The Layered Gabbro Series at Seiland, Northern Norway.

By

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With 4 text-figures.

Seiland is a large island on the northern coast of Norway, covering about 600 km². It lies within the zone of Caledonian orogeny and its southern and western parts are composed of gabbroic rocks, representing the north-eastern extremities of a large basic petrographic province extending for more than 100 km along the coast in a south-westerly direction (see fig. 1).

The island is in part more than usually wild and rugged; the highest elevation is 1075 m, and steep peaks between 800 and 1000 m high are common. Almost everywhere in the southern part the land mass rises abruptly from the sea to great heights; deeply dissected fiords and valleys exhibit almost vertical sides; thus precipices and shear cliffs ranging from 500 to 1000 m high are common.

The climate is rather wet and cold, and the geographical latitude is about 70½°; in combination with high elevation this results in snowfields of permanent character in the interior. There are two large glaciers on the island; the eastern is called Seilandsjøkelen and covers almost 30 km², while the western glacier, Nordmannsfjordjøkelen, covers about 15 km² but is over its whole area rather thin — — blue ice is seen only in a few localities, and in several places the rocky underground protrudes through regular windows in the snow cover. The retreat of this glacier must have been very fast during the last fifty years; according to the older maps its area today is only half of what it was in 1900. The reduction in volume must have been very much more.

A geological investigation in Seiland was started in 1952 by Norges Geologiske Undersøkelse with the view in mind to

develop commercially certain albite-nepheline pegmatite dikes which in restricted parts of the island attain great thicknesses.[1]

During the same summer the most interesting parts of the island were mapped geologically:

The Supracrustal Amphibolite-Gneiss Complex is rather highly metamorphosed and gneissic in appearance; it is derived mainly from sandstone, but in some places limestone seems to have been present in the original material. The inter-relationships of the amphilobites are obscure. Metasomatic processes must have been operative in shaping the complex.

The Igneous Rocks are gabbroic to ultrabasic. A great number of rock types occur: Anorthosite, gabbro, norite, olivine gabbro, tilaite, pyroxenite, ariègite, amphilobite, hornblendite, peridotite. All these rocks typically contain the following constituent minerals: basic plagioclase, olivine, pyroxene, hornblende, spinel, ore.

The type of form assumed by the Seiland gabbroic rock is of more than ordinary interest. Discordant contacts were not observed in the island. All gabbroic rocks form concordant bodies, and at several localities excellent profiles are exposed, exhibiting a typical *layered* structure[2]. The total thickness of the exposed layered series is well beyond 1000 m.

One of the wonders of geology is the occurrence at widely scattered localities in the world of sheets of igneous rocks which show a layered structure: Stillwater, Bushveld, Skærgaard in Greenland, etc. These previously described layered intrusives are all in non-orogenic areas, while the Seiland gabbro is in the zone of Caledonian orogeny. Other intrusives in orogenic zones, particularly early basic and ultrabasic intrusives accompanying orogeny, have been described as stratiform bodies injected into planes of structural weakness, but not as being layered themselves.

Buddington has made an interesting comparison between layered sheets and the layered structure of the crust of the earth itself; Wager thinks that the layers resulted from crystals in the

[1] Report deposited at N. G. U.

[2] The layering was first discovered by A. Kvale and H. Neumann at Kufjordtindene in 1937. (Diary deposited at N. G. U.).

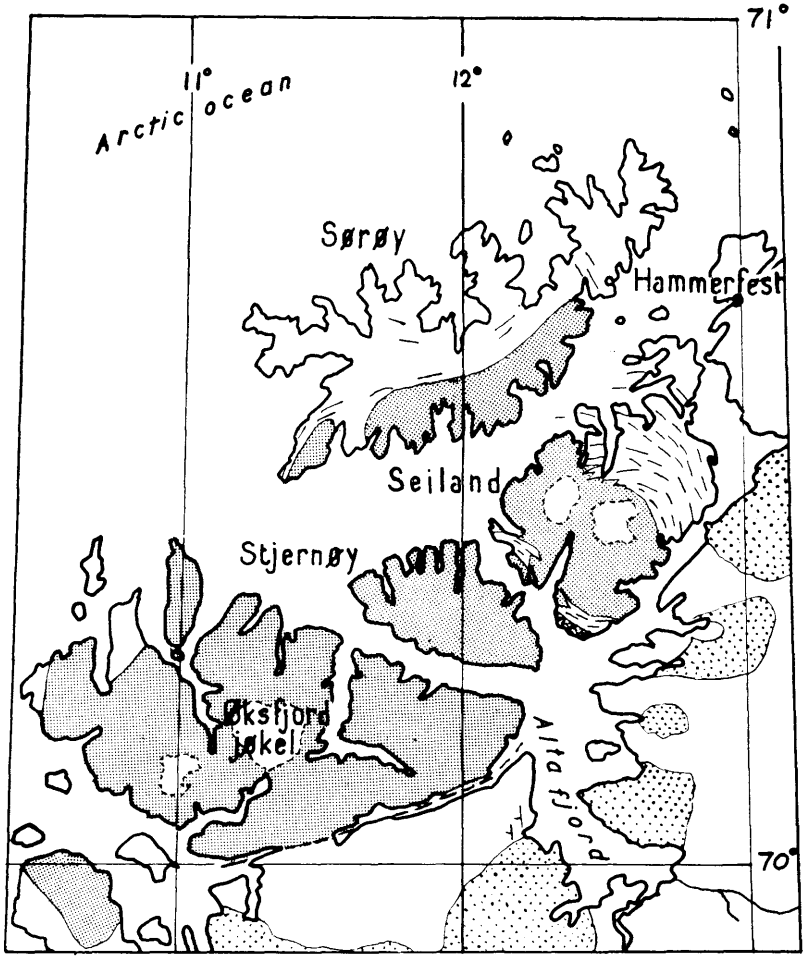

Fig. 1. The Seiland petrographic province.
Dens gray = Gabbroic rocks, partly layered. White = Caledonian sediments. Dots = Raipas Formation.

Mørk grått = gabbrobergarter, delvis lagdelte. Hvitt = Caledonske sedimenter. Prikket = Raipas formasjonen.

magma being precipitated under the action of convection currents. Again other scientists have proposed other ideas; one can safely say: *Autant d'hommes, autant d'avis.* The following profile gives an example of the nature of the layering found in Seiland.

Profile at Lille Kufjord, Seiland.

(Abbrevations: Plag. = plagioclase, aug. = augite, hy. = hypersthene, ol. = olivine, hbl. = hornblende.)

Top
?
5.4 m Peridotite: Ol., less than 10 % each plag., aug., hy., hbl., ore.
8.0 m Pyroxenite: Aug., less than 10 % each plag., ol., hy., hbl., ore, spinel.
8.2 m Peridotite: Ol., less than 10 % each plag., aug., hy., hbl., ore, spinel.
8.4 m Gabbro: Plag., aug., ol., hbl., ore, spinel.
18.7 m covered.
4.8 m Pyroxenite: Aug., hbl., ore.
1.5 m Pyroxenite: Aug., hbl. (ol.), (ore).
4.4 m Peridotite: Aug., ol., hbl., ore, spinel.
2.0 m Pyroxenite: Aug., less than 10 % each: hbl., ol., hy., plag., ore, spinel.
9.2 m Olivine gabbro: Plag., ol., aug., hy., hbl., ore, spinel.
7.0 m Gabbro: Plag., aug., hbl., ore, spinel, trace of ol. and hy.
2.6 m Peridotite: Ol., aug., hy., hbl., ore, spinel, 10 % plag.
6.0 m Olivine Gabbro: Plag., ol., aug., hy., hbl., spinel.
6.0 m Gabbro: Plag., aug., hy., hbl., spinel, ore.
?
Bottom.

This short profile chosen at random in the series can not lead to definite conclusions concerning the mode of origin of the rock complex. The investigations so far have been only of a reconnaissance nature. Not until more careful work has been done, and more data have been obtained, can one hope to contribute anything worthwile to the solution of these complex and enigmatic petrogenic problems. However, even few and unsystematic observations may foreshadow the great difficulties which will be encountered in explaining the phenomena by conventional assumptions:

1. At Søndre Bumannsfjord layering is conspicuous and is produced by a concentration of dark minerals in streaks and

bands often with indistinct contacts towards the adjacent lighter material, giving a rock very simliar in aspect to a metamorphic banded gneiss. Most bands are relatively coarse-grained; but one band in this locality is distinguished by its dense structure and composite character: the total thickness of the composite band is 30 cm, and it is composed of a fine-grained light central zone with dark borders. The central zone consists of colorless garnet, zoisite, and plagioclase, roughly in the proportions 50, 25, 25 % respectively; the dark margins consist of dark green spinel attaining 50 %, colorless garnet, zoisite, and plagioclase.

2. The mountains of Skreifjord are made up of banded metamorphic amphibolites. South of the head of the fiord are zones of crystalline limestones and of garnetiferous gneiss. North of Skreifjord (e. g. at Kårhamn) gneiss dominates. The dip angles are steep and the direction of the strike is roughly east and west over the entire area. The rock complex is apparently highly metamorphic, and at least in part, much sedimentary material enters into it. Toward the west the metamorphic rocks exhibit successively higher stages of metamorphic-anatectic transformation; with uniform westerly strike and steep dips they grade into the layered gabbro series north of the Nordmannsfjordjøkel.

In contradistinction to the layered gabbro of the Skærgaard intrusion, Greenland, the present layered series has no definite side walls, but seems to extend without a clear break into the contiguous and analogously layered amphibolite-gneiss complex.

Dikes.

Of further petrographic interest are the numerous dikes occurring everywhere in Seiland.

Basic dikes of several gnerations and of various petrographic types are conspicuous. Fig. 2 shows the occurrence of a dike complex on a small island mapped by Dr. H. Neumann and myself.

Pegmatite dikes ranging in width from 10 cm to more than 100 m are rather common and may be divided into a number of different types.

1. Granite pegmatites: Microcline perthite, quartz, oligoclase, magnetite, (biotite).

2. Syenite pegmatites: Albite antiperthite, magnetite, biotite.

2b. A peculiar variant is a pegmatite at Nordbukten composed of antiperthite, hornblende, magnetite, biotite, apatite, calcite.

3. Nepheline syenite pegmatites (= canadite pegmatites): Albite antiperthite, nepheline, scapolite, sodalite, biotite, magnetite, apatite, garnet, calcite, cancrinite, eucolite, (muscovite), (ilmenite).

4. Ringite Pegmatites: Albite antiperthite, calcite, biotite, apatite, tourmaline, magnetite, muscovite, zircon.

5. Quartz-diorite pegmatites: Oligoclase, quartz, muscovite, garnet, tourmaline.

6. Diorite pegmatites (= plumasites): Oligoclase, muscovite, biotite, magnetite, apatite, zircon, corundum, columbite, fergusonite.

7. Gabbro pegmatites: a) Labradorite, hornblende, calcite, pyrite (hematite). b) Labradorite, hornblende, augite, olivine.

The geological relations of these pegmatites are puzzling. They dissect the gabbroid rocks (only to a very limited extend do they enter into the metamorphic complex); and the gabbroic rocks are, indeed, the only visible igneous sources from which the pegmatites could derive. However, all these highly contrasted types of pegmatites cannot represent residual solutions of gabbroic magma — only type 7, the gabbroic pegmatite, and perhaps type 5 and 6 are possible differentiation-representatives of gabbroic magmas. The *fons et origo,* the relations, and the mode of development of e. g. the canadite or the ringite pegmatites are simply perplexing.

The largest pegmatite observed is a rather inhomogeneous canadite pegmatite striking westward from Bekkarfjordnes for many kilometers and attaining a width of more than 100 m. Part of it was mapped and is reproduced in fig. 3.

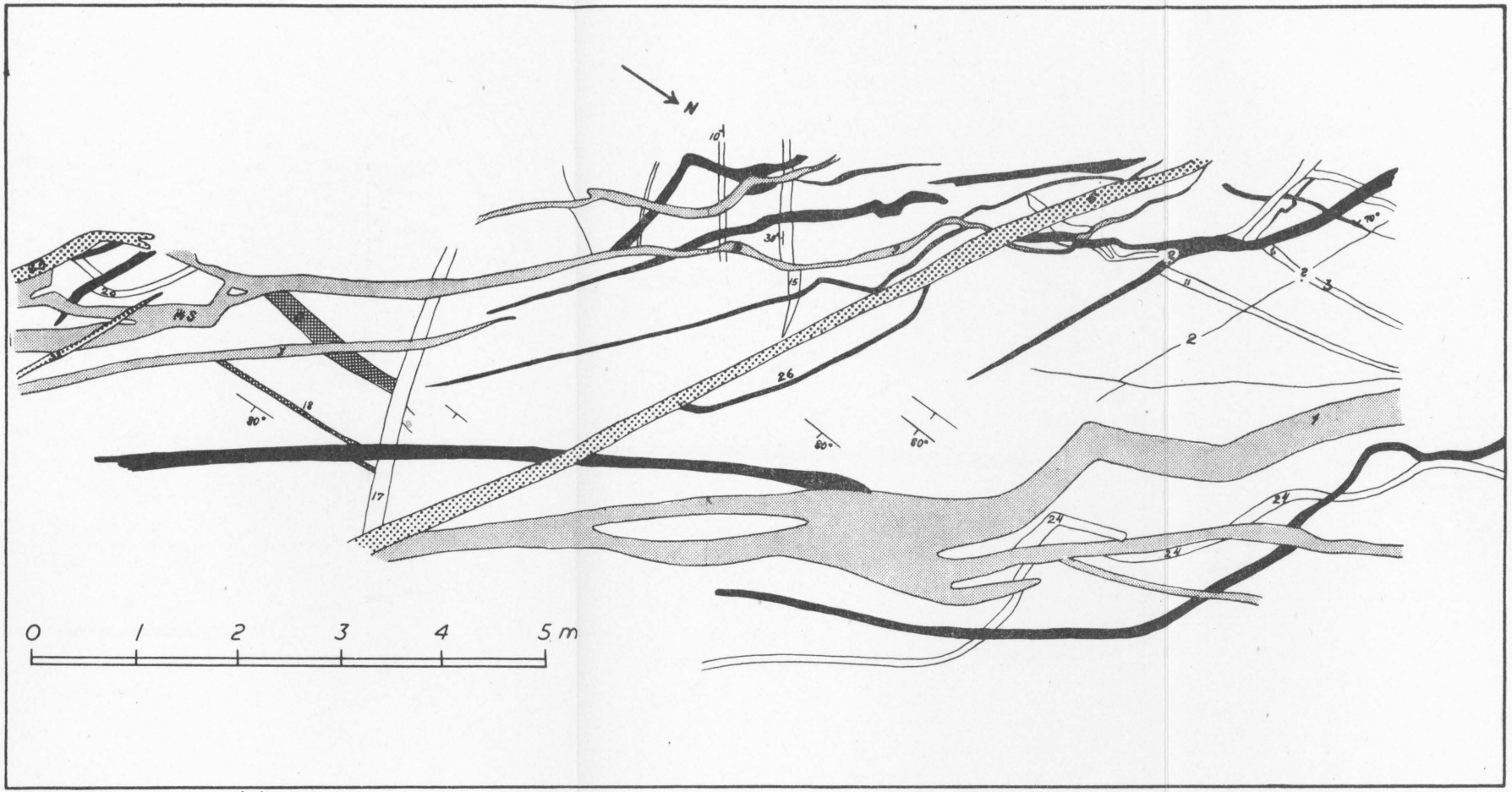

Fig. 2. Southern islet at Nordre Bumannsfjord.
Basic dikes penetrating layered gabbro.

Sydlige holme ved Nordre Bumannsfjord.
Ganger som gjennomsetter lagdelt gabbro.

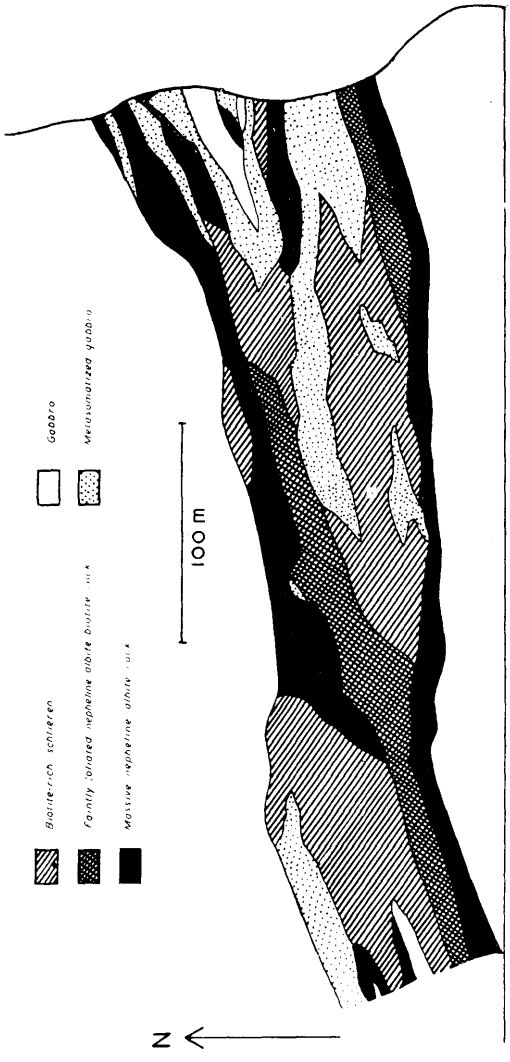

Fig. 3. Canadite pegmatite at Bekkarfjordnes.
Canaditpegmatit ved Bekkarfjordnes.

Acknowledgement.

The expedition to the Seiland area took place under the auspices of Norges geologiske undersøkelse — but the work of the planning of the expedition, the establishment of the necessary contact relations in Finnmark and elsewhere, the hiring of a sea-going vessel, etc. were mostly borne by Dr. H. Neumann. To him, and likewise to the director of the Survey, Mr. Sven Føyn, I wish to express my gratitude for generous cooperation and stimulating discussions in the field and in the laboratories

In the strenuous geological mapping I had dexterous and sure-footed assistance from stud. real. Jens Hysingjord and C. F. Wolff.

Sammendrag.

Den lagdelte gabbroserie på Seiland i Finnmark.

De geologiske undersøkelser av Seiland ble påbegynt for å klarlegge om de delvis meget mektige grovkornede ganger bestående av albit og nefelin, med mindre mengder av biotit og magnetit, kunne utnyttes økonomisk som råstoff i glass- og porselensfabrikasjon. En rapport om dette er levert til Norges Geologiske Undersøkelse og problemet er ikke nærmere berørt i nærværende avhandling som utelukkende beskjeftiger seg med en beskrivelse av den eiendommelige lagdelte gabbrobergart som opptrer over store deler av Seiland. Lignende bergarter er beskrevet fra noen få andre steder på jorden, for eksempel Syd-Afrika og Grønland; men noen tilfredsstillende forklaring på hvordan slike bergarter er blitt til har vitenskapen ennu ikke kunnet gi.

Et annet interessant fenomen som kan studeres ved bergartene på Seiland er de tallrike gjennomsettende ganger som i meget stort antall finnes så godt som over hele området. Det er to typer av ganger. 1) De mørke basiske ganger (se figur 2); et stort antall forskjellige bergartstyper er representert blant disse ganger. 2) De lyse, grovkornede pegmatittiske ganger, (se figur 3); også blant disse ganger finnes en hel del forskjellige petrografiske typer. Disse ganger er geologisk sett så merkverdige at det for øyeblikket ikke er mulig å gi noen tilfredstillende forklaring på hvordan de er oppstått.

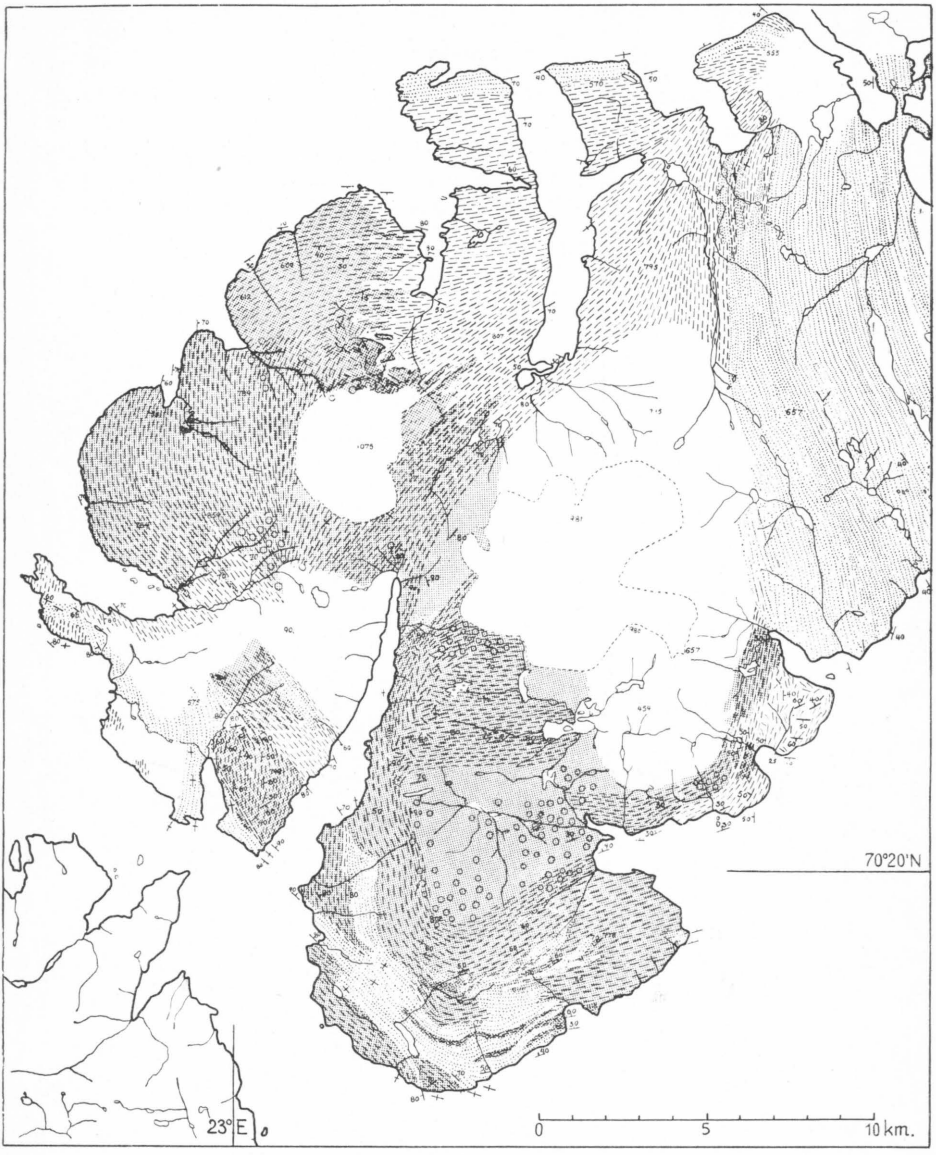

Fig. 4. Geological Map of Seiland.

Dotted = sedimentay gneisses. Stippled = mainly amphibolites. Grey shading = gabbroic rocks, layering is indicated by lines and by strike-and-dip symbols. Small circles indicate coarsegrained peridotite rocks.

Prikket = sedimentære gneiser. Strekêt = hovedsakelig amfibolit. Grå tone = gabbrobergarter, lagdelingen er antydet ved linjer. Små rundinger betyr grovkornet peridotitisk bergart.

Literature.

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