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# THE LARVIK—LANGESUND AND THE FEN AREAS

Larvikite and nepheline syenite pegmatite minerals  
per-alkaline rocks

## SOUTH NORWAY

Guide to excursions no. A 12 and no. C 8.

by

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Excursion no. A 12: Aug. 11th.–Aug. 14th. 1960.  
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## INTRODUCTION

The two neighbouring areas which will be visited are situated on and near the Skagerrack coast, approximately 150 km south of Oslo. Inland from the "skjærgård" (a series of skerries) and the coastal lowland, the elevation gradually increases into the hill country. The river Lågen reaches the coast at the town of Larvik, and the lake Norsjø is drained by the river Skien-elva which flows by the towns of Skien, Porsgrunn, and Brevik out into the Langesundsfjord. The Langesundsfjord marks the boundary between the county of Vestfold (west of "Fold", the ancient name for Oslofjord) to the east and the county of Telemark to the west.

The so-called "Ra", quaternary terminal moraine, which traverses the coastal districts in a NE-SW direction, forms widely cultivated land.

### *The Towns:*

*Larvik:* (pop. 11 500). Shipping, whaling, timber and timber products (the latter represented by the large estate Treschow-Fritzøe). The natural mineral water "Farris" comes from King Haakon's spring in the town. The beech forest seen to the north of the town, is situated on a part of the Ra moraine.

*Skien:* (pop. 15 200). One of the oldest towns in Norway and the administrative centre of the county of Telemark. The town's industry and export trade are based upon timber. There are two waterfalls and a sluice right in the town.

*Langesund:* (pop. 2200). This town exports much fish and has a canning industry (shrimps). It also has a ship-yard and is a pilot-station.

## THE GEOLOGY OF THE LARVIK—LANGESUND DISTRICT

By Ivar W. Oftedal

Geologically the Larvik—Langesund district includes the south west boundary of the Oslo Region. In the district around Larvik the predominant rock type is *larvikite*, a Permian monzonite. In the western part of the Langesundsfjord area, the larvikite cuts the sequence of Cambro-Silurian sediments and Permian sediments and lavas along a curved boundary line. See the maps figs. 1 and 2. The westernmost part of the map area is occupied by the *Precambrian gneisses* of the Bamble area. At the boundary just west of the town Langesund the sub-Cambrian peneplane and the lower Cambro-Silurian strata are seen to dip gently eastwards (Rognstrand). Farther east the dip of the strata increases until it becomes nearly vertical at the boundary towards the larvikite (Aroy, Stokøy). This structural feature is largely due to a series of *Permian normal faults*, most of them parallel to the strike, as described in detail by W. C. Brøgger (1883).

The main body of larvikite consists of a rather uniform rock type. But as the western boundary is approached, i.e. essentially on the islands of the Langesundsfjord, the larvikite is extensively penetrated by small and larger veins and bodies of a medium grained and often "schistose" nepheline syenite, which Brøgger named *ditroite*. The ditroite is decidedly younger than the larvikite, but the difference in age seems to be very slight. In the close vicinity of the boundary line the ditroite is the dominating rock type. Locally it contains xenoliths of altered and deformed rhomb porphyry and basalt which represent fragments of the Permian lava beds. In this boundary zone *nepheline-syenitic pegmatite dikes* are very abundant. The majority of these are quite small irregular veins, often not even particularly coarse grained. A few form platy bodies as much as some meters in thickness. Two of the larger

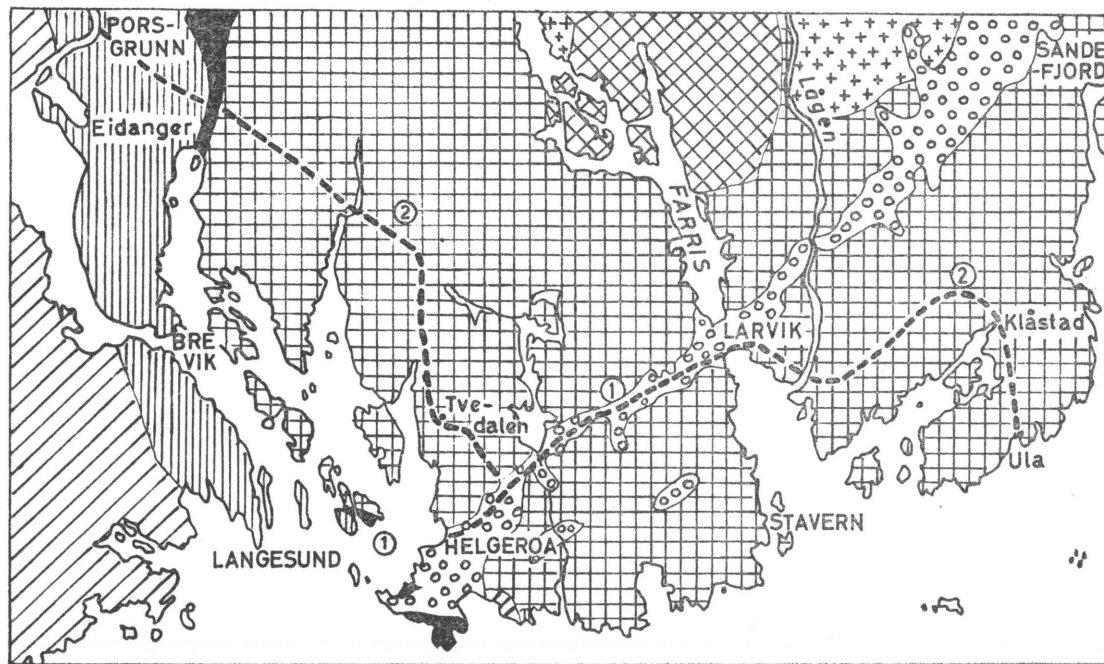
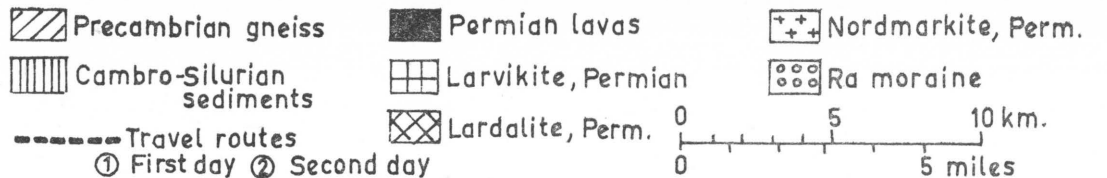


Fig. 1.

Route map for first and second day.

ones – the one forming the southern point of Stokøy and the “roof” of the islet of Låven, and the one in the islets of Skutesundskjær – will be visited by the excursion. See fig. 2. More than 70 mineral species are known from the Langesundsfjord pegmatites (Table 1). Many of these were originally described from these localities, and some are still unknown outside this area. The occurrence of rare minerals in the Langesundsfjord area was discovered as early as about 1830. Since then many prominent mineralogists have visited the deposits. The Langesundsfjord pegmatites gained world fame especially through the large monograph by W. C. Brøgger (1890).

In the autumn of 1894 a very intensive “Thorite Rush” started in the Kragerø district (30 km SW of Langesund) and also in the Langesundsfjord. It came to an end already in the spring of 1895, as the temporary high price of thorium suddenly dropped because of the discovery of the monazite sand in South America. To a visitor nowadays it seems almost incredible that the Langesundsfjord pegmatites have once been the object of thorite prospecting, as thorite is really very scarce in these deposits.

*Låven* (“the barn”) is an islet a couple of hundred feet across and less than 30 feet high. It is made up of altered basalt (augite porphyry) covered by a sheet of coarse grained nepheline-syenite pegmatite dipping gently southwards. The pegmatite is locally very rich in rare minerals. The surface of the pegmatite has been extensively and repeatedly blasted by mineral searchers and is now covered by loose rock fragments, among which many good mineral specimens may be found. Altogether Brøgger observed more than 30 mineral species in this locality.

*Skutesundskjær* is really two small islets nearly connected at low water. Also here the pegmatite has been extensively blasted, and large and small rock fragments are found scattered over the surface. The pegmatite here – as opposed to the Låven pegmatite – occurs in the larvikite itself, some 2 km from the boundary.

The *larvikite* is one of the most important and perhaps the most characteristic of the deepseated rock types of the Oslo Region. It belongs to the oldest members of the main sequence of Oslo igneous rocks. The corresponding lavas are rhomb porphyries. The larvikite was classified by Brøgger as “augite syenite”, but it really is a monzonite containing much alkali feldspar, which is often a schillerizing cryptoperthite, and plagioclase of the peculiar “rhomb feldspar” type. The appearance may vary considerably. East of

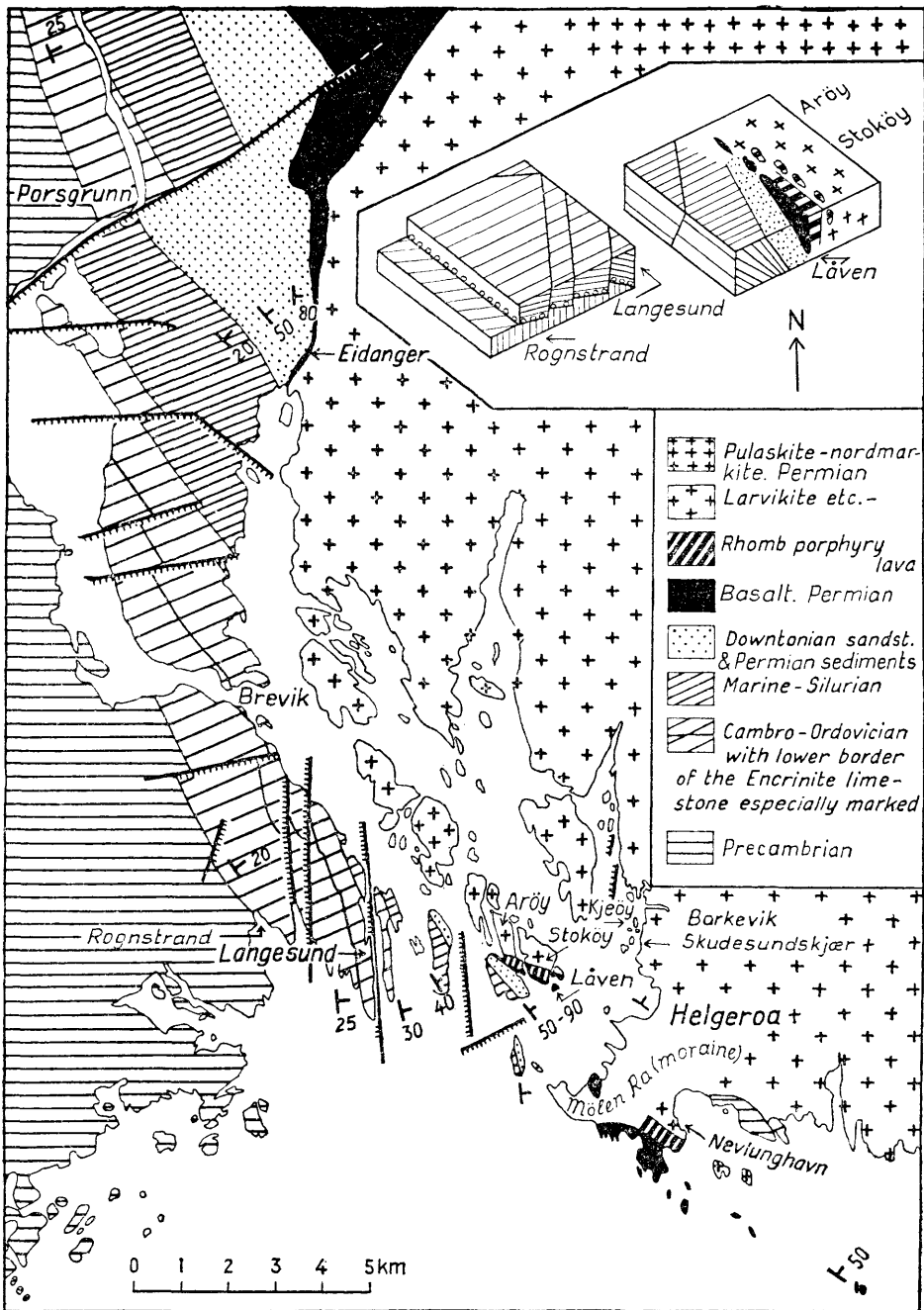


Fig. 2.

Sketch map of the Langesundsford area. Rhomb porphyry at Arøy and Stokøy mostly occurs as xenoliths in ditroite.

Table 1  
**MINERALS OF THE LANGESUNDSFJORD  
 PEGMATITES**

(For details see Brøgger's monograph, 1890)

Chief minerals.

Alkali feldspar, mostly microperthite.  
 Nepheline, often altered into a mixture of zeolites.  
 Sodalite, mostly altered into natrolite (Spreustein).  
 Aegirite. Barkevikite and related hornblendes.  
 Lepidomelane.

Ordinary accessory minerals.

Magnetite, titaniferous.  
 Sphene. Zircon. Garnets.  
 Fluorite.  
 Molybdenite. Sphalerite. Galena. Chalcopyrite.

Some interesting "rare" minerals. Characteristic elements indicated.

Occurrence in Låven (L.) and Skutesundskjær (Sk.) shown by +.

		L.	Sk.
Arsenides			
Löllingite	Fe	+	
"Niobates"			
Pyrochlore	F, Na, Ca	+	+
Hydroxides			
Hydrargillite	Al		(+)
Diaspore	Al		
Borates			
Nordenskiöldine	Sn, Ca		
Hambergite	Be		
Silicates			
Thorite	Th	+	+
Astrophyllite	Ti, Zr, Fe, Mn, K, Na, Ca	+	+
Catapleiite	Zr, Na	+	+
Eucolite	Zr, Nb, Fe, Na, Ca	+	+
Eudidymite	Be, Na		
Datolite	B, Ca		
Homilite	B, Ca, Fe		
Cappelenite	B, Y, Ce, Ba, Ca, Na		
Melanocerite	B, F, Zr, Ce, Y, Ca, Na		
Karyocerite	B, F, Zr, Ce, Y, Th, Ca, Na		
Tritomite	B, F, Zr, Ce, Ca	+	
Wöhlerite	F, Zr, Ca, Na	(+)	+
Låvenite	F, Zr, Ca, Na, Mn	+	
Rosenbuschite	F, Zr, Ti, Na, Ca, Fe		+
Mosandrite	F, Zr, Ti, Y, Ce, Ca, Na	+	+
Meliphanite	F, Be, Ca, Na, Al		
Leucophanite	F, Be, Ca, Na	+	(+)
Cancrinite	CO <sub>3</sub> , Na, Ca, Al	(+)	
Helvite	S, Be, Mn		

Larvik, in the parish of Tjølling, and near Helgeroa particularly beautiful varieties are quarried for various ornamental purposes (great amounts for export). Two quarries will be visited by the excursion.

In the Larvik district the larvikite contains numerous small *pegmatitic veins and dikes*. These sometimes exhibit beautiful coarse grained cryptoperthite (Brøgger 1890, Oftedahl 1948) which may in some cases deserve the name of moonstone. Such a pegmatite dike will be visited at the bathing resort Ula. The larvikite pegmatites may also contain some rare minerals, notably zircon (whence the old name "zircon syenite"), pyrochlore and polymignite.

## THE PER-ALKALINE ROCKS OF THE FEN AREA

*By Sveinung Bergstøl and Sverre Svinndal*

The Fen area lies near Ulefoss in Telemark, 119 km southwest of Oslo and 12 km west of the boundary of the Oslo region. The Precambrian basement in the area has been invaded by per-alkaline rocks and carbonatites over an area of about 5 square kilometres.

The area has been investigated and described by, inter alia, W. C. Brøgger (1921) and Egil Sæther (1957).

Mining operations for iron ore (rødberg, see below) took place in the area from 1652 to 1927 and since 1953 A/S Norsk Bergverk, Søve Gruver, has been mining niobium ore.

The geological mapping has been based on small and infrequent exposures since most of the area is heavily covered. Many of the rocks described below are only found as erratic blocks.

The age of the Fen area was considered by Brøgger to be Eocambrian; later attempts were made to correlate it with the Permian igneous rocks of the Oslo Region on the basis of the similarities between the two. Faul and coworkers (1959) carried out K/Ar age determinations on biotite occurring in søvite and arrived at an age of 565 million years. Sæther (1957) determined Th/Pb ages on columbite, koppite and zircon. He obtained a result between 400 and 600 million years. An unpublished K/Ar determination on K-feldspar from a hollaite pegmatite gave an age of 413 million

years (P. Schmidlin and W. Gentner). In this connection it may be mentioned that the petrologically similar Alnø area in Sweden has, in the opinion of von Eckermann, "a late or post-Jotnian" age. A preliminary determination of the maximum age of the Alnø rocks by U and Th in pyrochlore from søvite gave the result: 563 million years. (Eckermann & Wickmann 1956.)

The main rock types in the Fen area are:

*Fenite*

*Urtite-ijolite-melteigite-vipetoite*

*Søvite*

*Rauhaugite*

*Hollaite*

*Rødberg*

*Kimberlite (damtjernite)*

*Fenite* is an alkali syenite and is found in the peripheral parts of the Fen area. The main minerals in the rock are alkali feldspar, partly as a characteristic microperthite, aegirine, aegirine-augite and minor Na-amphibole. Apatite, zircon and pyrite occur as accessory minerals. Quartz is not found in the most typical fenite, but otherwise it occurs in greatly varying amounts.

The gneiss which surrounds the Fen area is a granitic gneiss with occasional layers of mica schist and some areas of amphibolite. The ratio oligoclase to microcline is generally 1 to 1. This gneiss is fenitized towards its boundary against the Fen area. The first sign of fenitization is that the biotite is replaced by aegirine and soda amphibole, at times also by iron oxide. Nearer to the complex the microcline of the gneiss, and later also the plagioclase, are substituted by a microperthite. Nepheline and calcite are also usual in typical fenite.

In some places the fenite constitutes only a narrow zone between the Fen rocks (see below) and the gneiss. Frequently granitic breccias also occur in this zone, consisting of gneiss fragments in a groundmass of finely crushed granitic material. These breccias also show transitions to kimberlite breccias (see later) where the gneiss fragments become scarce and the groundmass is a fine-grained kimberlite with biotite phenocrysts.

In the more central parts of the Fen area occur several different basic rocks, all of which are normally lacking in feldspar.

*Urtite*, consisting mainly of nepheline (70–90%), together with pyroxene and biotite.

*Ijolite*, consisting of nepheline and aegirine-augite in equal amounts.

*Melteigite*, which has aegirine-augite as its main constituent, with up to 30 % nepheline.

*Vipetoite* consists of augite, amphibole, biotite and minor calcite.

Titanomagnetite, apatite, pyrite, titanite, and occasionally melanite and cancrinite, occur as accessories in the rocks.

The above rocks have partly an hypidiomorphic texture and thus resemble igneous rocks.

Along the boundaries between the fenite and these basic rocks occur transitional types containing nepheline, feldspar, pyroxene, biotite and melanite. They are partly coarse-grained and partly fine-grained rocks. Brøgger (1921) has called them:

*Juvite*, which is a nepheline syenite with orthoclase, nepheline, aegirine, biotite and a little calcite.

*Tveitåsite*, a melanocratic rock consisting of alkali feldspar and aegirine-augite (shonkinite).

*Kampreite*, a melanocratic rock with alkali feldspar and biotite.

*Malignite*, consisting of alkali feldspar, nepheline and aegirine-augite.

*Tinguaite*, a leucocratic dyke rock.

These rocks have their widest development in the southern part of the Fen area, but they are also to be found in the northern part. They are invariably surrounded, and always separated from the basement rocks, by a zone of fenite. Within the actual melteigite there is also found pulaskite fenite.

Brøgger (1921) and Sæther (1957) were of the opinion that these basic rocks are magmatic. Sæther states further that the origin of such a magma is difficult to conceive, it must have had a long history of differentiation or assimilation before it could give rise to such end products.

Harry von Eckermann (1948) has shown that the melteigite-ijolite series in the Alnø area in Sweden has a metasomatic origin, and has been formed from the Precambrian rocks by addition of alkalis and removal of  $\text{SiO}_2$ ; in other words, by a continuation of the process of fenitization. He is further of the opinion that only the feldspar-nepheline-pyroxene rocks are of primary eruptive origin. In the Alnø area it can be seen clearly that the melanocratic areas in the strongly fenitized migmatite have been altered to melteigite-ijolite. This cannot be seen directly in the Fen area, but

in the Precambrian rocks round the complex are found small areas with melanocratic rocks which could give rise to melteigite through alkali metasomatism.

*Søvite*, which has a large areal extension in the Fen area, is a carbonate rock of variable composition. The rock was called *søvite* by Brøgger (1921) after Søve farm and agricultural college. *Søvite* is in parts coarse-grained, with a grain size from 2–4 mm, whilst otherwise it has more similarity to a normal marble. Ankerite and dolomite occur in variable amounts and in places can become quite dominant, in which case the rock is called *rauhaugite*. This rock occupies a large area in the eastern part of the Fen area. Mica minerals, magnetite, pyrochlore and apatite are found in the *søvite* in variable quantities.

The pyrochlore mineral is a *koppite* (a Ca-Na niobate, poor in Ti and Ta) which occurs as octahedra, varying in colour from light to dark brown. The *koppite* has partly gone over to columbite, but has retained its original octahedral form. The micas are chiefly phlogopites, occurring in both large and small crystals. The apatite is a fluor apatite and occurs as small prisms.

The mode of formation of the *søvite* is one of the central problems of the Fen area and is important for the understanding of the genesis of the area as a whole and of peralkaline rocks in general.

Brøgger (1921) came to the conclusion that *søvite* was magmatic. He drew this conclusion mainly from the fact that the rock occurs in dykes, which are typical of igneous rocks. The hollaite (see later) had, in his view, originated by mixing of the magmas which elsewhere formed *søvite* and melteigite, or in other places by the assimilation of fenite in *søvite* magma.

Bowen (1924 and 1926) was of the opinion that the *søvite* was formed metasomatically from silicate rocks (fenite, melteigite).

Sæther (1957) thinks that *søvite* has been formed metasomatically from silicate rocks and must be considered as a perimagmatic hydrothermal product of the same magma which gave rise to the already mentioned basic silicate rocks, and which has, partly, by means of plastic flow, been intruded into the older rocks. Sæther bases his theory in the main on the fact that there are found relics of vipetoite and melteigite in the *søvite*, which bears witness to metasomatic replacement of silicate rocks by carbonate rock. In addition the structures in the *søvite* provide evidence of mechanical deformation.

H. von Eckermann (1948) maintains that the søvite in the Alno area was formed by crystallisation of a carbonate melt at a temperature of 400–450° C. This melt, he suggests, found its way through the earth's crust by means of an explosion leading to the formation of søvite "cone sheets", which play an important role in this complex.

*Hollaite* is a hybrid rock, lying between søvite and the melteigite-ijolite series. This rock, which is of variable composition, has been called pyroxene-søvite and søvitic melteigite by Sæther (1957). It occurs both in contact with the søvite and by itself in the central part of the complex.

*Rødberg* ("redrock") is a carbonate rock which is red-coloured due to finely dispersed hematite. Hematite concentrations (along NW-SE striking fissures) formed by iron pneumatolysis are exploitable as iron ore (Fen iron mines). Some of the dyke-like masses show high radioactivity and an average content of 0.2 %  $\text{ThO}_2$  and 1 % rare earth elements (including  $\text{Ce}_2\text{O}_3$ ). Due to the fine-grained nature of the rock the mineral containing these elements is not known. The carbonate is mainly calcite, and mostly fine-grained. The hematite occurs as poikilitic inclusions in the carbonate crystals as well as between the grains. In thin section the rock appears full of reddish dust particles. This rock is as yet only known from the Fen area.

*Kimberlite* (Damtjernite) occurs in dykes, dyke-like bodies and as kimberlite breccias in volcanic plugs. This rock occurs both in the complex and outside it. The kimberlite dykes consist mainly of phenocrysts of biotite in a fine-grained groundmass of augite, amphibole, biotite, magnetite, nepheline and alkali feldspar. Phenocrysts of amphibole, pyroxene and olivine are also found in varying quantities.

In the kimberlite breccias fragments of the surrounding rocks occur in varying quantities. The fine-grained groundmass in the breccias is on the whole identical with that in the dyke rocks. The phenocrysts are also the same, but amphibole occurs here in greatest amount and in large individuals (up to 5 cm long). The amphibole is mostly a barkevikitic hornblende, the pyroxenes are diopside and aegirine-augite, and the olivine has a fayalite content of 12–18 %, often being altered to canbyite. The biotite crystals have hexagonal forms, but often have their corners rounded off.

The kimberlite is the only rock in the Fen area which can be said with certainty to be of igneous origin.

Sæther (1948) is of the opinion that the carbonatites, the rauhaugite and the rødberg are metasomatically altered kimberlite. He has found transitions between these rocks and thinks that the kimberlite was emplaced first and that the carbonatites were formed later by addition of CO<sub>2</sub> from deeper parts of the magma.

In the Precambrian rocks around the Fen area there are, besides the kimberlite dykes, tinguaitite, carbonate and dolerite dykes.

*Tinguaitite* occurs in large amounts as flat-lying dykes and as lava patches, and in lesser amounts as large dyke-like masses. This rock exhibits phenocrysts of nepheline, alkali feldspar and partly also aegirine-augite in a groundmass of alkali feldspar, nepheline and aegirine. The nepheline is partly altered to muscovite.

*Carbonate veins and dykes* occur in lesser numbers, but often together with the tinguaitite dykes and concordant to them. It has not so far been possible to prove that these are cone-sheets as in the Alnø area. Their composition varies from pure, light-coloured calcite veins to dark dykes carrying large amounts of chlorite and, in parts, hematite.

*Dolerite dykes* intersect both the Precambrian rocks and those of the Fen area. They are chiefly steeply dipping with N-S strikes.

## ITINERARY

1st. DAY, 11/8 & 27/8. By bus from Larvik to Helgeroa (16 km) (pop. 350, a fishing port and pilot station with ferry-connection to Langesund), from where motor boats will take the party across the Langesundsfjord for demonstration of the geology of the area (see fig. 2), and then land at *Låven* and *Skutesundskjær*, where ample time for mineral collecting will be allowed (see Table I). The landing at *Låven* is by special permission, as this famous locality has been protected by law. Return to Helgeroa, and to Larvik by bus in time for dinner. (Provisions for lunch will be taken along on the fjord trip.)

2nd. DAY, 12/8 & 28/8. Morning: Bus from Larvik to larvikite quarry in Tjølling (*Klåstad*), and then to *Ula* (14.5 km, pilot station) for cryptoperthite. Return to Larvik for lunch. Afternoon: Bus to

larvikite quarry at *Tvedalen* (near Helgeroa, 17.5 km), then across the main body of larvikite, a small part of the lava beds at Eidanger, and the Silurian sediments of the Skien valley, to Skien (35 km from Larvik), where the party will dine and stay overnight.

3rd. DAY, 13/8 & 29/8. The per-alkaline Fen area, in the vicinity of the industrial centre Ulefoss on lake Norsjø, is reached by bus (30 km from Skien). On the way from Skien to Ulefoss the *Eidanger Nitrate Factories* on the island of Herøya (near Porsgrunn) is passed. Norsk Hydro's largest plant (one bag of nitrate of lime is produced every other second). *Ulefoss* is a small industrial centre 300 years old, which has grown up around the Ulefoss iron works (owned by S. D. Cappelen). Of somewhat later date are important lumber works (both Cappelen and Aall-Ulefoss Brug). For the geology of the Fen area, see fig. 3 in which the numbers 1, 2, . . . 12 refer to localities to be visited, as described below.

At the Søve Mine office (1), a short introduction to the geology of the area will be given. A "pre-lunch" walk along the shore of Norsjø will allow the party to study the fenite (2) and the carbonatites (the carbonatites are chiefly in the form of dykes), at the *Tufte* tunnel (3) and at the *Hydro* and *Cappelen* localities (open pits), (4) and (5). Kimberlitic breccias are seen at (4) and (6). The *dressingsplant* of the underground mine is located at (7). After lunch, the party will proceed by bus to *Melteig* farm (8), the type locality for melteigite (a 100 m walk). Continue by bus and after a 300 m walk to *Steinsrud* (9), where a small plug kimberlitic breccia (olivine, canbyite and hisingerite) is seen surrounded by Precambrian gneiss. Near the road a tinguaita dyke outcrops.

Return by bus to Skien.

4th. DAY, 14/8 & 30/8. By bus to the Fen Iron Mine (10) at Norsjø, where the "rødberg" can be studied together with the hematite dykes and impregnations. East of the plant the actual border of the Fen area (11), which is the result of fenitisation and brecciation, will be demonstrated.

By bus to the central carbonatite plug (12).

Return by bus to Larvik.

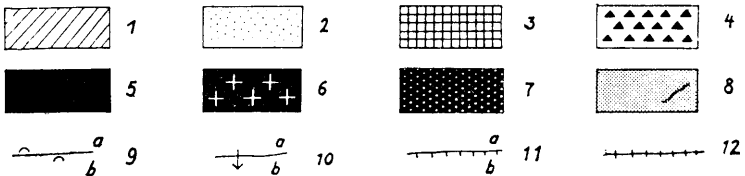
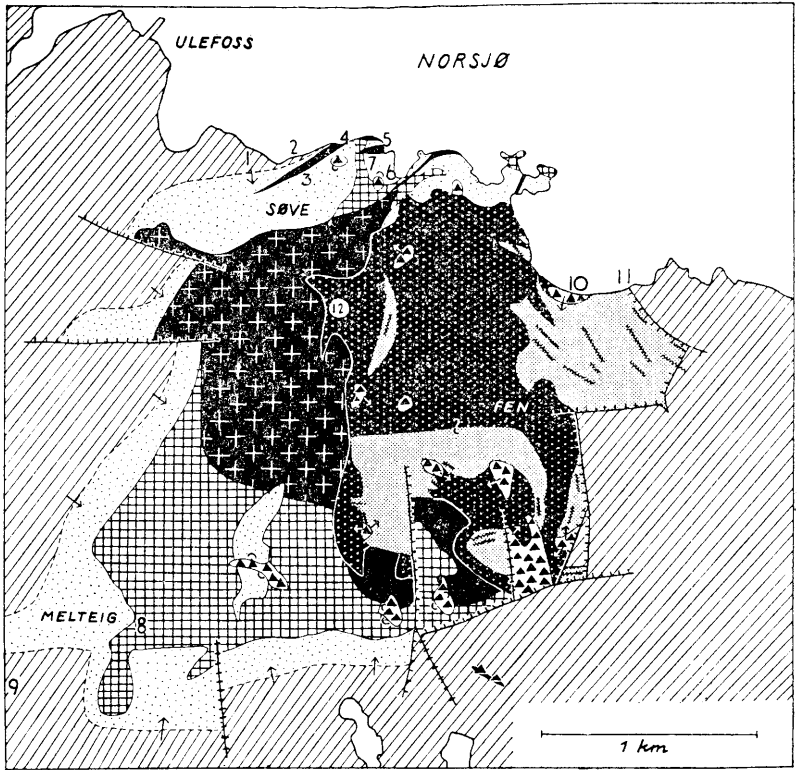


Fig. 3.

Generalised geological map of the Fen area, after Sæther 1949.

1. Precambrian gneisses.—2. Fenite.—3. Basic rocks (urtite-ijolite-melteigite-vipe-toite).—4. Kimberlite (damtjernite).—5. Søvite.—6. Hollaite.—7. Rauhaugite.—8. Rødberg ("redrock").—9. Intrusive contact (a older rocks, b younger).—10. Metasomatic contact (rock b is a metasomatic product of rock a).—11. Fault-line.—12. Fault-line, displacement unknown.

The numbers on the map refer to the localities to be visited.

## LITERATURE

The reader is referred to "Geology of Norway" edited by O. Holtedahl, Norges Geologiske Undersøkelse no. 208, Oslo 1960.

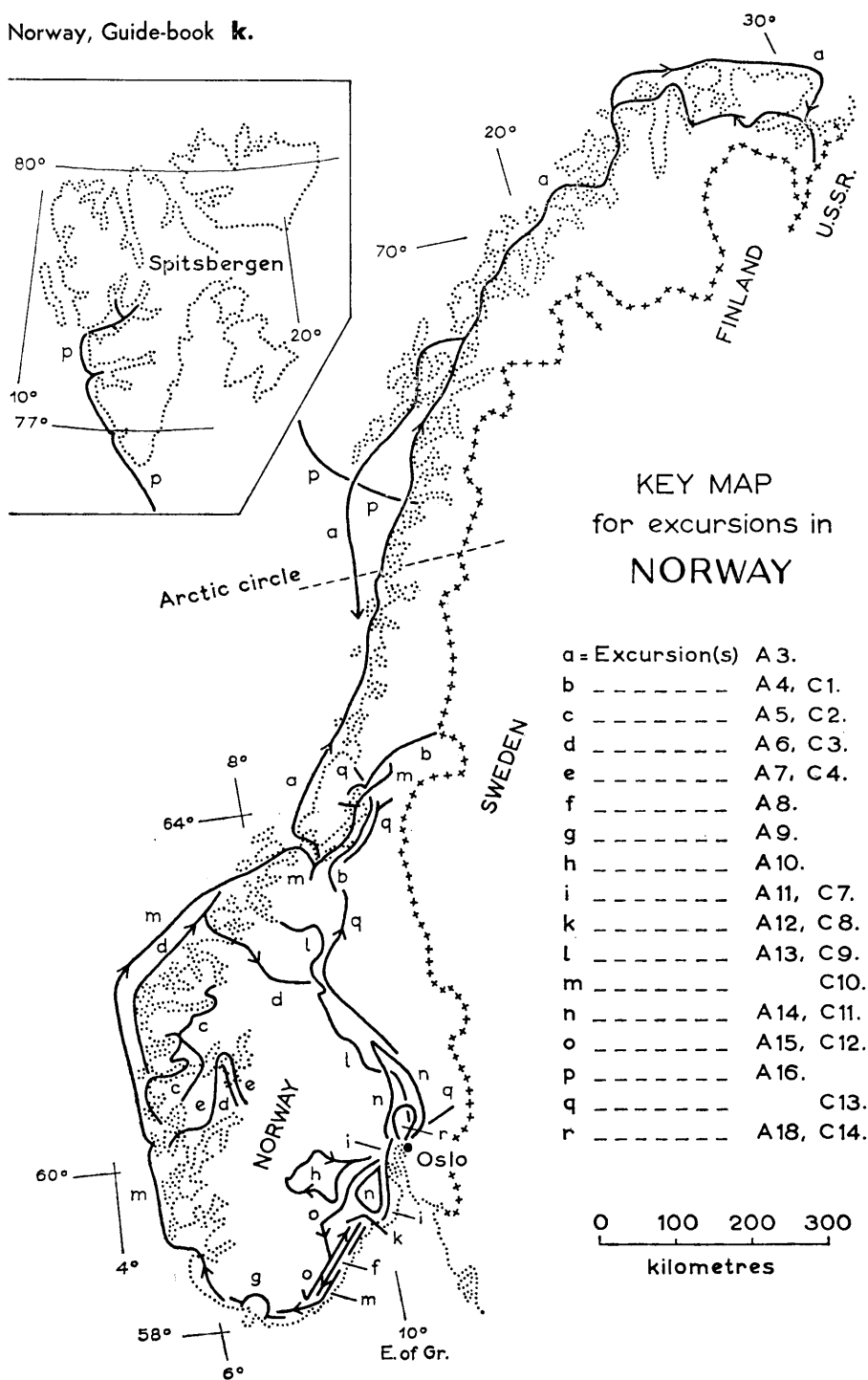
## Larvik—Langesund area:

- Brogger, W. C.*, 1883. Spaltenverwerfungen in der Gegend Langesund—Skien. *Nyt Mag. f. Naturv.* 28.
- 1890. Die Mineralien der Syenitpegmatitgänge der südnorwegischen Augit- und Nephelinsyenite, *Z. f. Krystallographie etc.* 16.
- Holtedahl, O.*, 1943. Studies on the Igneous Rock Complex of the Oslo Region. I. Some Structural Features of the District near Oslo. *Vid.-Akad. Skr. I. Mat.-Naturvit.klasse* 1943, No. 2.
- Oftedal, Chr.*, 1948. Studies on the Igneous Rock Complex of the Oslo Region. The feldspars. *Vid.-Akad. Skr. I. Mat.-Naturvit.klasse*, 1948, No. 3.

## Fen area:

- Bjørlykke, H.*, 1935. Norwegische Mikrolithmineralien. *Norsk Geol. Tidsskr.* 14, 1934.
- 1955. The niobium deposits at Søve, Southern Norway. *Mining Journal* (London) 224.
- Bowen, N. L.*, 1924. The Fen Area in Telemark, Norway. *Am. J. of Science*, 8.
- 1926. The Carbonate Rocks of the Fen Area in Norway, *Am. J. of Science*, Vol. 12.
- 1926. Die Carbonatgesteine des Fen gebietes in Norwegen. *Centralblatt f. Min.* 1926, A.
- Brauns, R.*, 1926. Primärer Calcit in Tiefengesteine oder Verdrängung der Silicate durch Calcit? *Centralblatt f. Min.* 1926, A.
- Brogger, W. C.*, 1921. Die Eruptivgesteine des Kristianiagebietes. IV. Das Fengebiet in Telemark, Norwegen. *Vid.-Akad. Skr. I Mat.-Naturvit. klasse* 1920, No. 9.
- Eckermann, Harry von*, 1948. The Alkaline District of Alnø Island. *Sveriges Geol. Unders.*, Ser. Ca. No. 36.
- See also *Geol. Förening i Stockholm Förhand.* 64 (1942) and 68 (1946).
- Eckermann, Harry von, & F. Wickmann*, 1956. A preliminary determination of the maximum age of the Alnø rocks. *Geol. Förening i Stockholm Förhand.* 78.
- Faul, H., P. L. D. Eldmore and W. W. Brannock*, 1959. Age of the Fen carbonate and its relation to the Oslo region (Norway). *Geochimica et Cosmochimica Acta*, Volume 17, Nos. 1/2 August 1959.
- Sæther, E.*, 1949. Foreløpig meddelelse om resultatet av undersøkelser i Fensfeltet. *Norsk Geol. Tidsskr.* 27.
- 1948. On the Genesis of Peralkaline Rock Provinces. *Intern. Geol. Congr.* 18th. Session, Part II (p. 123–130).
- 1957. The Alkaline Rock Province of the Fen Area in Southern Norway. *Det Kgl. Norske videnskabers selskaps skrifter* 1957, nr. 1.

*Notes.*



### KEY MAP for excursions in NORWAY

- a = Excursion(s) A 3.
- b ----- A 4, C 1.
- c ----- A 5, C 2.
- d ----- A 6, C 3.
- e ----- A 7, C 4.
- f ----- A 8.
- g ----- A 9.
- h ----- A 10.
- i ----- A 11, C 7.
- k ----- A 12, C 8.
- l ----- A 13, C 9.
- m ----- C 10.
- n ----- A 14, C 11.
- o ----- A 15, C 12.
- p ----- A 16.
- q ----- C 13.
- r ----- A 18, C 14.

0 100 200 300  
kilometres