west while the northernmost one possibly curves so far northward that its continuation passes north of the western wall of the quarry. Most likely the dykes' centre of eruption should be sought towards the east.

The least altered form will be found in dyke No. 2 counting from N.E. (in the eastern wall). The rock of this dyke is a dark augite porphyrite rich in phenocrysts, of a type very closely resembling the best preserved melaphyres from the Tolånga district described by Hadding, and which without doubt classifies the rock as belonging to their group (*9*). In some ways it also resembles the dykes in Bohuslän, described by Ljungner as madeirite (*20*, p. 31 ff.), which, however, seem to have a more alkaline character and are albite-bearing, in addition to which the ground-mass contains augite and not hornblende. The resemblance is somewhat greater to the limburgite dykes which also occur in Bohuslän (*20*, p. 41 ff.), where, according to Ljungner, however, the phenocrysts seem to be exclusively olivine. The rock at Torpa Klint differs from typical limburgite in that the ground-mass contains no augite but a brown hornblende.

A geometric analysis of the dyke in question disclosed the following composition:

	Vol. %
Augite phenocrysts	39.7
Olivine phenocrysts (serpentinized)	9.3
Brown hornblende	37.8
Ores	6.8
Glass (devitrified)	6.4
	100.0

The numerous augite phenocrysts (Fig. 8) reach a size of 2—6 mm and are idiomorphically developed with the crystal faces (100), (110), (010), and (001). Twinning on (100) occurs.

$$\gamma - \alpha = 0.021.$$
$$2\,V_\gamma = 54°.$$
$$c : \gamma = 47°.$$
$$n = \text{ca. } 1.71.$$

A zonal banding may sometimes be observed. Usually the pyroxene is practically colourless. In exceptional cases it displays a quite faint pleochroism with α slightly reddish brown, γ faintly greyish green.

The olivine phenocrysts are smaller than the augite phenocrysts. Usually they have an acute, rhombic form, and are entirely altered and replaced by a fine aggregate of fibrous serpentine, chlorite, and calcite of varying proportions. Besides these pseudomorphs there are also — though mostly towards the marginal zones of the dyke — sparse amygdaloids of serpentine with a double refraction which is sometimes fairly high — very much higher than in the serpentine of the olivine pseudomorphs — and with a faint pleochroism. Carbonate is also found in these amygdaloids.

The ground-mass in the augite porphyrite consists of brown hornblende, apatite, ore grains, and partly devitrified glass of a greyish or brownish colour. Small olivine pseudomorphs consisting of chlorite will sometimes also be found in the ground-mass.

The hornblende forms idiomorphic, 6-sided prismatic crystals bounded by (110) and (010). Twinning on (100) also occurs, although more rarely. The pleochroism is as follows:

α very light brown $< \beta = \gamma$ brown with a tint in brownish green.

$$\gamma - \alpha = 0.020.$$
$$2\,V_\alpha = 73°.$$
$$c : \gamma = 13° - 15°.$$
$$n = \text{ca. } 1.69.$$

Due to its low double refraction the hornblende cannot be referred to as basaltic hornblende, but on the other hand in certain respects resembles barkevikite whose optic angle, however, is much smaller. It seems to correspond fairly well with the hornblende occurring in the Tolånga melaphyres, which, however, according to Hadding has a somewhat higher birefringence: $\gamma - \alpha =$ $= 0.025$ (9, p. 9).

The ore grains consist partly of magnetite, probably containing titanium, and partly of pyrite. The former usually forms octahedral crystals.

The marginal zone of the dyke now described presents an entirely different appearance and consists of a fine-grained rock varying in colour from dark grey to dark reddish brown and with numerous round amygdaloids of red feldspar often a mm in diameter. There are also red feldspar veins. Otherwise the rock consists of hornblende and magnetite which lie in a bottom web of feldspar with red pigments, in all probability mainly consisting of andesine. Apatite occurs in hexagonal prismatic crystals. Chlorite, epidote, and carbonate form pseudomorphs after earlier pyroxene and olivine phenocrysts. The hornblende is of a type similar to that found in the main part of the dyke, but slightly greener, and forms extended, idiomorphic prisms. The feldspar in the red amygdaloids appears mainly to be alkali feldspar. In addition, however, andesine is also found. In the middle of the amygdaloids a kernel of carbonate is sometimes encountered.

This marginal zone constitutes a transition to the types more similar to kullaite which are found in other dykes at Torpa Klint.

The dyke farthest N.E. consists of a fairly fine-grained, dark grey rock which macroscopically is identified by calcite amygdaloids of varying sizes, often surrounded by a thin border of red alkali feldspar. The middle of the amygdaloids sometimes consists of quartz. Otherwise the rock is composed of diverging laths of plagioclase and alkali feldspar, enclosed by chlorite and carbonate. The latter mineral is so plentiful that it may almost be looked upon as the matrix of the rock. Magnetite and apatite both occur in fairly considerable quantities. Usually the feldspar is disintegrated. The plagioclase is an andesine. Upon analysis of a somewhat larger grain, the composition was found to be about 45 % An for the kernel and about 30 % An for the marginal zone. Otherwise the An-content is usually lower: for the kernel slightly above 30 % and for the marginal zone about 20 %. — Petrographically, the dyke most closely resembles the kullaite type (see below).

Dyke No. 3, counting from N.E., is generally developed into a greyish green, fairly fine-grained and altered rock with numerous amygdaloids of calcite, chlorite, epidote, and alkali feldspar. The latter are actually not amygdaloids but rather nodular feldspar aggregates with no marked boundary towards the surroundings. It is particularly interesting that this dyke locally changes into a better preserved type, like dyke No. 2, with phenocrysts of augite and olivine pseudomorphs in a ground-mass rich in chlorite, which also contains numerous calcite amygdaloids.

The altered rock which constitutes the bulk of the dyke, consists of divergent laths of usually red pigmented feldspar, between which are found delessite, augite, brown hornblende, magnetite, apatite, and calcite. Sometimes, brown, partly devitrified glass may also be observed. In addition there are larger augite phenocrysts, usually partly or entirely replaced by carbonate, and olivine pseudomorphs consisting of serpentine. Light green delessite aggregates with a typical olivine shape also occur. The feldspar consists partly — and mostly — of andesine, partly of alkali feldspar. The composition of the andesine is usually about 35 % An. A somewhat larger grain that was analysed had an average composition of 38—40 % An. In a couple of instances dark brown biotite was observed instead of the hornblende, which forms short prismatic individuals. In all probability the magnetite contains some titanium, which is indicated by the fact that it is often surrounded by leucoxene. The apatite, which occurs in rather large quantities, forms narrow, 6-sided prisms.

The numerous true amygdaloids consist of epidote, delessite, and calcite. Macroscopically, the epidote is of a bright grass-green colour and usually forms divergent beams of thin long-prismatic individuals which radiate from the edges of the cavities (Fig. 11). The mineral seems to be comparatively rich in iron.

$$\gamma - \alpha = 0.051.$$
$$2\,V_\alpha = 66°.$$
$$n = \text{ca. } 1.77.$$

The pleochroism is as follows:

α light green $<$ γ deep yellowish green.

The delessite is pale green, faintly pleochroic. The double refraction is low.

The calcite occurs, *inter alia*, as tabular individuals bounded by (0001), the section of which is that of a narrow lath.

The amygdaloids pass into nodules of red or greyish red feldspar which often contain a kernel of carbonate, epidote, or delessite (Fig. 12). The feldspar, which is strongly pigmented, consists largely of alkali feldspar, but also tabular andesine individuals are seen to grow into the nodules from the surroundings.

The rock now described displays so much similarity to the kullaite earlier described from Kullen in north-western Scania (*11*) and from Romeleåsen (*12*), that it doubtlessly should be given the same name. In its typical development the kullaite from Kullen and Romeleåsen consists largely of andesine, alkali feldspar, and delessite, to which are added fair quantities of titanomagnetite and some augite, epidote, and apatite. In the Kullen rock also quartz and biotite are found in small quantities. The kullaite is further characterized by numerous drusy or amygdaloidal accumulations of alkali feldspar, epidote, delessite, and calcite. The agreement is thus very good with the rock above described from Torpa Klint. On the other hand, in the same dyke of the latter there is present augite porphyrite of a type accordant with the Tolånga melaphyres, which proves beyond doubt that there exists an irrefutable connexion between the kullaite and the Scanian melaphyres.

Acid Fragments in the Basic Dykes.

In the basic dykes there are found larger and smaller fragments of a more acid composition, sometimes sharply delimited from the surrounding hypabyssal rock, in other cases partly incorporated in it and with indistinct margins towards it. A closer scrutiny discloses that these fragments represent a whole series of different types, ranging from easily recognizable granite-gneiss to amygdaloidal or nodular agglomerates mainly consisting of red feldspar.

A very characteristic feature with these acid enclosures is that they are rapidly syenitized. Whereas the larger fragments are generally still quartz-bearing, all the quartz has usually vanished in the smaller ones. Connected with the disappearance of the quartz, there was probably an influx of aluminium and alkalis. An enclosure of granite-gneiss measuring 2 × 5 dm displayed no very considerable divergencies compared with the surrounding granite-gneiss except that the quartz was partly accumulated in veins. In small fragments in the same dyke, however, quartz was entirely lacking, the texture also having changed and the rock presenting a porphyric appearance. Simultaneously with the change in the chemical composition from granitic to syenitic, there thus occurred a recrystallization, the granite-gneiss changing into a syenite porphyry. A syenitization of this kind appears to be a not infrequent occurrence with quartz-bearing rocks enclosed as fragments in basic hypabyssal and volcanic rocks. A very similar thing occurs when fragments of pure quartz are feldspathized and change into syenite-like rocks, mainly due to an introduction of alkalis and aluminium. In this connexion it is sufficient to refer to Doris Reynolds' investigations (*26, 27*). To a certain degree the fenitization may be said to be an aspect of the same process though of a special kind. A related phenomenon has been observed close to the contact of the kullaite dyke at Dalby, east of Lund (*12*, p. 258). There a very narrow, only 1—2 cm wide zone of an acid, aplitic gneiss has changed into a quartz-free syenite consisting of coarse tabular alkali-feldspar, acid plagioclase, chlorite, and calcite. The texture is not porphyritic, but otherwise the appearance very much reminds of the recrystallized and syenitized fragments of granite-gneiss in the basic dykes at Torpa Klint.

Under the microscope it is possible to follow the development from preserved to completely obliterated fragments. The first phase in the transformation of the granite-gneiss is expressed by the quartz assembling in lumpy masses or veins, the rock otherwise remaining unaltered. The next change is represented by a quartz-free or almost quartz-free, gneiss-textured rock whose feldspar consists of microcline-perthite and albite, which present a rather disintegrated appearance, but as regards form differ but slightly from the feldspars in the original granite-gneiss. Externally, the rock still resembles the original material. The metamorphosis continuing, a syenite porphyry results. In addition to the quartz having disappeared and the primary texture having changed, the feldspar has altered its character, the perthite having been replaced by homogeneous alkali feldspar. A completely new rock has thus arisen, which differs very decidedly from the original granite-gneiss. The last phase in the transformation, finally, *i. e.* the last in which it is possible to trace the position of the original material, involves amygdaloidal or nodular formations, mainly made up of feldspar, which hardly have any resemblance to the granite-gneiss originally present. In certain cases the alteration goes still farther. The basic rock then completely incorporates the original fragments and the result is a homogeneous rock of basic composition with alkali feldspar as a not inessential constituent of the ground-mass. Amygdaloidal feldspar aggregates may occur simultaneously. This final product is kullaite.

Fig. 15 shows a microphoto of a syenite porphyry occurring as an enclosure with its contact towards the surrounding basic dyke rock visible in the picture. In an allotriomorphically textured and rather coarse ground-mass, chiefly consisting of feldspar, large, tabular feldspar phenocrysts are dispersed. They consist partly of anorthoclase, which forms partially mottled grains with red pigmented marginal zones, partly of greatly disintegrated, in all probability potassic albite with fine twin lamellae. The anorthoclase has a small optic angle. On the universal stage direct measurements of a grain gave the result $2\,V_{\alpha} = 37°$. The feldspar of the ground-mass is a highly red pigmented potash feldspar which also occurs in rather large grains. Between the feldspar individuals there are more fine-grained parts, consisting of pyroxene, epidote, chlorite, apatite, magnetite, and carbonate. It is evident that there has been an influx of material into the fragment from the basic rock. In another similar syenitic fragment no pyroxene or epidote were seen, but instead a dark brown biotite.

The amygdaloidal or nodular formations that constitute the last visible remains of the original granite-gneiss fractures are composed of highly red pigmented feldspar, dark brown biotite, brown prismatic hornblende, and grains of ore. The middle is often filled out with calcite, chlorite or epidote. The feldspar is of a wide tabular form and consists largely of alkali feldspar. Due to the strong pigmentation it is not possible to secure reliable optic data. Also andesine with 30—35 % An occurs as lath-shaped individuals which grow into the amygdaloids from the surrounding basic rock.

In the kullaite dyke at Dalby there are numerous feldspar nodules of a type that closely resembles the one described above. Speaking of these formations, the author has previously (*12*, p. 254) pointed out their drusy character, borne out by the successive change into pure epidote, chlorite, and calcite amygdaloids. In the same place it was stated that no local assimilation of neighbouring rocks could be shown by the kullaite, but that, on the other hand, the possibility could not be denied that at greater depths the kullaite might have assimilated parts of the gneissic country rock (*12*, p. 262). Considering the evidence provided by the conditions at Torpa Klint, where the change from recognizable fragments of the country rock to feldspar-bearing amygdaloids or nodules can be followed, it is only reasonable to assume that also the feldspar-bearing amygdaloids in the Dalby kullaite represent original fragments of the country-rock gneiss.

The Syenite Porphyry Dyke.

The syenite porphyry dyke that occurs in the quarry at Torpa Klint is a bright red rock which immediately strikes the eye. No similar rock has ever been encountered among the post-Silurian dykes of Scania, so for this reason alone the syenite porphyry is of particular geological interest. The width of the dyke is 1—4 m, the strike N. 55°—80° W., and the dip 65° towards S.W.

In the middle of the dyke the rock is medium-grained. The colour varies from reddish brown to brick-red. The numerous feldspar phenocrysts are from 5—10 mm and have a wide tabular habit. Their colour is somewhat lighter brick-red than that of the surrounding rock. There are also isolated large, black biotite scales. Towards the contact the dyke becomes more fine-grained, the colour at the same time growing darker reddish brown or brownish violet. The feldspar phenocrysts, which are slightly smaller than in the centre of the dyke and of a lighter reddish brown or sometimes almost white colour, contrast sharply to the fine-grained ground-mass which usually shows a flow-structure.

Under the microscope the rock has the appearance of Fig. 16. Numerous large, fairly light phenocrysts of alkali feldspar lie in a fine-grained ground-mass, partly of flow-structure, which mainly consists of highly iron-oxide pigmented potash feldspar. Apart from the feldspar phenocrysts there are also isolated large biotite scales. Biotite, magnetite, apatite, chlorite, and calcite are further found in the ground-mass.

The large feldspar phenocrysts are idiomorphically developed. They are usually of a wide tabular form parallel to (010) with rectangular cross-sections. Otherwise the individuals are bounded by (110), $(1\bar{1}0)$, and (001). $(\bar{2}01)$ also occurs. However, (010) completely dominates the crystal habit, there thus being a distinct dissimilarity as compared with the feldspar phenocrysts in the rhomb-porphyries, which are bounded only by (110), $(1\bar{1}0)$, and $(\bar{2}01)$. The phenocrysts are partly turbid due to the presence of very fine sericite scales. The middle is usually clear, however, while the margins are strongly red pigmented. The crystals also occur in groups. Penetration twins do occur, but usually the phenocrysts form twins according to the Carlsbad law with (010) as the composition-plane. The optic angle is rather small. It was determined in 9 different grains, the following values for $2\ V_\alpha$ being obtained: 51°, 53°, 55°, 56°, 58°, 58°, 59°, 62°, 62°. Sometimes the optic angle is considerably greater in the marginal zone than in the kernel, a condition that appears to be common in alkali feldspars and probably indicates a decreasing soda-content towards the margin (*14*, p. 142). The index of refraction is low:

$$n_\alpha = 1.529 \pm 0.002.$$
$$n_\gamma = 1.536 \pm 0.002.$$

The extinction is generally uneven. The extinction angle on (010), measured to (001) cleavage, varies, and in one grain with an optic angle of 56° it was determined at 16°. Fine twin lamellae are often seen, albite as well as pericline lamellae, the latter, however, more rarely. Indications of grating-structure have also been observed. No visible perthite lamellæ or anything that might indicate a crypto-perthitic development have been observed. The crystallographic character is distinctly triclinic and the mineral should thus be classified as anorthoclase, although its optic properties do not coincide with those that usually characterize the latter mineral. However, the relationship between chemical composition and optic properties in the alkali feldspars acting as rock-forming minerals is too little known for it to be safe to pay any attention to the above-mentioned disagreement. Nor is it at present possible on the basis of the optic properties to calculate the proportions of potash and soda in the mineral (*39*, p. 357). Judging from the chemical analysis (see below) the feldspar is rich in soda.

The refractive index of the potash feldspar in the ground-mass is lower and and its optic angle is larger ($2\ V_{\alpha} = 75°$) than those of the phenocrysts. The ground-mass feldspar usually occurs as Carlsbad twins. No doubt also this feldspar is fairly rich in soda (cf. chemical analysis below), although not to the same degree as the phenocrysts.

The biotite is generally brown. The edges are sometimes of a greenish colour. The pleochroism is as follows:

$$\gamma = \beta \text{ brown} > \alpha \text{ pale straw-coloured.}$$

The double refraction is unusually high:

$$\gamma - \alpha = \text{ca. } 0.070.$$
$$2\ V_{\alpha} = 10°.$$
$$n_{\gamma} = 1.660 \pm 0.002.$$

The biotite brings to mind the biotite in the altered gneiss fragments that occur in the basic dykes, just as well as the entire syenite porphyry is very similar to the syenite-porphyritically developed fragments.

The magnetite usually forms small lumps without a crystal habit of their own, but also somewhat larger, well-developed octahedrons occur. In all probability it is titaniferous. The apatite is found in the shape of idiomorphic, 6-sided prisms up to one mm in length. Chlorite and calcite are secondary alteration products. The former replaces biotite and is often built up of small, fine spherulites. The calcite forms isolated spots in the feldspar phenocrysts, but also occurs in the ground-mass.

A chemical analysis of the rock has been made with the following result. Analyst S. Palmqvist.

Syenite Porphyry, Torpa Klint.

	Weight %	Mol. Prop.	Norm		Actual composition Weight %	
SiO_2	58.04	963	Q	6.3	Anorthocl ase phenocrysts	10.8
TiO_2	0.40	5	Or	35.7	Feldspar of the ground-mass	76.5
Al_2O_3	19.27	188	Ab	36.3	Biotite	9.2
Fe_2O_3	2.49	16	An	2.0	Apatite	0.9
FeO	2.63	37	C	4.9	Magnetite	2.6
MnO	0.10	1	Sal	85.2		100.0
MgO	1.22	30	Hy	5.2		
CaO	1.94	35	Mt	3.7		
Na_2O	4.25	69	Il	0.8		
K_2O	6.03	64	Ap	1.3		
P_2O_5	0.64	4	Fem	11.0		
CO_2	0.64	14	Cc	1.4		
H_2O^+	1.46	—	H_2O	1.5		
	99.11			99.1		
H_2O^-	0.61					

Or : Ab : An = 46.9 : 50.6 : 2.5.

Quantitative system: I (II). 5.1.3. Phlegrose.

The actual mineral composition has been obtained by volumetric measurements of two different slices. Quartz is found in the norm while there is no free quartz in the rock. Most likely the surplus of silica is concealed in the feldspar. The molecular proportions of Na_2O and K_2O are about the same. Even if the phenocrysts consisted of pure soda feldspar — which they do not — the feldspar of the ground-mass would contain nearly equal quantities of soda and potash feldspar. The 10.8 % for the feldspar phenocrysts may be too low a figure, however, and should be increased at the expense of the feldspar in the ground-mass.

Genesis of the Syenite Porphyry.

It has already been mentioned that there is a marked similarity between the syenite porphyry dyke and the fragments of granite-gneiss that have been changed into syenite porphyry and which occur in the basic dykes. In both cases we are concerned with a quartz-free rock containing anorthoclase phenocrysts in a ground-mass chiefly consisting of alkali feldspar with more potash than the phenocrysts. The same dark brown biotite that is characteristic of the syenite porphyry dyke is also encountered in a number of fragments which, however, and naturally enough, have a more varying appearance, due to different local influences from the surrounding basic rock. The biotite may therefore sometimes be replaced by brown hornblende of the same type as that encountered in the melaphyre.

The fragments of granite-gneiss which are developed as syenite porphyry are not only completely recrystallized; they have undergone such a change that it must be supposed that they have been remelted. In addition to the lumpy fragments themselves, syenitic veins have also been observed in the basic dykes, mainly consisting of alkali feldspar, which must have been in a magmatic stage with a power to intrude into the country rock. A similar phenomenon has been observed in the kullaite dyke at Dalby, where a narrow dyke of syenitic development and chiefly consisting of alkali feldspar, andesine, and epidote, emanating from the kullaite, intrudes not only the kullaite itself but also the country rock (*12*, p. 258). This dyke has the same composition as the nodular feldspar aggregates in the kullaite, which probably constitute original fragments of the country rock.

These circumstances lead to the conclusion that the syenite porphyry dyke in Torpa Klint has the same origin as the syenite porphyry fragments, *i. e.* that it is a regenerate part of the granite-gneiss melted by the basic magma and syenitized and then — as a result of tectonic influences — pressed upwards as a comparatively thick dyke into the rock above. There can be no doubt regarding the magmatic character of the syenite porphyry. As already mentioned the dyke presents an independent intrusive appearance. The texture is that of a primary solidifying and the size of the grains diminishes noticeably towards the contact, the rock simultaneously adopting a flow-structure.

The alkali ratio in the granite-gneiss as well as in the syenite porphyry is intermediary. In the former the feldspar consists of microcline-perthite and albite; in the latter of anorthoclase and sodic potash feldspar. For a direct comparison of the alkali relation in the two rocks, the alkalis were determined in a sample of granite-gneiss.

	Weight %	
	K_2O	Na_2O
Granite-gneiss	4.86	4.37
Syenite porphyry	6.03	4.25

Compared to the granite-gneiss the syenite porphyry thus shows a slightly higher potash content. The difference is too small, however, to be ascribed any great amount of importance. In all probability the alkali relation varies somewhat in different parts of the granite-gneiss.

Survey of the Post-Silurian Dykes of Scania.

Excepting the tertiary basalts, the younger basic dyke rocks of Scania may be classified under three headings, *viz.* quartz dolerites, melaphyres, and kullaites. The former, which Törnebohm gave the name Konga dolerites (*36*, p. 9), are, petrographically, above all characterized by the fact that the last crystallization product is quartz or a micropegmatitic mixture of quartz and alkali feldspar, very often constituting a not inconsiderable part of the rock. Other-

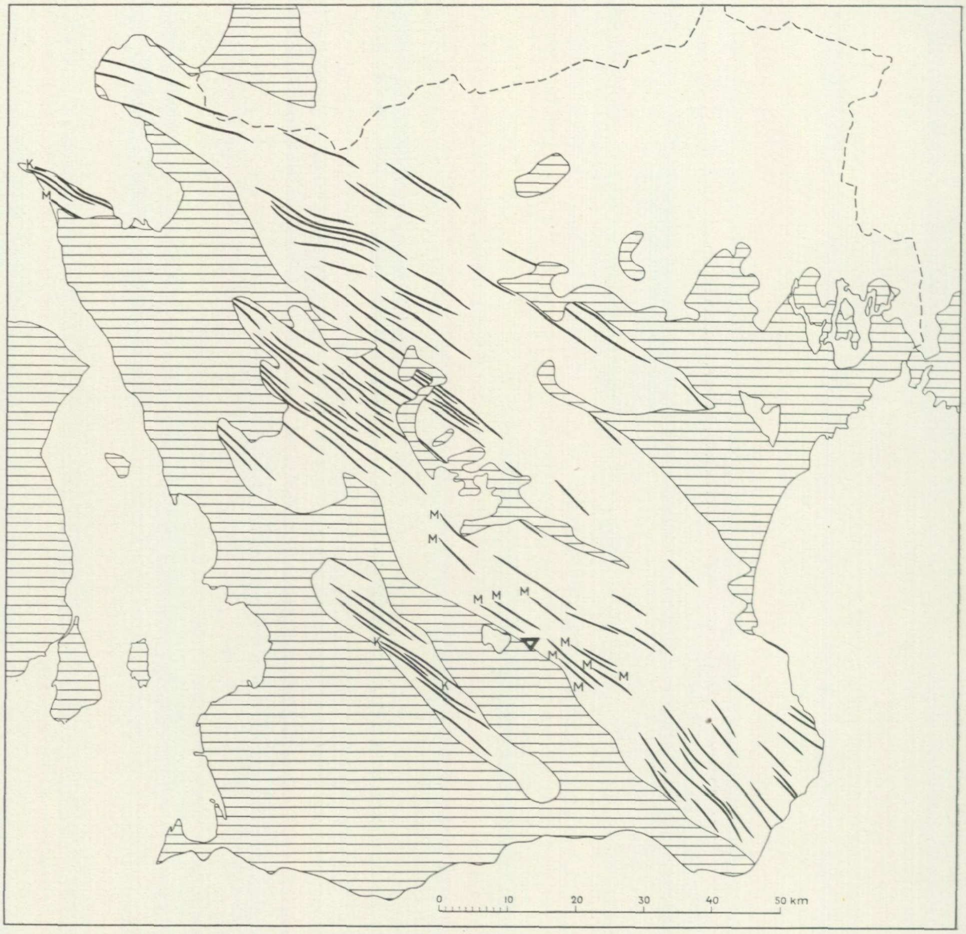

Fig. 2. Map showing the distribution of the younger dykes of Scania. Most of them are quartz dolerites. M = melaphyre. K = kullaite. Triangle = quarry at Torpa Klint. Mesozoic and younger deposits are lined, the pre-mesozoic rock has no designation.

wise it is composed of augite, labradorite, magnetite, and apatite. Olivine does not occur here. Olivine-bearing dolerites, however, are closely related to the Konga dolerites, so closely even that the marginal zones of the latter may be developed as olivine dolerite. Even narrow apophyses which emanate from Konga dolerites usually consist of olivine dolerite. It is thus impossible sharply to distinguish between these two types in field geology. Quartz dolerites, as well as subordinate olivine dolerites, form the large majority of the Scanian post-Silurian dykes (see map, fig. 2).

The melaphyres are far more basic than the quartz dolerites. In their typical form they are augite porphyrites, either of a type closely resembling limburgite with augite and olivine phenocrysts in a feldspar-free ground-mass, or else they are feldspar-bearing porphyrites, also with plagioclase phenocrysts.

In his paper on the Tolånga melaphyres (9, p. 12 ff.), Hadding published a number of analyses of melaphyres compared with analyses of Scanian quartz dolerites, which show the rather prominent chemical difference: Apart from the lower SiO_2-content, also a very much higher lime-content. The melaphyre magma seems to have been characterized by a large content of water, which often has resulted in an autometasomatic alteration of the original rock, when, *inter alia*, pyroxene and olivine have been replaced by chlorite and serpentine. This alteration may have been so thorough that the character of the primary rock no longer can be distinguished. Another result of the high content of volatile constituents is often a bountiful occurrence of amygdaloids. — The melaphyres are especially frequent within an area in central Scania east of Vombsjön, but isolated dykes of this type have also been found in other parts of the province (Fig. 2). It is probable that their number would be increased if a systematic inventory were made of the younger dykes of Scania.

As has been shown above, the kullaite is closely related to the melaphyres. It might really be looked upon as a variety of them, which under certain special conditions has adopted a composition and development which distinguishes it from the other Scanian dyke rocks. The kullaite is characterized by its comparatively high content of alkali feldspar, which occurs evenly distributed in the rock or accumulated in nodular aggregates. By autometasomatic alteration, the original pyroxene and olivine have been replaced by epidote, delessite, and carbonate, which also occur in the shape of amygdaloids. The author has earlier (*12*, p. 267) expressed his opinion that the kullaite originated from a basic dolerite magma, which by fractional crystallization was enriched in aluminium, alkalis, particularly potash, and water. Considering what has been learnt from the conditions at Torpa Klint, however, it must be thought highly probable that the kullaite received its special composition by the assimilation of other rocks. In other words, the kullaite arose from a watery basic magma, a melaphyre magma, which due to its volatile constituents had the ability actively to influence its country rock and in its turn to be influenced by it. Where it has penetrated the acid granite rocks of the Archaean it has absorbed parts of them and thus altered its composition as indicated above. Hypabyssal rocks of the kullaite type occur in several places in Scania. Naturally enough, however, they are rare as compared with quartz dolerites and true melaphyres. As is the case with the latter, the kullaites to would no doubt increase in number upon a general inventory being made of the Scanian dyke rocks.

The syenite porphyry at Torpa Klint stands out as quite a special type among the Scanian post-Silurian dykes. Its origin connects it with the kullaite and places it at the extreme end of the series melaphyre-kullaite-syenite porphyry.

Age and General Geological Significance of the Dykes.

The kullaite dyke at Dalby intersects an olivine dolerite dyke belonging to the post-Silurian dolerites, and is thus undoubtedly younger than that dyke (*12*, p. 267, *13*, p. 275). On account of the close relationship of the kullaite to the melaphyres, this might be thought to indicate that the kullaites as well as the melaphyres are considerably younger than the quartz and olivine dolerites of Scania, which — as far as the melaphyres are concerned — seems to have played in the minds of earlier writers. Thus Törnebohm says (*37*, p. 87) that the melaphyres must be younger than the Konga dolerites, »which is also indicated by their petrographic character». Hadding writes (*9*, p. 34) that it has not been possible to determine the exact age of the melaphyres, but that it appears probable that they are younger than the true dolerites of Scania. There is, however, no univocal and conclusive proof of this age difference. In his description to the map-sheet of Sövdeborg, H. Johansson says (*24*, p. 35): »The reasons produced to determine the different ages of the Konga dolerites and the Tolånga melaphyres cannot be attributed any great conclusiveness», and Troedsson states (*25*, p. 321) that »the proofs of such an age difference are, however, unreliable».

All the younger dykes that traverse Scania approximately N.W.—S.E. are tectonically closely related to each other. This tectonic uniformity combined with the fact that the dykes occur in a regionally rather limited area, make it seem little likely that they originate from widely different periods. Minor age differences are of course possible, as is demonstrated by the Dalby case related above, but on the whole the entire series of dykes probably belongs to the same tectonic epoch in the geological development of Scania. The fact that different petrographic types occur among the dykes need of course not imply that these types are of different ages.

What we know for certain regarding the age of the younger dolerites of Scania is that they intrude the Colonus shale (lower Ludlow) and are thus not older than Silurian (as a rule they have been called post-Silurian), and furthermore — on account of the occurrence of dolerite pebbles in mesozoic conglomerates — they must be older than the oldest mesozoic strata of Scania.

The intrusion of the Scanian dykes is closely connected with considerable tectonic movements, accompanied by faults in a N.W.—S.E.-ly direction, *i. e.* in the same direction as is represented by the dolerite dykes. These movements were in some cases earlier than the appearance of the dolerites, in others they were later, this indicating that there is a genetic connexion between them and that they belong to the same tectonic epoch. The Scanian dislocations in a N.W.—S.E. direction have usually been assumed to have originated already in the Palaeozoic era. Troedsson states, 1920, (*33*, p. 285) that the system of dislocations was distinct already in the beginning of that era. Hadding maintains (*10*, p. 46) that these dislocations (in the Röstånga field) must have occurred mainly in Palaeozoic times and after the Silurian period. The author arrived at the same result when studying faults on the south-western side of Romeleåsen (*13*, p. 288). After Holtedahl's work on young-Palaeozoic fossils in the Oslo area was published (*17*), Troedsson expressed as his opinion that the south-western boundary of the fault-block of northern Scania must mainly be Variscan (*34*, p. 226). These extensive movements of the earth crust were of great regional importance. They created a geological boundary between Fenno-Scandia and Central Europe. The N.W.—S.E.-ly dislocations of Scania thus demarcate the south-western border of Fenno-Scandia, which on the whole has the character of an enormous flexure along which the south-western part has sunk in relation to the north-eastern part.

The Scanian suite of younger dolerite dykes runs across the whole province from S.E. towards N.W. and there points out into the Kattegat (see map, fig. 2). The dolerite-bearing belt is sharply delimited towards N.E. and ceases simultaneously with the disappearance, in that direction, of the dislocations running from N.W.—S.E. Outside Scania similar hypabyssal rocks appear in the vicinity of Gothenburg and can then be followed in a narrow zone along the coast northwards to the Oslo field. These dykes are partly dolerites, partly rhomb-porphyries and augite porphyrites (madeirites, limburgites). The southern dykes, *i. e.* the dolerites in the vicinity of Gothenburg and in the middle parts of Bohuslän display a W.N.W.—E.S.E.-ly direction, thus in agreement with the Scanian dykes, whereas the rhomb-porphyries and the porphyrites of northern Bohuslän follow the coast and run predominantly northwards. That is also the predominant direction of the dykes in the Oslo field. There are, however, (according to verbal information received from W. Larsson) also other directions represented among the rhomb-porphyries of Bohuslän, also the Scanian N.W.—S.E. direction. As regards the age of these dykes, the rhomb-porphyries and the madeirites, etc., are direct offshoots from the Oslo field and are thus of the same age as that field. Statements regarding the age of the southern dolerite dykes have been rather vague and earlier authors have not dared to claim a direct connexion between them and the northern dykes. H. Johansson says (*23*, p. 68) that with reference to their petrographic character the dolerite dykes in the vicinity of Gothenburg are most closely related to the pre-Cambrian dolerites of middle Sweden, but that the obvious agreement as regards appearance and strike when compared with the Konga dolerites of Scania, indicates a younger, post-Silurian age. Ljungner expresses as his opinion (*20*, p. 115) that on the whole the W.N.W.-ly dykes in western Sweden petrographically best correspond to the post-Jotnian, pre-Cambrian dolerites of Sweden, but on the other hand states (*20*, p. 111) that petrographic conditions are not sufficient to indicate any definite age. This last statement is of course correct, generally speaking, even though under certain circumstances the petrographic character may be of great value when determining the age. It is, what more, quite evident from Ljungner's own statements (*20*, p. 112 ff.) that at least two of the west-Swedish dykes have their parallels among the post-Silurian dolerite beds of Västergötland.

The dykes in western Sweden are situated within a fairly narrow belt running from northern Halland northwards towards the Norwegian frontier. East of this belt there follows a wide zone in which dolerite dykes are lacking. Then we strike the area of the pre-Cambrian dolerites of middle and eastern Sweden. If the dykes in western Sweden really belonged to the last-mentioned group of dolerites, the above-mentioned dolerite-free zone would be rather difficult to explain. The dykes in northern Bohuslän belonging to the series of dykes of the Oslo field are located in the continuation of and within the same belt as the dolerite dykes of the Gothenburg district and middle Bohuslän. Geographically it is thus reasonable that the last-mentioned dykes be connected with the rhomb-porphyries of northern Bohuslän and that they thus be presumed to have been formed at the same time. As already mentioned, the N.W.—S.E. direction typical of the dykes in the southern part of the west-coast district, is also found among the rhomb-porphyries farther north, and furthermore the Oslo field includes dolerite dykes which both with regard to direction and petrographic character are closely related to the dykes occurring near Gothenburg. On the other hand, the latter form a bridge between the post-Silurian dykes of Scania and the dykes of the Oslo field and thus allow us to connect these two groups with each other.

The Oslo field is characterized, *inter alia*, by a profuse system of dykes in different directions, the north-southerly being predominant, however. Others, *e. g.* N.W.—S.E. or W.S.W.—E.N.E. are not so frequent (*18*, p. 349). The Oslo field is evidently a centre where different tectonic lines meet. Several petrographic types are represented among the dykes. In addition to common dolerites, there are rhomb-porphyries, porphyrites, and, on the whole, numerous dykes that have been given special names. The dykes are closely connected with the extensive dislocations in the Oslo field (*17*, p. 334) and in this respect correspond to the Scanian dykes connected with the N.W.—S.E. dislocations of Scania. As has been demonstrated by Holtedahl (*17*, *18*), the igneous rocks of the Oslo region are younger than the oldest Permian deposits and are very probably of Lower Permian age.

From the Oslo field a dolerite-bearing zone runs southwards along the Norwegian coast, the dykes on the whole running parallel to the coast. The condition is fairly similar to that above described from Bohuslän, where dykes from the Oslo field continue southwards in a narrow zone along the west-coast of Sweden and parallel to the coast. In the Kongsberg field there exist E.N.E.—W.S.W. dolerite dykes which are closely related to the rocks of the Oslo field (*7*, p. 102 ff.), and farther south, in the neighbourhood of Arendal, there are found dykes of rhomb-porphyry and dolerite (*32*) which must also be considered as offshoots from the Oslo field. Their direction is approximately N.E.—S.W., *i. e.* they run fairly parallel to the coast in this region. Farther westwards the coast-line curves towards N.W. and N., the dolerite dykes changing their direction in an analogous manner. Thus in the coastal belt at Ekersund in south-western Norway there are dolerite dykes of post-Silurian age, running W.N.W.—E.S.E. (*19*, p. 204), and farther north, in the district south of Bergen, we find post-Silurian dykes of melaphyre with a northerly or north-west by northerly direction, *i. e.* parallel to the main direction of the coast in those parts (*28*, p. 32).

This dolerite-bearing belt which can be followed along the Norwegian coast from the vicinity of Bergen through the Oslo region to the Swedish frontier and which then continues along the west-coast of Sweden and turns up in

Fig. 3. The young-Palæozoic dykes on the southern and south-western margin of Fenno-Scandia and in northern England and Scotland.

Scania, seems to represent a zone of weakness, of tectonic origin, in the earth-crust, within which zone, and at a certain stage, dolerites and other hypabyssal rocks penetrated, frequently apparently in connexion with considerable dislocations. As is the case in Scania, the whole of this zone probably has the character of an enormous flexure forming Fenno-Scandia's boundary towards the south and south-west. Holtedahl has pointed out (*18*, p. 356) that the dislocations of the Oslo fjord may quite naturally be considered to be structurally closely related to the N.W.—S.E. dislocations of Scania, and this conception is emphasized by Störmer (*31*, p. 103). According to Holtedahl the Oslo field is most probably Lower Permian. The dislocations there are compared to Stille's »saalic» phase in the Variscan folding (*17*, p. 334). Owing to the uniform character of the entire dolerite-bearing south-western marginal zone of Fenno-Scandia, it is reasonable to suppose that the whole of this zone originated during the same epoch and, similarly, that the dykes occurring here and connected with the zone are practically of the same age. Both westwards along the Norwegian coast and southwards along the coast of Sweden, these dykes are directly or indirectly connected with the Oslo field. The natural conclusion is thus that all these dykes, usually considered to be post-Silurian, from the west-coast of Norway to the south-eastern point of Scania, very probably are mainly Lower Permian, and that the dislocations, too, which created the S.W. boundary of Fenno-Scandia, are of the same age and belong to the Variscan movements in Europe. On the whole, the Lower Permian epoch was in very great parts of Europe a time characterized by very intensive volcanic activity and in this respect differs quite considerably from Upper Carboniferous as well as Zechstein. The boundary-line mentioned then gets another, general significance, *viz.* as the northern boundary of the Permian sea, to Scandinavia.

On the other side of the North Sea (see map, fig. 3) we find a similar belt of dykes of Lower Permian or Permo-Carboniferous age, in Great Britain (*8*, *16*, *21*, *29*). The dykes there are predominantly of an E.—W. or E.N.E.—W.S.W. direction. The majority appear to consist of quartz-dolerites, the same types being found there as are the most common ones in the Scanian dykes. It seems probable that also the British dykes belong to the system of dyke rocks that has been described above and that the appearance of all these dykes is connected with the Variscan movements in North and North-Western Europe.

Notes on the illustrations.

The map fig. 2 is based on a map of Scania compiled by J. Eklund (*22*, Pl. 4). Some boundaries have been corrected on the basis of observations made during the geophysical investigation of south-western Scania which is still going on. The dolerite dykes have been entered mainly according to the Geological Survey of Sweden's map-sheets in the scale 1 : 50,000. For northern Scania an unpublished map by H. E. Johansson has been used. In some cases the map has been supplemented on the basis of the author's own observations.

Fig. 3 is compiled of material from different sources and it is thus not quite uniform as regards the values. The Scanian dykes have been entered according to fig. 2. For Western Sweden maps found in the publications of the Geological Survey of Sweden have been used, completed with a map in Ljungner's paper on the Swedish Skagerrack coast (*20*). In the Oslo field only the dykes of rhomb-porphyry have been indicated, mainly on the basis of Brögger's data (*4*). They must be considered representative in this case. To my knowledge there exists no uniform general map of the very numerous dykes in the Oslo field. For the remaining parts of southern and south-western Norway I have used maps by Bugge (*7*), Suleng (*32*), Kolderup (*19*), and Reusch (*28*). The dykes in Northern England and Scotland have been reproduced from Richey (*29*) and Eastwood (*8*).

Of the microphotos, figs. 8, 15, and 16, were taken by A. Karlsson, the remainder by the author.

List of references.

1. Bailey, E. B. and Holtedahl, O., Northwestern Europe Caledonides (Reg. Geol. d. Erde, Bd 2: Palaeoz. Tafeln u. Gebirge). Leipzig 1938.
2. Becker, H., Mittel- und Westeuropa (Reg. Geol. d. Erde, Bd 2: Palaeoz. Tafeln u. Gebirge). Leipzig 1938.
3. Brögger, W. C., Die Eruptivgesteine des Oslogebietes. VI. Über verschiedene Ganggesteine des Oslogebietes. Norske Vid. Akad. skrifter. 1932. No. 7.
4. — Om rombeporfyrgangene og de dem ledsagende forkastninger i Oslofeltet. N. G. U. Nr 139. Oslo 1933.
5. Bubnoff, S. von, Geologie von Europa, I. Berlin 1926.
6. Bugge, A., Flesberg og Eiker. Beskriv. til de geologiske gradavdelingskarter F. 35 Ø og F 35 V. N. G. U. Nr 143. Oslo 1937.
7. Bugge, C., Kongsbergfeltets geologi. N. G. U. Nr 82. Kristiania 1917.
8. Eastwood, T., Northern England. (British Regional Geology). London 1935.
9. Hadding, A., Iakttagelser över melafyrerna i Tolångatrakten. Lunds univ. årsskrift. N. F. Avd. 2, Bd. 13. Lund 1916.
10. — Tektoniska och petrografiska undersökningar inom Fennoskandias södra randzon. I. Röstångafältet. Lunds univ. årsskrift. N. F. Avd. 2, Bd 19. Lund 1922.
11. Hennig, A., Kullens kristalliniska bergarter. II. Den postsiluriska gångformationen. Lunds univ. årsskrift. Bd. 35. Lund 1899.
12. Hjelmqvist, S., Kullait von Dalby. G. F. F. Bd 52. 1930.
13. — Dalby stenbrott. En geologisk detaljstudie inom Skånes horstområde. G. F. F. Bd. 53. 1931.
14. — Zur Geologie des südschwedischen Grundgebirges. Die kristallinischen Gesteine des Romeleåses. Lund 1934.
15. Holmes, A., Transfusion of quartz xenoliths in alkali basic and ultrabasic lavas, South-west Uganda. Min. Mag. Vol. 24. 1936.
16. — and Mockler, G. S., Late carboniferous and tertiary intrusions. In Contributions to the geology of Northumberland and Durham. Proc. Geol. Assoc., Vol. 42. 1931.
17. Holtedahl, O., Jungpaläozoische Fossilien im Oslogebiete. Eine vorläufige Mitteilung. Norsk geol. tidsskrift. Bd 12. 1931.
18. — and others, The geology of parts of Southern Norway. Proc. Geol. Assoc., Vol. 45. 1934.
19. Kolderup, C. F., Die Labradorfelse des westlichen Norwegens. Bergens Museums Aarbog 1896.

20. Ljungner, E., Spaltentektonik und Morphologie der schwedischen Skagerrakküste. Bull. Geol. Inst. Univ. Upsala. Vol. 21. 1927.
21. Macgregor, M. and Macgregor, A. G., The Midland Valley of Scotland. (British Regional Geology). Edinburgh 1936.
22. Molin, K., A general earth magnetic investigation of Sweden. I. S. G. U. Ser. Ca. N:o 25. Stockholm 1936.
23. Munthe, H., Johansson H. E. and Sandegren, R., Göteborgstraktens geologi. Göteborg 1924.
24. — Johansson, H. E. and Grönwall, K. A., Beskrivning till kartbladet Sövdeborg. S. G. U. Ser. Aa. N:o 142. Stockholm 1920.
25. Ramsay, W., Geologiens grunder. 3 uppl. omarb. av P. Eskola, B. Asklund, G. Troedsson och M. Sauramo. Bd II. Stockholm 1931.
26. Reynolds, Doris L., Demonstrations in petrogenesis from Kiloran Bay, Colonsay. I. The transfusion of quartzite. Min. Mag. Vol. 24. 1936.
27. — Transfusion phenomena in lamprophyre dykes and their bearing on petrogenesis. Geol. Mag. Vol. 75. 1938.
28. Reusch, H., Bömmelöen og Karmöen med omgivelser. Udg. af Den geol. undersögelse. Kristiania 1888.
29. Richey, J. E., The dykes of Scotland. Trans. Edin. Geol. Soc. Vol. 13. 1939.
30. Rosenbusch, H. u. Osann, A., Elemente der Gesteinslehre. Stuttgart 1923.
31. Störmer, L., Contribution to the geology of the southern part of the Oslofjord. Norsk geol. tidsskrift. Bd 15. 1935.
32. Suleng, H., Spaltedannelser og yngre eruptiver i Arendal-Grimstad-trakten. Naturen 43. Bergen 1919.
33. Troedsson, G., Skånes Dalmanitesskiffer, en strandbildning. G. F. F. Bd 42. 1920.
34. — Några tektoniska och stratigrafiska problem i Skåne. G. F. F. Bd 54. 1932.
35. Törnebohm, A. E., Augitporfyr i trakten af Strömstad. G. F. F. Bd 3. 1877.
36. — Om Sveriges vigtigare diabas- och gabbroarter. K. V. A. Handl. Bd 14. Nr 13. Stockholm 1877.
37. — och Hennig, A., Beskrifning till blad 1 & 2. S. G. U. Ser. A_1a. Berggrundskartor med beskrifningar. Stockholm 1904.
38. Werenskiold, W., Fornebolandet og Snarøen i Østre Baerum. N. G. U. Nr 58. Kristiania 1911.
39. Winchell, A. N., Elements of optical mineralogy. II. Third ed. New York 1933.

Fig. 4. Granite-gneiss, Torpa Klint. × 20. + nic.

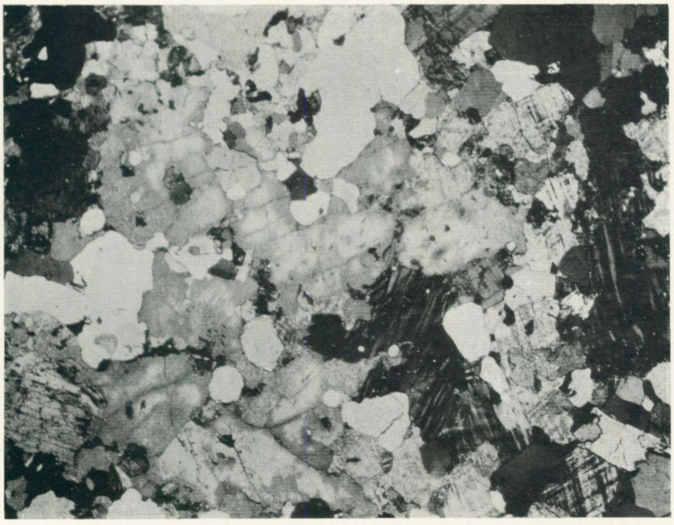

Fig. 5. Altered granite-gneiss, Torpa Klint. × 20. + nic. The light grey, mottled grains in the middle are anorthoclase.

Fig. 6. Anorthoclase individual in altered granite-gneiss. × 30. + nic.

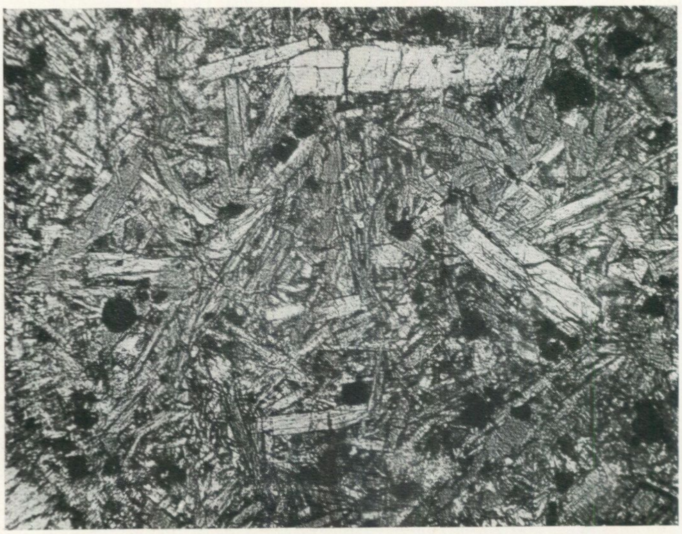

Fig. 7. Melaphyre, Torpa Klint. × 60. 1 nic. Detail of the groundmass rich in hornblende.

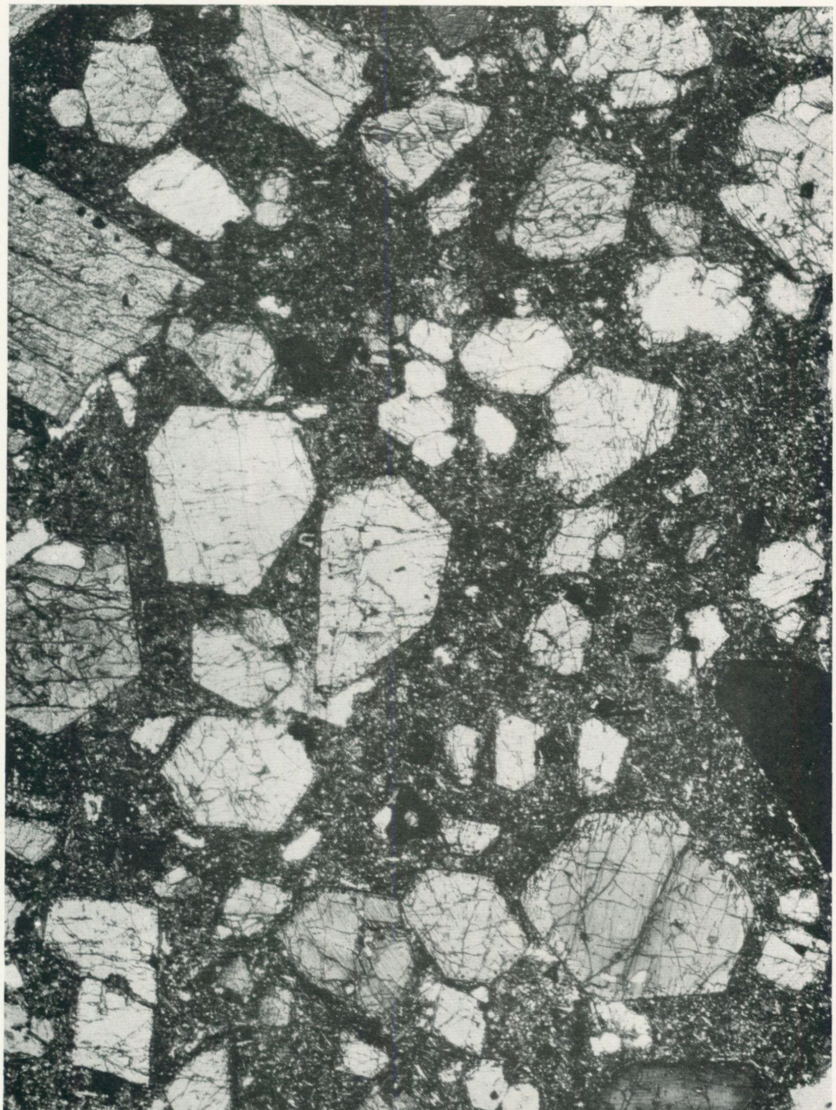

Fig. 8. Melaphyre, Torpa Klint. × 10. 1 nic.

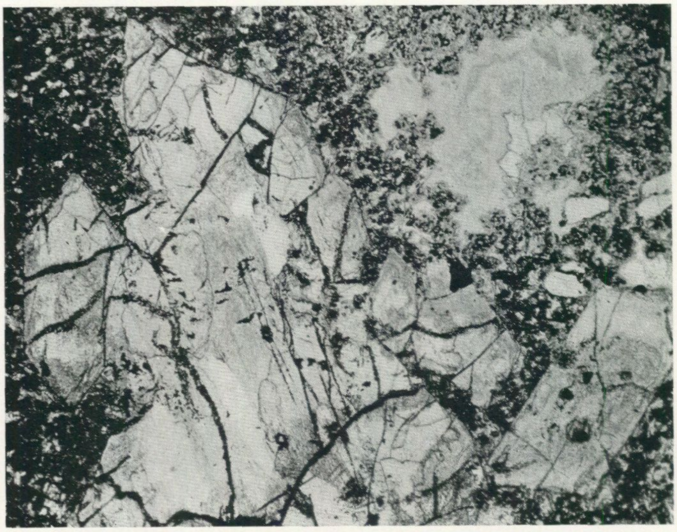

Fig. 9. Olivine pseudomorph in melaphyre. × 20. 1 nic.

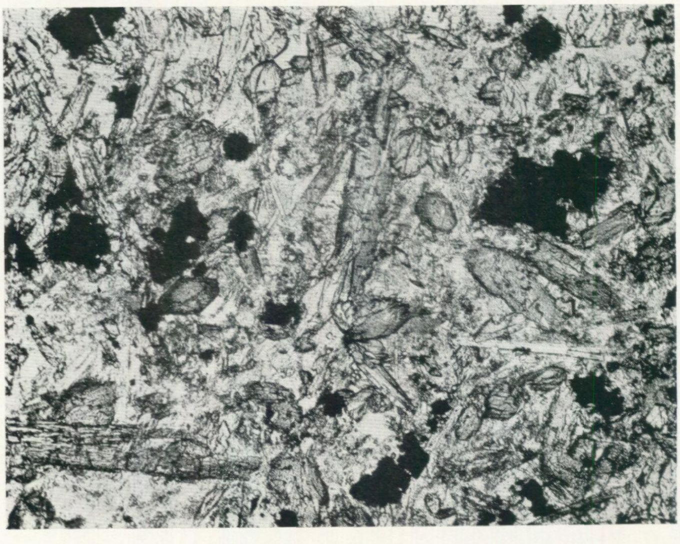

Fig. 10. Marginal zone of melaphyre, Torpa Klint. × 60. 1 nic. Chiefly hornblende and magnetite in a ground-mass rich in feldspar.

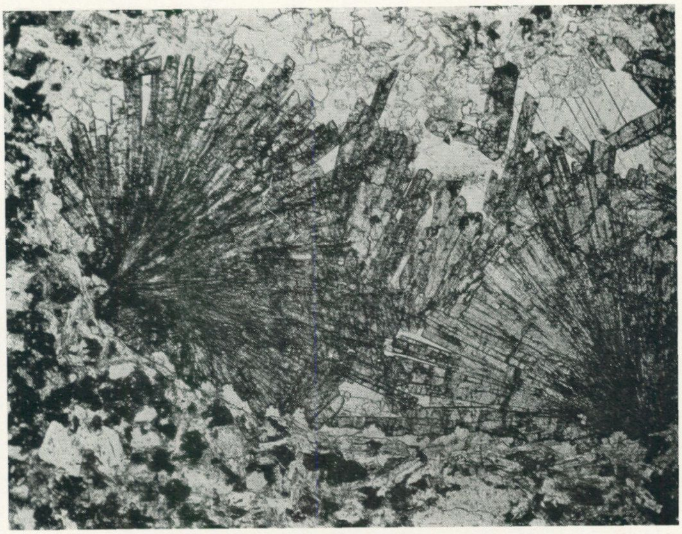

Fig. 11. Divergent bundles of epidote in a calcite-epidote amygdaloid. × 20. 1 nic.

Fig. 12. Amygdaloidal formation of red pigmented feldspar, hornblende, and magnetite, and with a kernel of epidote and calcite. × 30. 1 nic.

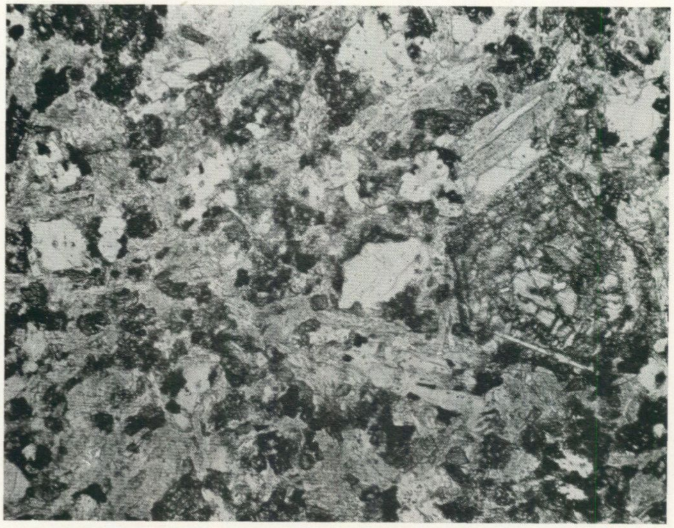

Fig. 13. Kullaite, Torpa Klint. × 30. 1 nic. To the right a large grain of augite. Otherwise chiefly andesine, alkali-feldspar, and delessite.

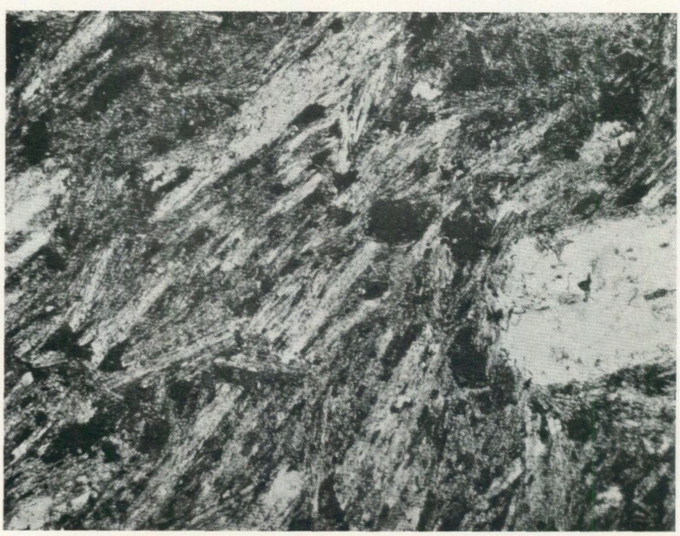

Fig. 14. Syenite porphyry, Torpa Klint. × 60. 1 nic. Detail of the ground-mass with flow-structure.

Fig. 15. Fragment of granite-gneiss altered to syenite porphyry. × 10. 1 nic. In the upper part of the picture the surrounding basic dyke rock.

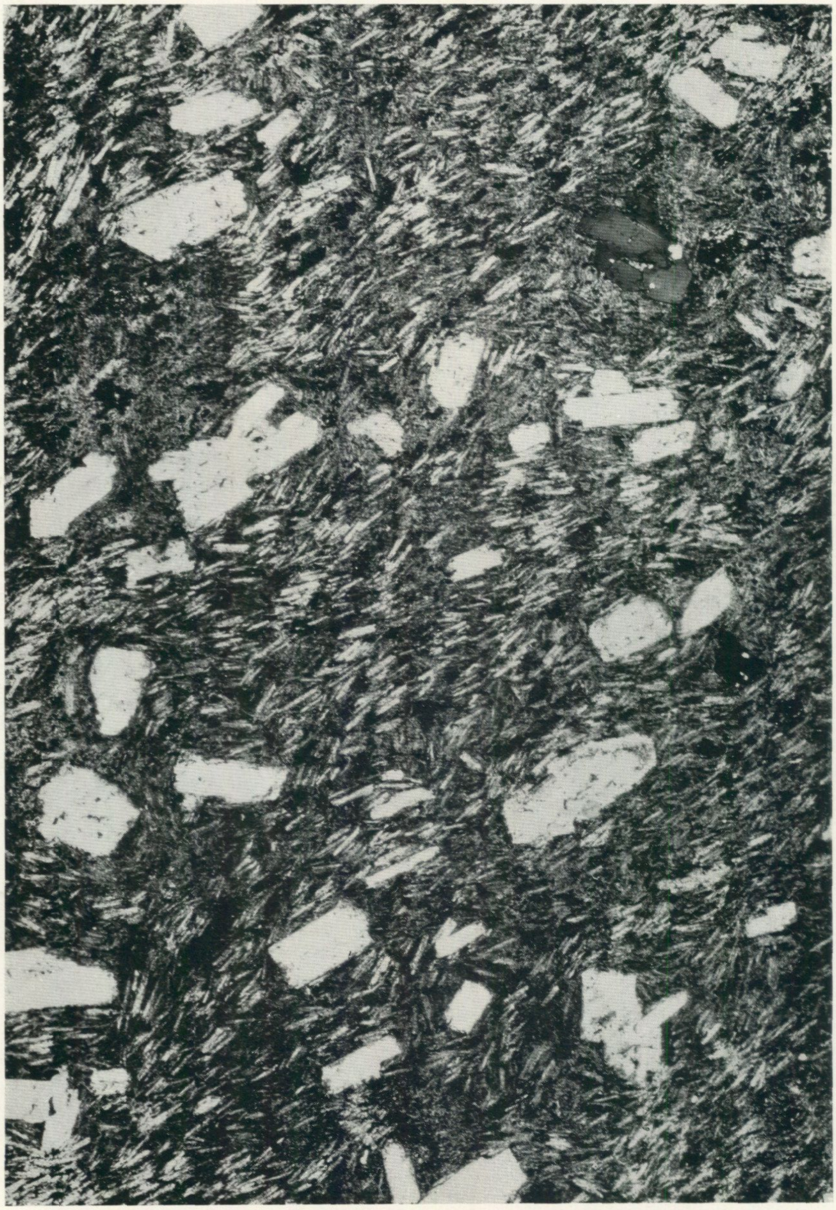

Fig. 16. Syenite porphyry, Torpa Klint. × 10. 1 nic.

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