GEOLOGICAL GUIDE
TO OSLO AND DISTRICT

TEXT TO "GEOLOGISK KART OVER OSLO OG OMEGN"
(SCALE 1: 50000) PUBLISHED 1952

EDITED BY
OLAF HOLTEDAHL
AND
JOHANNES A. DONS

WITH 42 FIGURES IN THE TEXT

SKRIFTER UTGITT AV DET NORSKE VIDENSKAPS-AKADEMI I OSLO
I. MAT.-NATURV. KLASSE. 1957. No. 3

OSLO
I KOMMISJON HOS H. ASCHEHOUG & CO. (W. NYGAARD)
1957

Skrifter utgitt av
Det Norske Videnskaps-Akademi i Oslo.
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A. W. BRØGGERS BOKTRYKKERI A/S

Contents.

Introduction.

By

Olaf Holtedahl

"The neighbourhood of Christiania is, geologically speaking, both rich and historically noteworthy". So wrote Professor Th. Kjerulf in a paper of 1865 where he gave a geological description with map of the district around the Norwegian capital (Geologisk Veiviser ved Excursioner i Christiania Omegn). This area had been visited by, amongst others, a number of well known foreign geologists and observations from this district had been of great value for the understanding of important geological phenomena.

Since then the researches of a long succession of geologists have both confirmed and enhanced the fame of this area. First and foremost to be mentioned is the wonderfully comprehensive work of W. C. Brøgger. But important contributions have also been forthcoming from many other quarters. In a rather special class is a treatise of J. Kiær on the Silurian (1908) and one of V. M. Goldschmidt on the contact metamorphism (1911). The district is indeed classic ground in geological research.

Kjerulf's above mentioned paper which deals especially with the Cambro-Silurian series and associated fossils, was accompanied by a coloured geological map on the scale of 1/100 000. This map covers approximately the area from Grøttum in Sørkedalen to the north, to the inner part of Bundefjorden to the south and from Lierdalen in the west to the south-easterly part of Nittedal in the east. This area makes up parts of four different map sheets of the official topographical survey map in 1/100 000, viz. Oslo (Kristiania), Fet, Hønefoss and Nannestad. These were also published as geological maps by Norges Geologiske Undersøkelse in Kjerulf's time, after the above-mentioned map of 1865 had been published. A new set of maps issued by N. G. U. 1917—1919 and prepared by W. C. Brøgger and J. Schetelig, contains a wealth of new data, especially concerning the eruptive rocks. Of these maps three (Kristiania, Fet and Nannestad) are now out of stock.

For many reasons it was thought desirable to have a geological map on a larger scale covering especially the area which can be considered as Oslo's excursion ground. In 1933 therefore I laid before Professor Brøgger a proposal to begin to collect additional observations for such a map. This required much new field work in the area of eruptive rocks north of the city of Oslo. It was also necessary to deal with the Pre-Cambrian areas to the south-east, in continuation of O. A. Broch's detailed work in the Nesodden Peninsula. Brøgger supported the plan and provided some financial aid. The programme was begun (by S. Føyn) in the Alnsjø district and continued with interuptions in succeeding years. The field work was mainly done by geological students, with some financial support from Det Videnskapelige Forskningsfond av 1919. The names of the co-workers are given on the map. Especially should be mentioned the comprehensive work of Egil Sæther on the igneous bodies in the northern half of the map area.

It has been of great importance that the results of mapping carried out for N. G. U. by Chr. C. Gleditsch in the Pre-Cambrian areas of Nesodden and Røyken could be included in the new map. For the Cambro-Silurian and the westerly lava areas this map is based mainly on the Brøgger-Schetelig maps.

The manuscript map was on a scale of 1/25 000 with the topographic base taken mainly from the Oslo-district (Oslo omegn) maps. Most of the draughtmanship was executed by Mrs. Ruth Dahl; a part later on, by Mrs. Nussa Bø.

During the work on the manuscript-map, and at the time of printing, I had, from 1948, as fellow-worker the scientific assistant in the Geological Institute of the University of Oslo, now conservator at the Mineralogical-Geological Museum, Johannes A. Dons.

The printing of the map, during 1951—52, by the firm of Emil Moestue A/S, was paid for by Det Norske Videnskaps-Akademi i Oslo, with a substantial contribution from Det Videnskapelige Forskningsfond av 1919.

In close connection with the research work for the new map a series of publications was begun with the common title "Studies on the igneous rock complex of the Oslo Region", printed in the "Skrifter" of the Academy. This series can be regarded as a continuation of W. C. Brøgger's "Eruptivgesteine des Kristiania-(Oslo)Gebietes, I—VII, 1894—1933": A list of the papers of the new series published up to and including 1954, is given on p. 85—86. Several of these papers are based on field work carried out in connection with the new map.

One of the purposes of the map was to make available a handy and up-to-date *excursion-map,* for use both by professional geologists and others interested. It was also thought desirable to provide short descriptions on a number of excursion routes with details of what could be seen on them. Earlier descriptions of excursions within the map area include the section on geology by S. Føyn in "Ekskursjonsbok for Oslo og omegn" (1952) where, besides a short geological summary a number of excursion routes are described.

A more comprehensive collection of excursion descriptions is now provided, with a general introductory account of the geology within the map area. It was felt that there is need on the one hand for a text of a more popular nature, and on the other a text (written in English) designed for professional geologists, including the many from abroad who from year to year come to the Oslo district to become personally acquainted with the geology. For this reason two separate volumes,[1] with somewhat different lay-outs, have been prepared.

Dr. P. Padget and Dr. F. M. Vokes have kindly corrected the English of the present edition.

A hearty vote of thanks is due to all who have helped in the work on the new map and the geological guides.

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[1] The Norwegian edition, "Geologisk fører for Oslo-trakten", appeared in October 1955. — For practical reasons the text-figure blocks made for that edition have generally been used also for the English one.

General Account of the Geology.

Pre-Cambrian (Archaean).

By

Chr. C. Gleditsch

Pre-Cambrian rocks are exposed in the southern and eastern parts of the map-area. East of the Oslofjord they represent the northern continuation of the Archaean territory which stretches southwards into Sweden and makes up a part of the structural zone of the "Gothides".

The strike of the highly metamorphic rocks with which we are dealing, is mostly more or less north-south. Especially in the western part of the map area we notice, however, other directions, and smoothly curving trend-lines are common. To the east, more or less coarse-grained gneisses (no doubt of migmatitic origin) predominate, while in western districts rocks largely of other types occur. We have here rocks of leptite- and mica-schist character, for which a primarily supracrustal origin may be assumed, and also granitic rocks, some of a very massive, unfoliated type.

We shall now deal separately with the following three main districts: 1. Røyken district, west of Oslofjord, 2. Nesodden Peninsula, 3. District east of Bunnefjord (Østmarka etc.).

Røyken district. A main type of rock is leptite, this term being used here for light-coloured, fine-grained metamorphic rocks made up of quartz, feldspar and some mica. (Their genetic origin is not taken into consideration). With increasing content of mica the rocks show a distinct schistosity. Generally both plagioclase and microcline are present. In Røyken, the rocks under consideration are largely developed as quartzporphyry-leptites. This character is, however, exhibited much better in districts south of the map (cf. excursion 2). It is probable that the Røyken-leptites represent metamorphic rhyolites. The typical leptites in many places pass into leptite-gneisses.

Also typical of the greater part of the district under consideration are zones (generally narrow) of coarser granitic rocks. These zones may increase in number and thickness and e. g., in Aukeåsen (211 m) north-west of Bårsrudvann, we have massive granite with inclusions of leptite, the borders generally sharp. South of the map area we have examples of a more transitional grading from leptite to granite, with increase of the grain-size and disappearance of the planar structure. Thus we have probably in Røyken two types of granitization, possibly corresponding to two structural levels during the time of migmatization, the more southerly types representing the deeper level.

The granite of Aukeåsen is a relatively coarse rock, the feldspar being mainly microcline-perthite with some plagioclase (generally 10—12 % An). The mica is dominantly biotite, in places muscovite is also present. In the Skryset-district 3 km to the WNW, where we also have granite with leptite-inclusions, the granite is distinctly porphyritic, commonly also somewhat foliated, resembling an augen-gneiss. Concerning the area east of the Bårdsrudvann-valley, marked as granite in the map, the rocks are here transitionally connected with the Aukeåsen-granite, but they show largely a distinct foliation, except in districts far to the east. The size of grain varies considerably, and to some extent also the quantitative relation of the minerals plagioclase, microcline and mica.

As to basic rocks, relatively narrow zones of amphibolite with trends generally parallel to that of the adjacent rocks, are common. In some places we have similar basic rocks with a more lens-like shape. Locally the massive granite contains half "digested" inclusions of rocks of this type. South of the map-area occur somewhat larger basic bodies, notably one of massive saussurite-gabbro at Sundby, about 3 km south of the northern end of Bårsrudvann. This body is elongated in the W-E direction while the structural trend of the adjoining schistose rocks is about N-S.

Nesodden Peninsula. Here, too, there are leptites in certain districts. They seem to be somewhat more metamorphic than the southern Røyken-leptites. They are more coarse-grained and generally without traces of the primary, porphyric texture. However, on the island of South Langåra, to the south, we meet with leptite of the Røyken-type. Leptite-like rocks rich in mica, in places also with kyanite, occur at several localities in Nesodden. Locally, as in the far north-east, we meet with rocks that must be termed micaschists. Minerals rich in aluminium, like kyanite and staurolite, are especially characteristic of this part of the peninsula, and most probably we are dealing with rocks of sedimentary origin.

The leptites of Nesodden often grade into leptite-gneisses (or leptite-migmatites) of distinctly coarser grain. Rocks of this type can, for instance, be seen along the coast, at Spro (in the SW). Still more altered migmatitic rocks are represented by augen-gneisses. Locally we have, between rocks of leptite-like character and the augengneiss, a zone where the leptite-mass contains distinct bands of granitic character (cp. the Røyken area). In the augen-gneiss masses pegmatite and ptygmatic veins (folded veins with their main direction cutting the schistosity of the gneiss) are common. Sometimes breccia-like structures (agmatite) are seen in connection with the pegmatites. The common occurrence of pegmatite in Nesodden (as in the area east of Bunnefjorden) and its absence in Røyken is a point of interest, telling of

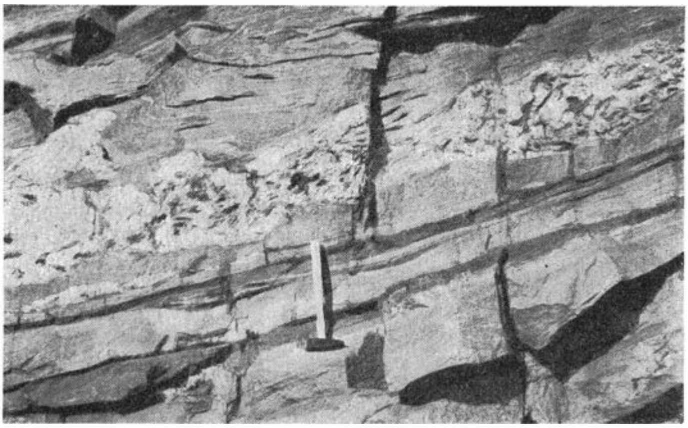

Fig. 1. Grey gneiss with bands of amphibolite and, above them, a pegmatite mass. Road section near Ljabru, east of the midle part of Bunnefjord. O. Holtedahl photo.

different kinds of granitization in west and east. Further characteristic gneissose rocks of the Nesodden district are phlebites (veined gneisses), comprising comparatively coarse-grained gneisses with numerous narrow layers, lenses (and cross-cutting veins) of very coarse, more or less pegmatitic material. Also in Nesodden occur relatively small masses of non-schistose granitic rocks, generally more or less closely connected with leptitic rocks. Finally we have in the north-west a comparatively large area of granite-gneiss, in part grading towards leptite or leptite-micaschist rocks, in part passing into augen-gneiss.

Regarding basic rocks, bands of amphibolite are common in Nesodden, occurring in the schistose rocks (and in the granite-gneiss). Sometimes they are seen to cut the schistosity of the adjacent rocks, and, like the gneisses, they are cut by pegmatite masses. The amphibolites often contain garnet, especially in the far north-east. The gneisses also are not infrequently garnetiferous. In this respect there is a difference compared with the Pre-Cambrian area on the west side of the fjord where garnet is practically non-existent.

District east of Bunnefjord. Only parts of this district have been studied in detail. There is a close resemblance to the Nesodden district, but quartz-plagioclase-biotite-gneisses, largely phlebites and augen-gneisses of different types, are more dominant. Beside phlebites we have gneissose rocks of more homogeneous character, lighter or darker according to content of biotite. We commonly notice a gradual transition from one rock type to the other. Leptite-like rocks are known from only a few narrow zones. Very typical are concordant amphibolitic bands (Fig. 1) and zones with thicknesses sometimes of several tens of meters. The hornblende may to a considerable extent be altered into biotite. Garnet (almandine) is a widely distributed mineral and, especially in the amphibolites, often of a large size (up to $2^1/_2$ cm).

Pegmatitic material, in parallel or cross-cutting veins, sometimes as larger compact masses, is generally a very characteristic feature both in gneiss and amphibolite. We know of no granite body which can be regarded as the source of this material and must regard the coarse granitic substance as more or less local segregations. —

The Archaean rocks of the map area have been mylonitized and brecciated both along the dislocations cutting through Permian rocks (p. 34) and in belts away from the dislocations. There was presumably considerable faulting already in Pre-Cambrian time.

Literature: 2, 17, 18, 19.

Cambro-Silurian Sequence.

By

Leif Størmer

Cambro-Silurian limestones and shales, folded in Caledonian (post-Downtonian) time, make up the low ground of Oslo and westwards along the fjord. The thickness of the marine sediments is about 1100 m of which the Cambrian amounts to 50—60 m, the Ordovician to 400 m, and the Silurian to 670 m. This does not include the non-marine "Downtonian Sandstone", (Ringerike Sandstone) of which a thickness of about 500 m is preserved in Kolsås (1000 m in Ringerike).

The Cambrian strata begin with a basal conglomerate of Middle Cambrian age resting uncomformably on the strongly denuded, peneplaned Pre-Cambrian (Fig. 2). Then follows about 50—60 m of alum shale containing up to 16-17 % carbon, a good deal of pyrite (and small amounts of uranium). The fossils occur in dark lenses of limestone (stinkstone).

The *Lower Ordovician* has alternating zones of graptolite shale and limestone beds with shelly faunas. The *Middle and Upper Ordovician* are mostly nodular limestones and shales with limestones lenses. Arenaceous beds appear in the Llandeilo ($4a\alpha_4$, cf. p. 13) and in the Ashgill; the uppermost beds (5 b) form a calcareous sandstone and conglomerate, the latter with pebbles of limestone and sandstone.

The *Silurian* is mainly represented by calcareous, often arenaceous shales and by partly rather pure and massive limestones. Characteristic for these shallow water sediments are brachiopods: pentamerids in the Llandovery (6-7) and spiriferids in the Wenlock-Ludlow (8-9). Other groups, as ostracods and graptolites, are important index fossils where they occur. The "Downtonian Sandstone" or Ringerike Sandstone (partly Ludlow) is a red to greyish continental sandstone. Non-marine fossils (ostracoderms and eurypterids) have been found, near the base, in Ringerike 30 km NW of Oslo. —

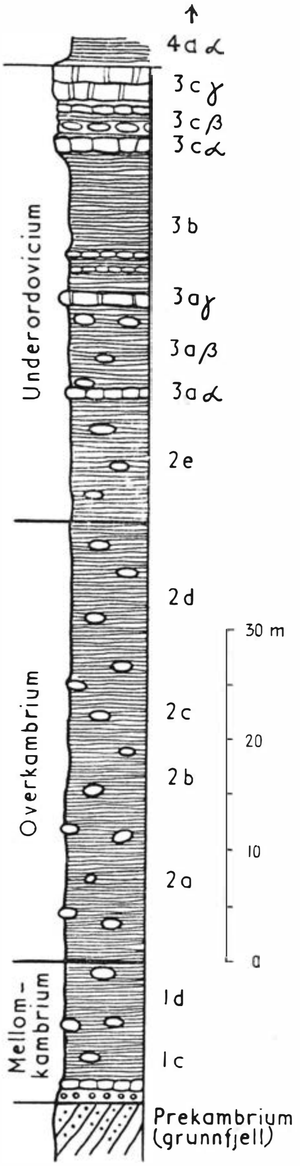

Fig. 2. Stratigraphic column showing Middle Cambrian, Upper Cambrian and Lower Ordovician strata above the Pre-Cambrian basement.

Below is given the main divisions of the Cambro-Silurian sequence. It is divided into 10 "stages" of which each is again divided into smaller units. Stages 1-2d belong to the Cambrian, 2e-5 to the Ordovician and 6-10 to the Silurian-Downtonian. 1a-b=Lower Cambrian, 1c-d = Middle C., 2a-d = Upper C., 2e-3a = Tremadoc, 3b-c = Arenig, $4a\alpha_{1\text{-}2}$ = Llanvirn, $4a\alpha_{3\text{-}4}$ = Llandeilo, 4aβ-4cα = Caradoc, 4cβ-5b = Ashgill, 6-7 = Llandovery, 8-9b = Wenlock, 9c-10 (lower part) = Ludlow, 10 (upper part) = Downtonian. Thickness in meters.

Cambrian.

1a-b	Not present at Oslo.
1c-d	Conglomerate and alum shale w. *Paradoxides*, agnostids a.o.(Fig. 3, No. 7-16), about 10-20 m.
2a	Alum shale w. *Agnostus, Olenus* (Fig. 3, No. 17-19).
2b	Alum shale w. *Parabolina, Orusia* (Fig. 3, No. 20—22).
2c	Alum shale w. *Eurycare* (Fig. 3, No. 23, 24).
2d	Alum shale w. *Peltura, Sphaerophthalmus* (Fig. 3, No. 25, 26). 2a-d about 40 m.

Ordovician.

2e	Dictyonema Shale w. *Dictyonema* (Fig. 4, No. 1) about 9 m.
3aα	Shale and limestone w. *Symphysurus, Peltura* (Fig. 4, No. 2-5), 4 m.
3aβ	Ceratopyge Shale w. *Bryograptus* (Fig. 4, No. 6), 11 m.
3aγ	Ceratopyge Limestone w. *Ceratopyge, Niobe, Euloma* (Fig. 4, No. 11-16), 1-1,5 m.
3b	Lower Didymograptus Shale w. *Tetragraptus, Phyllograptus, Didymograptus* (extensiformed) (Fig. 5, No. 2-5), about 9 m.
3c	Orthoceras Limestone.
3cα	Megalaspis Limestone w. *Megalaspis* (Fig. 5, No. 8-9), 1-1,5 m.
3cβ	Asaphus Shale (= Expansus Shale) w. *Asaphus, Megalaspis* (Fig. 5, No. 6-9), *Illaenus* (Fig. 5, No. 12, 13), 3-5 m.
3cγ	Endoceras Limestone (= Orthoceras Limestone s. str.) w. *Cyclendoceras* (Fig. 5, No. 14, 15), 4 m.

4aα1-2	Upper Didymograptus Shale w. *Didymograptus* (tuningforked), *Glyptograptus, Climacograptus* (Fig. 5, No. 16-20), 32 m.
4aα3-4	Ogygiocaris Shale, shale with lenses and arenaceous beds w. *Ogygiocaris, Trinucleus* (Fig. 5, No. 23, 24), about 25 m.
4aβ	Ampyx Limestone w. *Ampyx* forms, *Reedolithus* (Fig. 6, No. 2, 3), 45-50 m.
4bα-β	Lower Chasmops Shale and Limestone w. *Chasmops conicophthalma* (Fig. 6, No. 11), about 25 m.
4bγ-δ	Upper Chasmops Shale and Limestone w. *Chasmops extensa* (Fig. 6, No. 17), about 30—40 m.
4cα	Tretaspis Shale. Black shale w. *Tretaspis seticornis,* about 7 m.
4cβ-γ-4dα-γ	Tretaspis-Isotelus beds. Shales with arenaceous limestones beds and fine-noduled limestone (4cβ) w. *Tretaspis latilimba* (Fig. 7, No. 3, 4), 90-100 m.
5a	Gastropod Limestone. Arenaceous limestone and shale w. *Tretaspis latilimba, "Syringophyllum organum"* (Fig. 7, No. 3, 4, 11), about 30 m.
5b	Calcareous Sandstone w. conglomerate. *Holorhynchus giganteus, Dalmanitina* (Fig. 8, No. 1, 2), variable thickness.

Silurian with *Downtonian.*

6a	Shale w. *Climacograptus scalaris normalis,* 60 m.
6b	Shale w. *Atrypa reticularis, Sowerbyella, Bilobites biloba* (Fig. 8, No. 5—8), 50 m.
6c	Shale w. limestones beds w. *Striclandia lens* (Fig. 8, No. 10, 11), 35 m.
7a, b	Pentamerus Limestone w. *Pentamerus laevis* (Fig. 8, No. 13, 14), 75 m.
7c	Red shale and nodular limesetone w. crinoid stems (Fig. 8, No. 18), 50 m.
8a, b	Monograptus Shale w. *Monograptus priodon, M. vomerinus crenulatus* (Fig. 9, No. 13, 14), 80 m.
8c	Limestones and shaye w. *Eospirifer plicatellus, Rhynchotreta cuneata* (Fig. 9, No. 1, 2, 5, 6), 7 m.
8d	Malmøy Limestone w. *Wilsonella, Encrinurus* (Fig. 9, No. 15, 16), 10-15 m.
9a	Nodular limestone w. *Camarotoechia nucula* (Fig. 9, No. 27, 28), 10 m.
9b, c	Limestone w. *Leperditia phaseolus,* 50—60 m.
9d	Nodular limestone w. *Delthyris elevata* (Fig. 9, No. 17, 18), 25-30 m.
9e-g	Limestone w. *Chonetes* (Fig. 9, No. 25), *Favosites, Amplexopora.* 100 m.
10	Red sandstone, "Downtonian Sandstone". Lower part apparently Ludlowian. Thickness at least 500 m. At Ringerike fossils in the lower part: *Dictyocaris,* eurypterids and ostracoderms (Fig. 10, No. 1, 3-6).

Some of the fossils shown in Fig. 3-10 do not occur in the Oslo district. The Lower Cambrian species shown in Fig. 3, No.1-6, are found in the Mjøsa district and those from the "Downtonian Sandstone", Fig. 10, have been collected at Ringerike and Jeløy near Moss. The fossils on Fig. 3-10 have been arranged by L. Størmer for "Norges Geologi" published by O. Holtedahl 1953.

Literature: 1, 3, 5, 24, 29, 30, 33, 36, 38.

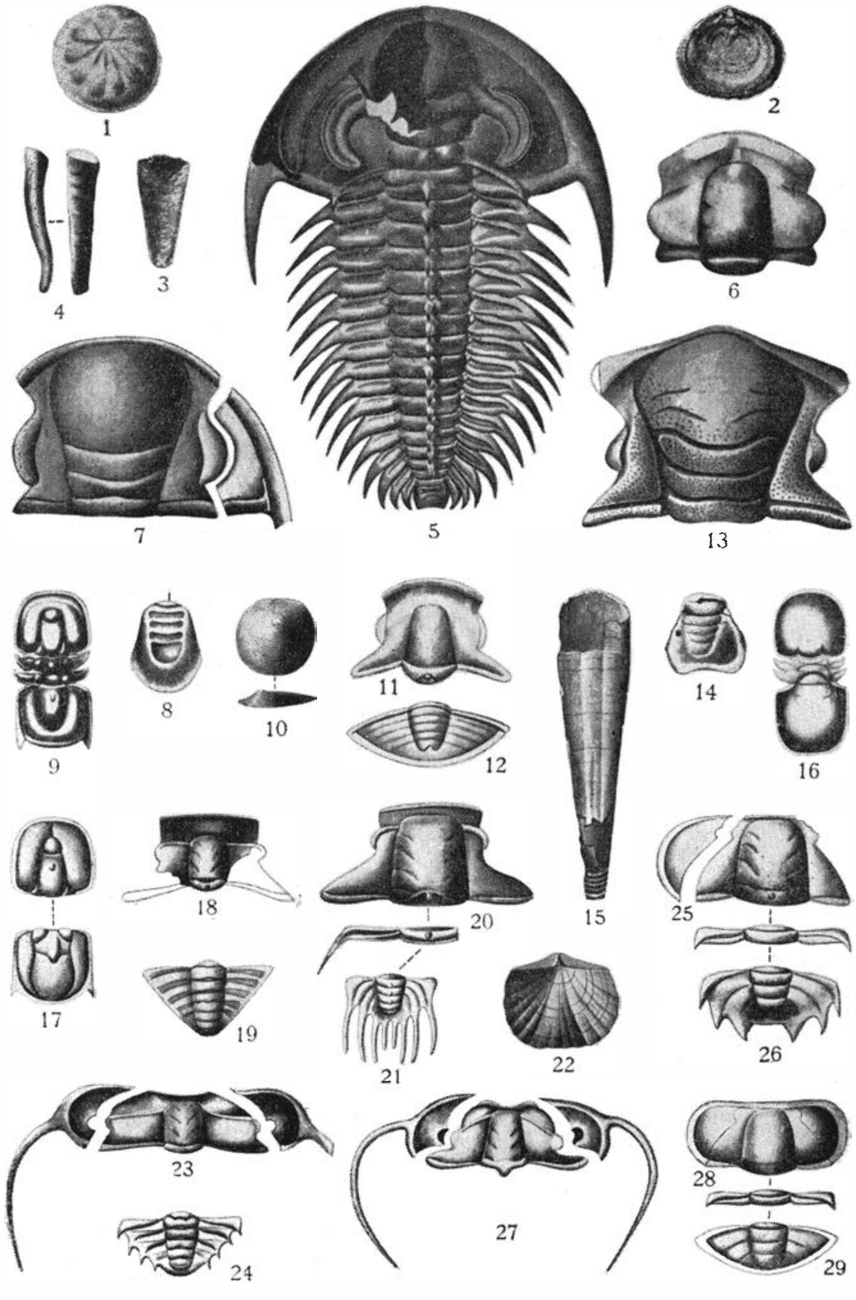

Fig. 3. Cambrian fossils (1a-2d).

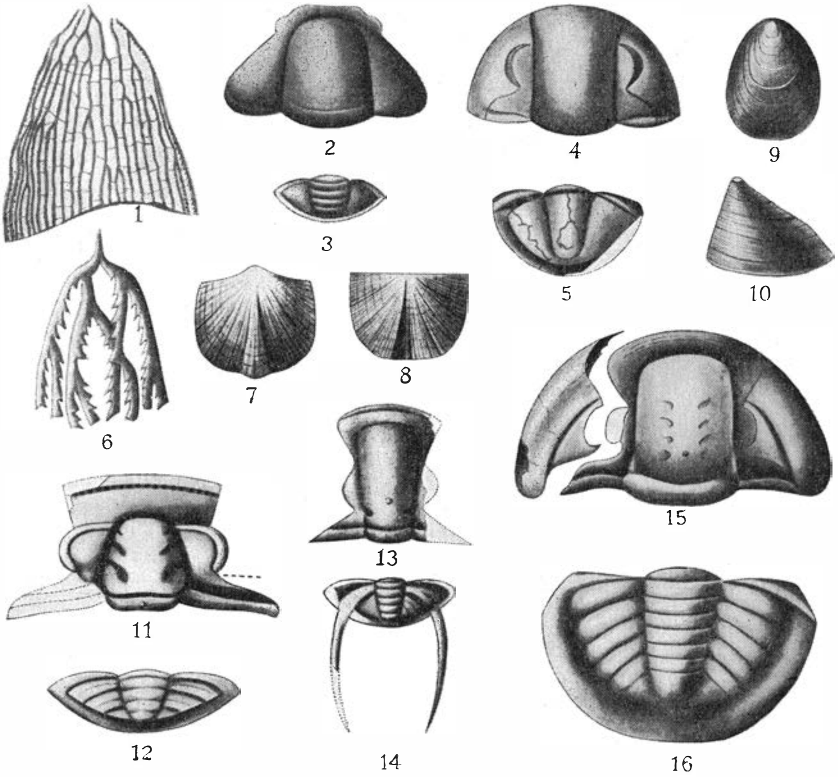

Fig. 4. Tremadocian fossils (2e-3a).

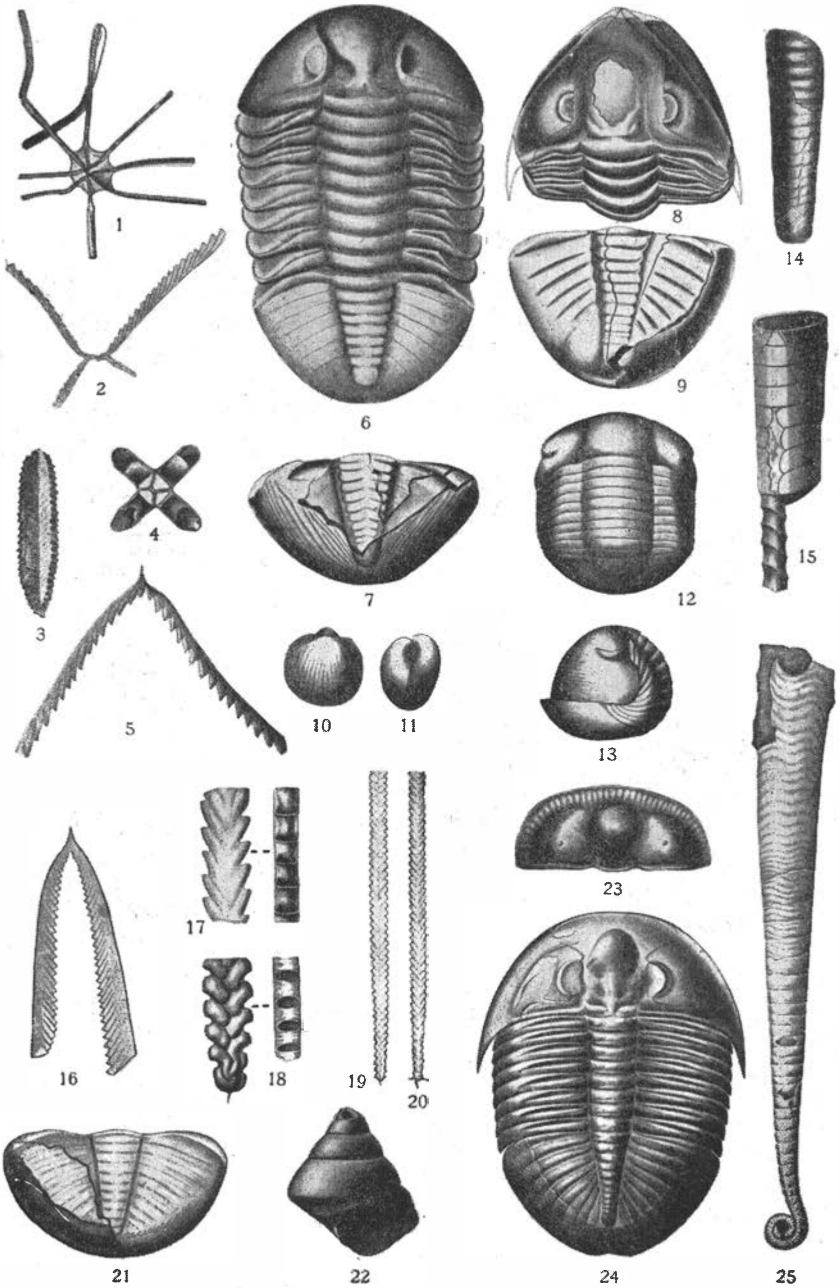

Fig. 5. Lower Ordovician and lowermost Middle Ordovician fossils (3b-4aα).

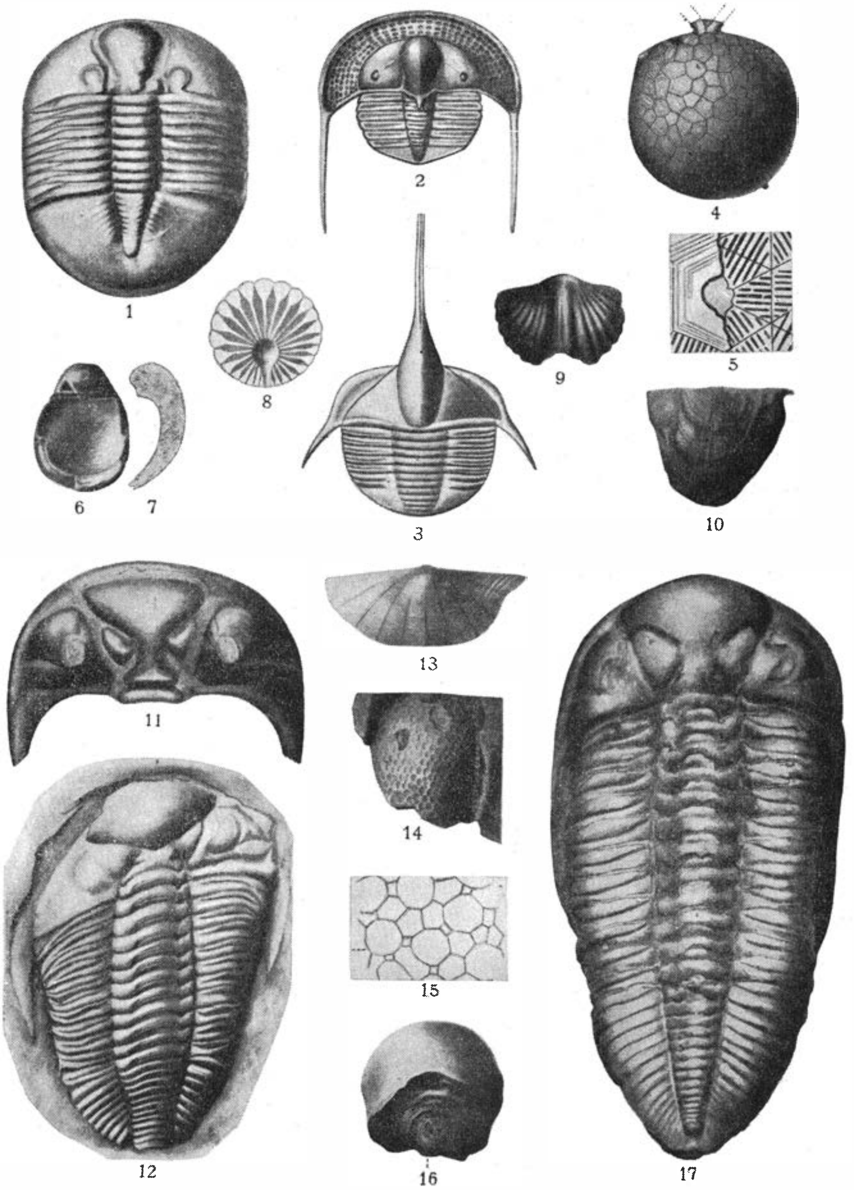

Fig. 6. Middle Ordovician fossils (4aβ-4b).

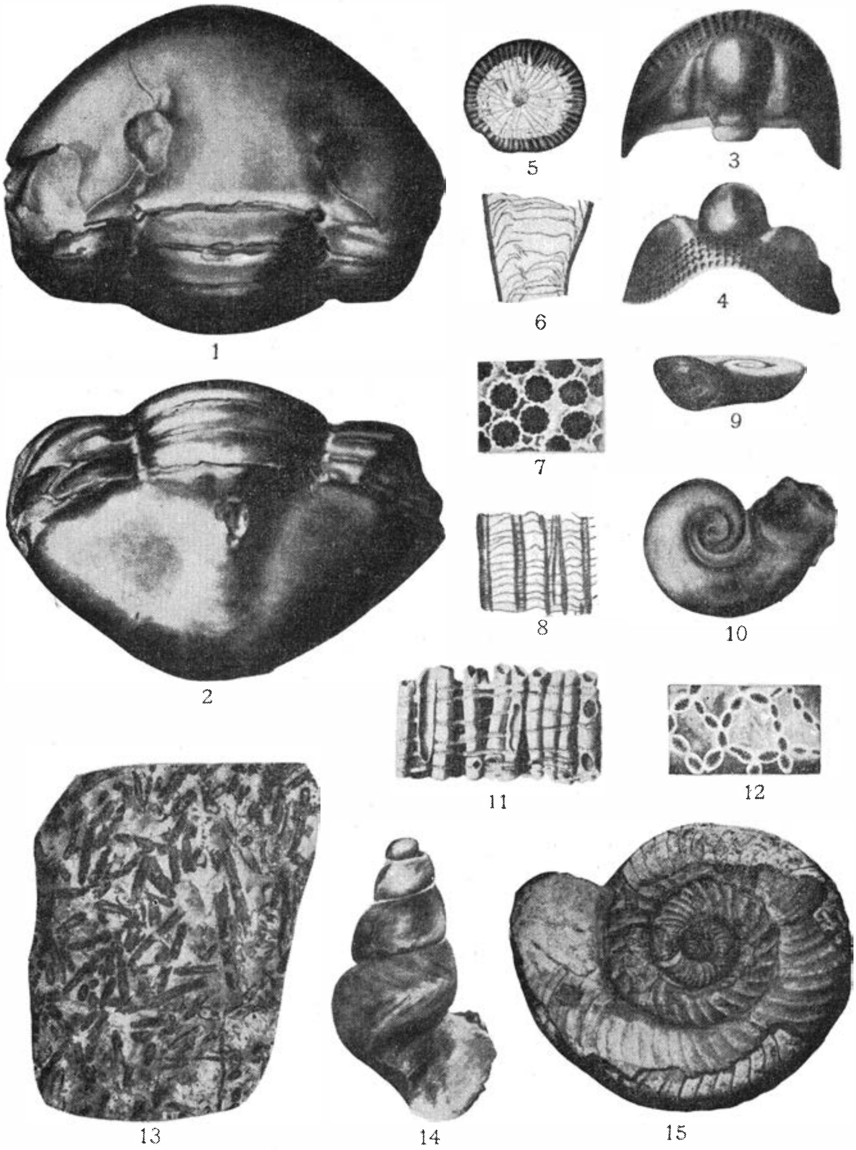

Fig. 7. Upper Ordovician fossils (4c-5a).

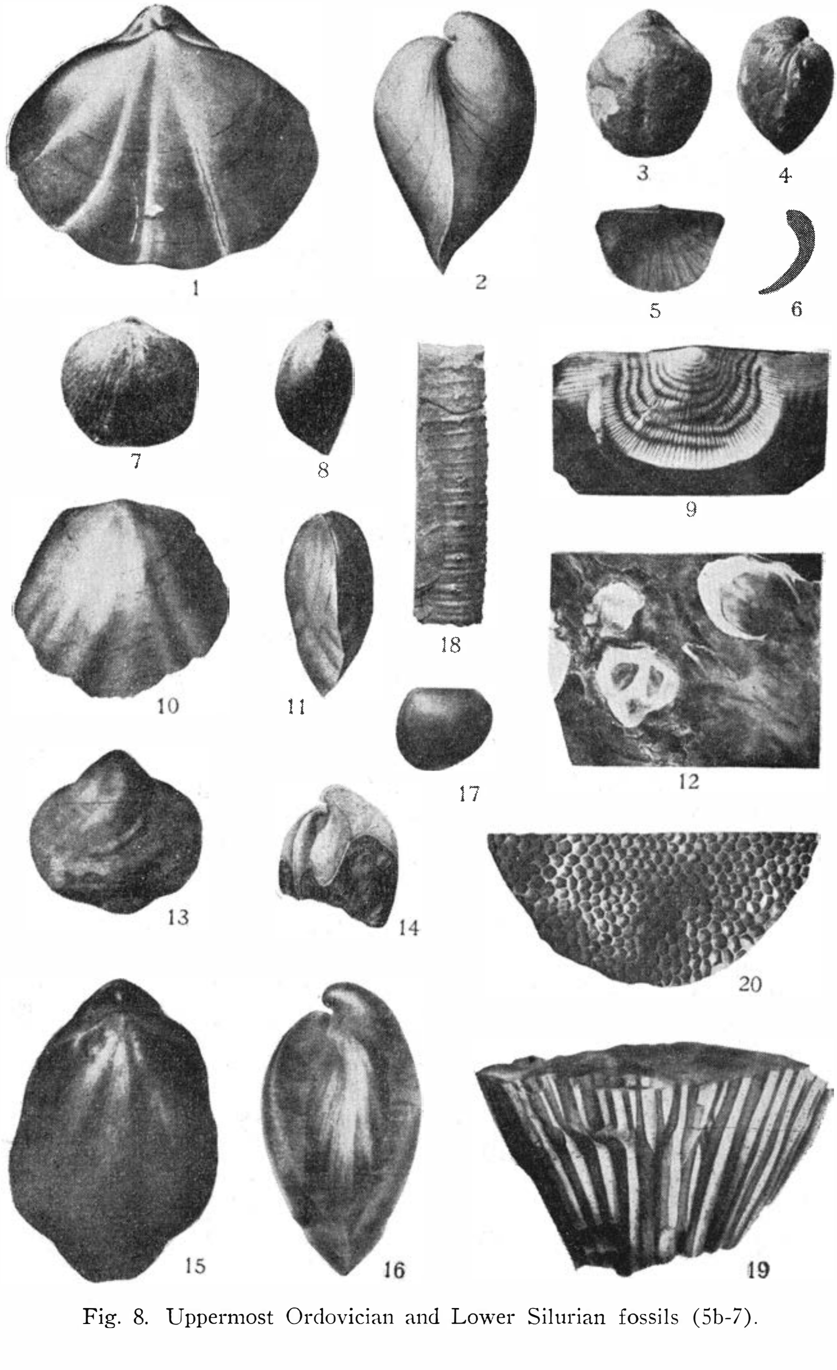

Fig. 8. Uppermost Ordovician and Lower Silurian fossils (5b-7).

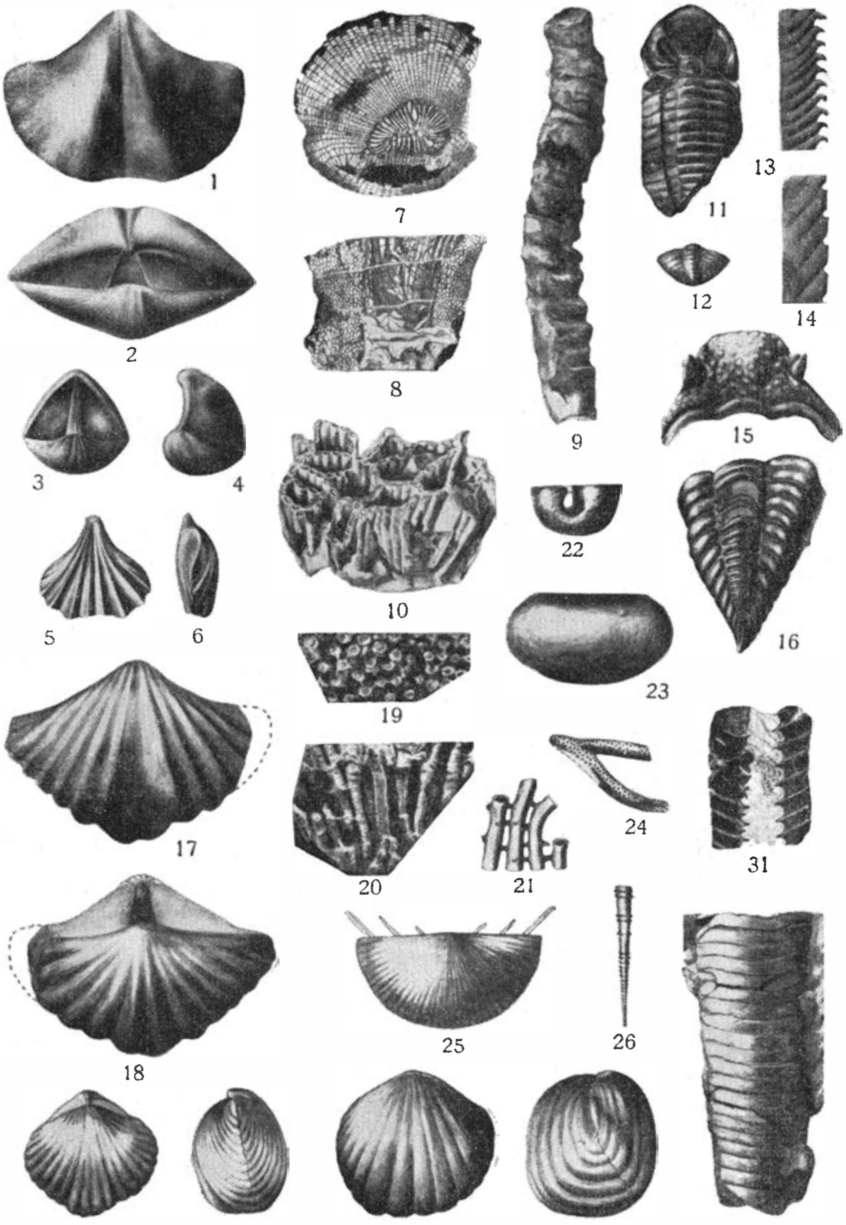

Fig. 9. Upper Silurian fossils (8-9).

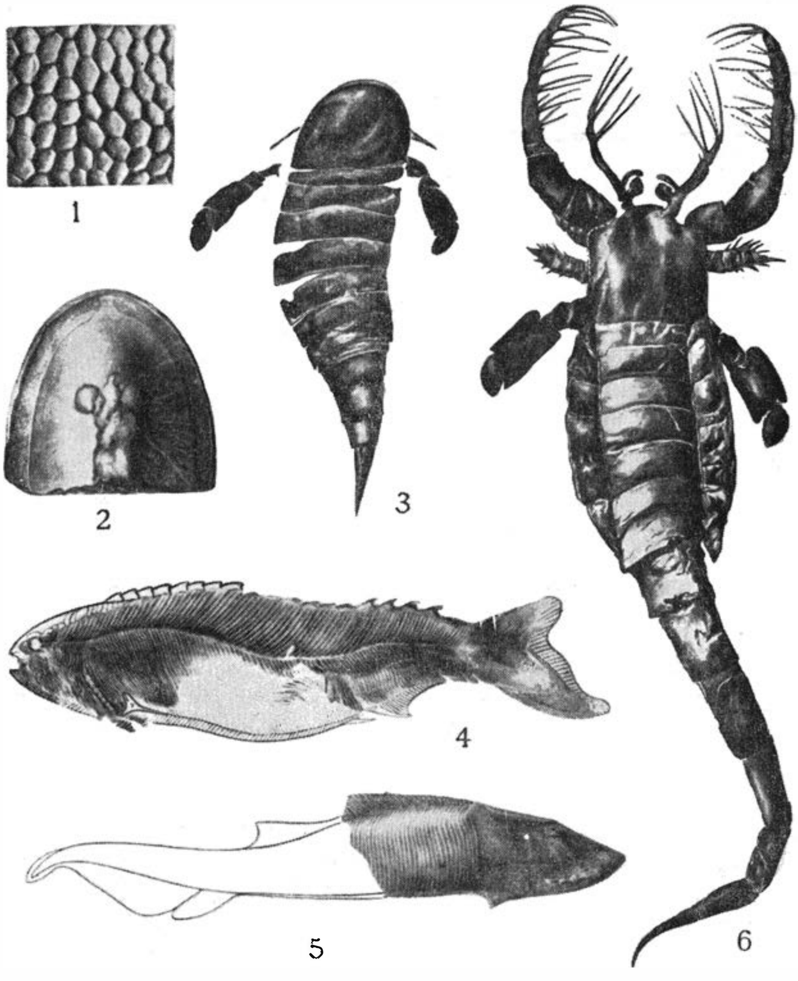

Fig. 10. Downtonian fossils (10).

Fig. 3. Cambrian fossils (1a-2d).

1. *Discinella brästadi*, × 8 (1aα_2). — 2. *Obolella rotundata*, × 2 (1bα). — 3. *Volborthella tenuis*, × 4 (1aβ-1bα). — 4. *Torellella laevigata*, ca. × 2.5 (1b). — 5. *Holmia kjerulfi*, × 1 (1b). — 6. *Strenuella linnarssoni*, × 1.4 (1bβ). — 7-8. *Paradoxides paradoxissimus* (= *P. tessini*), × 1 (1cβ-δ). — 9. *Peronopsis fallax*, × 2 (1cβ-1dα). — 10. *Acrothele coriacea*, × 5 (1cβ-1d). — 11-12. *Parasolenopleura linnarsoni*, × $^{3}/_{2}$, × 3 (1cβ). — 13-14. *Paradoxides forchhammeri*, × $^{1}/_{3}$ (1d). — 15. *Hyolithes tenuistriatus*, × $^{2}/_{5}$ (1cβ-1d). — 16. *Lejopyge laevigata*, × 2 (1cδ-1d). — 17. *Agnostus pisiformis*, × 2 (2aα). — 18-19. *Olenus truncatus*, ×$^{3}/_{2}$, ×2 (2aβ). — 20-21. *Parabolina spinulosa*, ×$^{3}/_{4}$ (2b) — 22. *Orusia lenticularis*, × 2 (2b). — 23-24. *Eurycare latum*, × $^{4}/_{5}$, × 2 (2c). — 25-26. *Peltura scarabaeoides*, × $^{3}/_{4}$, ca. × 2 (2d). — 27. *Ctenopyge spectabilis*, × $^{4}/_{3}$ (2d). — 28-29. *Peltura costata*, × $^{3}/_{4}$, × $^{3}/_{2}$ (2d).

Fig. 4. Tremadocian fossils (2e-3a).

1. *Dictyonema flabelliforme flabelliforme*, × $^{3}/_{4}$ (2e).— 2-3. *Peltura norvegica*, × 1 (3aα). —4-5. *Symphysurus incipiens*. × $^{3}/_{4}$ (3aα). — 6. *Bryograptus kjerulfi*, × 2 (2e). — 7-8. *Archaeorthis christianiae*, × 2 (3a). — 9. *Lingulella lepis(?)*, × 3 (3a). — 10. *Acrotreta seebachi*, ca. × 10 (3a). — 11-12. *Euloma ornatum*, × $^{4}/_{5}$ (3aβ-γ). — 13-14. *Ceratopyge forficula*, × $^{3}/_{2}$, × $^{3}/_{4}$ (3aβ-γ). — 15-16. *Niobe insignis*, × $^{3}/_{5}$ (3aβ-γ).

Fig. 5. Lower Ordovician and lowermost Middle Ordovician fossils (3b-4aα).

1. *Dichograptus octobrachiatus*, ca. × $^{1}/_{2}$ (3bβ-γ). — 2. *Tetragraptus serra*, ca. × 1 (3bβ-δ). — 3-4. *Phyllograptus angustifolius*, ca. × $^{1}/_{2}$ (3bγ-δ). — 5. *Didymograptus vacillans*, ca. × $^{1}/_{2}$ (3b). — 6-7. *Asaphus expansus*, × $^{3}/_{5}$, × $^{3}/_{4}$ (3cβ). — 8-9. *Megalaspis limbata*, × $^{3}/_{5}$ (3cα-β). — 10-11. *Lycophoria nucella*, × 2 (3cβ-γ). — 12-13. *Illaenus sarsi*, × $^{1}/_{2}$ (3c). — 14. *Cyclendoceras vaginatum*, ca. × $^{1}/_{3}$ (3cβ-γ). — 15. *Cyclendoceras* sp., ca. × $^{1}/_{3}$ (3cβ-γ). — 16. *Didymograptus geminus*, ca. × 1 (4aα). — 17, 20. *Diplograptus (Glyptograptus) teretiusculus*, × 3, × 1 (4aα). — 18—19. *Climacograptus scharenbergi*, × 3, × 1 (4aα). — 21. *Pseudomegalaspis patagiata*, ca. × $^{1}/_{2}$ (4aα). — 22. *Clathrospira hyperborea*, × 2 (4aα). — 23. *Trinucleus foveolatus*, × 4 (4aα). — 24. *Ogygiocaris dilatata sarsi*, × $^{2}/_{3}$ (4aα). — 25. *Lituites lituus*, × $^{1}/_{4}$ (4aα).

Fig. 6. Middle Ordovician fossils (4aβ-4b).

1. *Asaphus* sp., ca. × $^{1}/_{2}$ (4aβ). — 2. *Reedolithus carinatus*, × $2^{1}/_{2}$ (4aβ). — 3. *Lonchodomas rostratus*, × 2 (4aα-β). — 4-5. *Echinosphaerites aurantium*, × $^{3}/_{4}$, × 5 (4aβ-4b). — 6-7. *Christiania tenuicincta*, × $^{3}/_{4}$ (4bα, 5a? 6a?). — 8. *Coelospaeridium cyclocrionphilum*, ca. × 1 (4b). — 9. *Platystrophia* sp., ca. × $^{3}/_{4}$ (4b-?). — 10. *Rafinesquina* sp., ca. × $^{3}/_{4}$ (4b). — 11. *Chasmops conicophthalma*, ca. × 1 (4bα-β). — 12. *Chasmops* sp., × 1 (4bα-β). — 13. *Sowerbyella acuminata*, × $^{4}/_{3}$ (4bα). — 14. *Mastopora concava*, ca. × $^{1}/_{2}$ (4b-?). — 15-16. *Diplotrypa petropolitana*, ca. × 10, ca. × $^{2}/_{3}$ (?-4b-?). — 17. *Chasmops extensa*, × $^{3}/_{5}$ (4bγ-δ).

Fig. 7. Upper Ordovician fossils (4c-5a).

1-2. *Brachyaspis* sp., × $^{2}/_{3}$ (4d). — 3-4. *Tretaspis latilimba*, × 2 (4cβ-5a). — 5-6. *Dybowskia* sp., ca. × $^{4}/_{3}$ (5a). — 7-8. *Proheliolithes dubius*, × 2, × 4 (5a-b). — 9-10. *Maclurites neritoides*, ca. × $^{1}/_{2}$ (5a). — 11. "*Syringophyllum organum*", ca. × $^{3}/_{4}$ (5a). — 12. *Halysites escharoides*, ca. × $^{3}/_{2}$ (5a-7). — 13. *Palaeoporella variabilis*, × $^{1}/_{2}$ (4d-5a). — 14. *Hormotoma insignis*, ca. × $^{1}/_{2}$ (5a). — 15. *Discoceras antiquissimum*, × $^{2}/_{5}$ (5a).

Fig. 8. Uppermost Ordovician and Lower Silurian fossils (5b-7).

1-2. *Holorhynchus giganteus,* × 1/2 (5b). — 3-4. *Meristella? crassa,* × 2/3 (5b). — 5-6. *Sowerbyella* sp., ca. × 1 (6-8). — 7-8. *Atrypa reticularis,* × 4/5 (6-9f). — 9. *Leptaena rhomboidalis* (?), × 1 (6-9e). — 10-11. *Striclandia lens,* × 2/3 (6b-c). — 12, 15-16. *Pentamerus borealis,* ca. × 1/2, × 2/3 (7a). — 13-14. *Pentamerus laevis,* × 1 (7b). — 17. *Leperditia abbreviata,* × 2/3 (7b). — 18. *Crinoid stems,* × 2/3 (7b-c, 8c, 9d). — 19-20. *Favosites* sp., ca. × 1 (?-6-9).

Fig. 9. Upper Silurian fossils (8-9).

1-2. *Eospirifer plicatellus,* × 1 (7c-8). — 3-4. *Cyrtia exporrecta,* × 1 (7c-8a). — 5-6. *Rhynchotreta cuneata,* × 1 (7c-9f). — 7-9.*Semaiophyllum* sp. (= *Cyatophyllum articulatum*), × 2/3, × 1/6 (8c—d). — 10. *Halysites catenularius,* × 3/5 (6c, 7, 8c-d, 9d). — 11-12. *Phacops stokesi(?),* × 2/3 (7c-8b). — 13. *Monograptus priodon,* × 2 (7c-8b). — 14. *Monograptus vomerinus crenulatus,* × 2 (7c-8b). — 15-16. *Encrinurus punctatus,* ca. × 1, × 2/3 (6-8, 9c-d). — 17-18. *Delthyris* [= *Spirifer*] *elevatus,* × 3/4 (9c-g). — 19-21. *Syringopora bifurcata,* × 2/3, ×3/4 (7b, 8c-d, 9a-c-d). — *Beyrichia* sp., ca. × 4 (6b-7c, 8b-9c, e-g). — 23. *Leperditia norvegica,* × 2 (9 g). — 24. *Coenites repens,* × 1 (7b, 9c-d). — 25. *Chonetes* sp., × 3/2 (8b-c, 9a, e). — 26. *Tentaculites ornatus,* × 3/2 (8d, 9a, c-e). — 27-28. *Camarotoechia nucula,* × 3/2 (9). — 29-30. *Wilsonella wilsoni,* × 3/2 (8d, 9d-f). — 31-32. *Armenoceras kiæri,* ca. × 1/4 (8d, 9a, c-d).

Fig. 10. Downtonian fossils (10).

1. *Dictyocaris slimoni,* × 6. Surface ornamentation — 2. *Hemicyclaspis kiæri,* ca. × 2/3. —3. *Hughmilleria norvegica* × 2/3. — 4. *Pterolepis nitidus,* × 1. — 5. *Aceraspis robustus,* ca. × 2/5. — 6. *Mixopterus kiæri,* ca. × 1/7.

Caledonian Folding.

By

Leif Størmer

The Cambro-Silurian (including the Ringerike Sandstone) has been subjected to fairly intensive folding. The type of folding is different in competent and incompetent beds, and is dependent on the thickness of the units. The Cambrian alum shale at the base of the stratigraphic column shows minute folding with numerous slickensides. The limestone beds of moderate thickness (1-10 m) form folds of small amplitude often breaking into thrust faults (Orthoceras Limestone at Huk, Bygdøy, Fig. 26). Minor tectonic breccias have been formed in strongly folded competent beds (the Orthoceras Limestone and the Calcareous Sandstone). The shales with limestone lenses are well folded, with a certain amount of thrusting along the bedding planes; the folding is generally controlled by massive rocks (Limestone or Sandstones) above or below. Thick competent beds, such as the Ringerike Sandstone form gentle folds, as for instance the broad syncline below the Kolsås mountain and W of it.

The trend of the folds is WSW-ENE, a direction well expressed in the shape of the islands and sounds S and W of the city of Oslo.

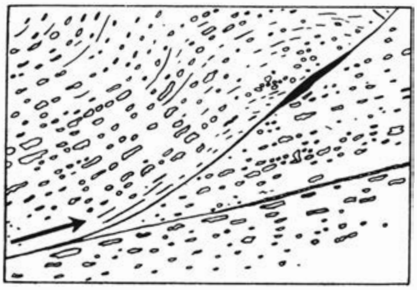

Fig. 11. Thrusts in folded shale (with limestone nodules). 4cβ Bygdøy. After L. Størmer.

The Pre-Cambrian substratum below the well-developed sub-Cambrian peneplane has not taken part in the folding which thus appears as a surface folding, a "plissement de couverture", comparable more or less to that of the Jura Mountains.

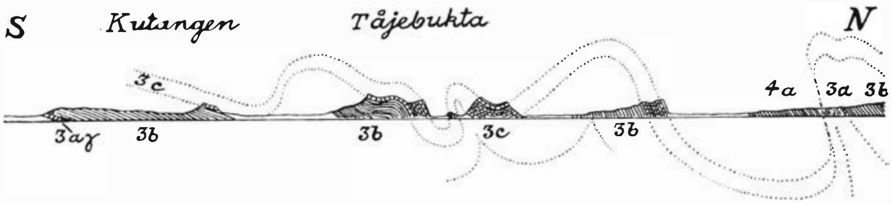

Fig. 12. Section along the coast north of Slemmestad (cf. Fig. 25). After W. C. Brøgger.

The folding belongs to the Caledonian orogeny. Since Ringerike Sandstone is involved, the folding cannot be older than Lower Devonian. On the other hand the sub-Permian peneplane cutting the Caledonian folds, forms an upper limit in time. A Lower Devonian age seems most probable from correlation with the Caledonian movements of central Norway.

Literature: 1, 3, 11, 38.

Permian Sedimentary Rocks.

By

Olaf Holtedahl

The Caledonian folds have been cut by a very even plane of denudation upon which a younger sedimentary series was laid down. Thanks to a find of fossils in 1931 this series can be dated as Lower Permian and the denudation surface below it we therefore call the *sub-Permian peneplane.*

The thickness and stratigraphy of the sedimentary series under consideration varies considerably within the map area, the most complete sequence being found to the south-west, in Asker. Typical of all known sections is a quartz conglomerate which rests on shaly beds. The latter are inter alia well exposed in the southern part of Kolsås and in a road-cut 1.3 km west of Slependen railway station. The colour of the shale is vivid red and the

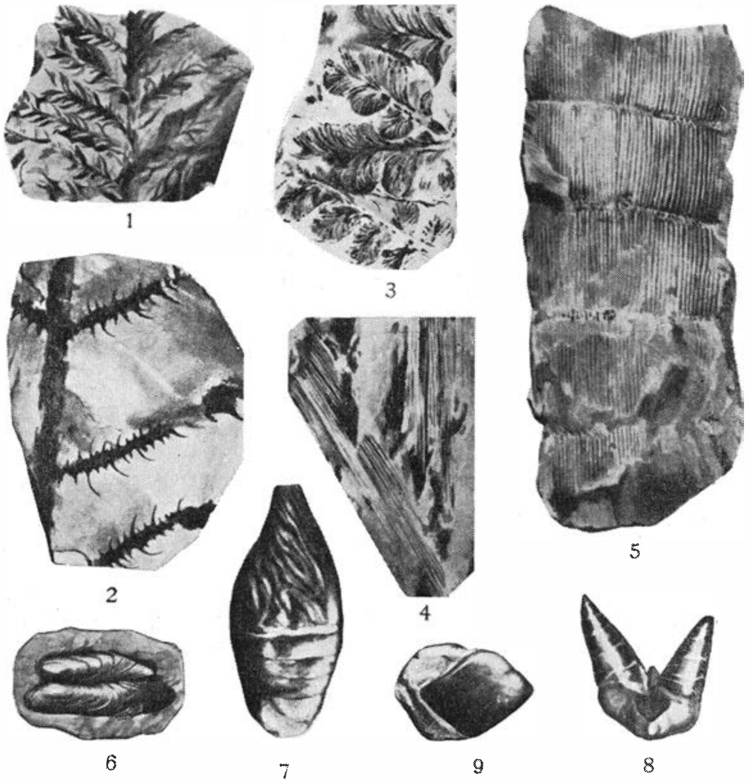

Fig. 13. Fossils from the Lower Permian strata at Semsvik in Asker.

1. *Lebachia (Walchia) piniformis,* × $^{1}/_{2}$. — 2. *Walchia (Ernestiodendron?) arnhardtii,* $^{1}/_{2}$. — 3. *Callipteris* (?) sp., $^{1}/_{1}$. — 4. *Cordaites* (fragments of leaves), $^{3}/_{5}$. — 5. *Calamites undulatus,* $^{1}/_{3}$. — 6. *Palæanodonta* sp., $^{4}/_{5}$. — 7. Coprolite of fish, $^{1}/_{1}$. — 8. *Pleuracanthus,* tooth, $^{1}/_{1}$. — 9. *Megalichthys,* scale, $^{5}/_{4}$. From O. Holtedahl "Norges geologi".

thickness at least 10 m. The conglomerate, which sometimes shows an intercalation of arenaceous layers, has in the western part of the map area a thickness of about 8 m. It is predominantly made up of well rounded quartzite or pegmatite-quartz pebbles, up to apple-size. These must have been transported from outside the Oslo region, probably by rivers. While in Kolsås the oldest lava bed (B_1) lies directly above the conglomerate, there occurs in the extreme south-west, at Semsvik, west of the Semsvann Lake, a sedimentary sequence, 15-20 m thick, between the conglomerate and the basalt. In the lower part this series consists of soft, in some layers fossiliferous shale, mainly greenish-gray in colour while higher up comes sandstone which in its upper part contains tuff-like material. On top, just below the lava, come conglomeratic beds, a "lava-conglomerate" made up of pebbles or somewhat larger stones, largely of a type of porphyritic basalt (labradorite porphyrite) which forms part of the oldest basalt sequence in more southerly parts of the Oslo Region (e. g. at Holmestrand).

The fossils in the shale are predominantly plants, the majority being *Calamites*, *Walchia* and *Cordaites* types. (Høeg 1935.) Furthermore fish remains (Heintz 1934) and specimens of a lamellibranch, *Palæanodonta* (Dix and Trueman 1935) have been found. We are dealing with continental deposits of, according to Høeg, probably Middle Lower Permian age. In a still more western locality red sandstone layers with *Walchia piniformis* occur above a zone of lava conglomerate, and from a section near Billingstad Brøgger has (1933b) mentioned the presence of a thin bed of basic lava as an intercalation in the quartz conglomerate. Evidently the volcanism of the Oslo Region had started at the time when the plant-bearing deposits were laid down.

Relatively thin layers of sandstone and lava-conglomerate are known also as intercalations in the lava-series of the map area. We can refer to excursion 8 and to Sæther's description of the Nittedal lavas and B_3 rocks of the Bærum cauldron (Oslo Series 1945 and 1946). In the Alnsjø district (excursion 14, cf. also the coloured map) there occurs, above lavas (and agglomerates) of either B_2 or B_3: 1. a thick sedimentary series of argillite and arkose, the material of which must have been largely derived from volcanic rocks; 2. (the youngest stratigraphic zone of the district) a conglomerate mainly made up of lava material.

Literature: 12, 21, 23, 27, 41, 45.

Permian Igneous Rocks.

By

CHRISTOFFER OFTEDAHL

The Oslo region contains a great multitude of igneous rock types, often with a complicated history. In this introduction the geological history of the rock types of major importance is presented, and a brief petrographical description given.

For convenience the rocks are grouped into Lavas, Plutonic rocks and Dyke rocks.

The Lavas.

The igneous activity started with the pouring out of a basalt flow, B_1, on to a very flat rock floor of Permian sedimentary rocks (see p. 24) resting on a peneplane of folded Cambro-Silurian sediments. The basalt flow has a thickness of 10—30 meters. During a short period of erosion a bed of basaltic detritus and quartz sand formed in many places.

Suddenly the effusive activity changed its character, and huge masses of lavas of monzonitic composition were extruded. The phenocrysts have a characteristic size, shape and density of packing in each lava type. Thus more

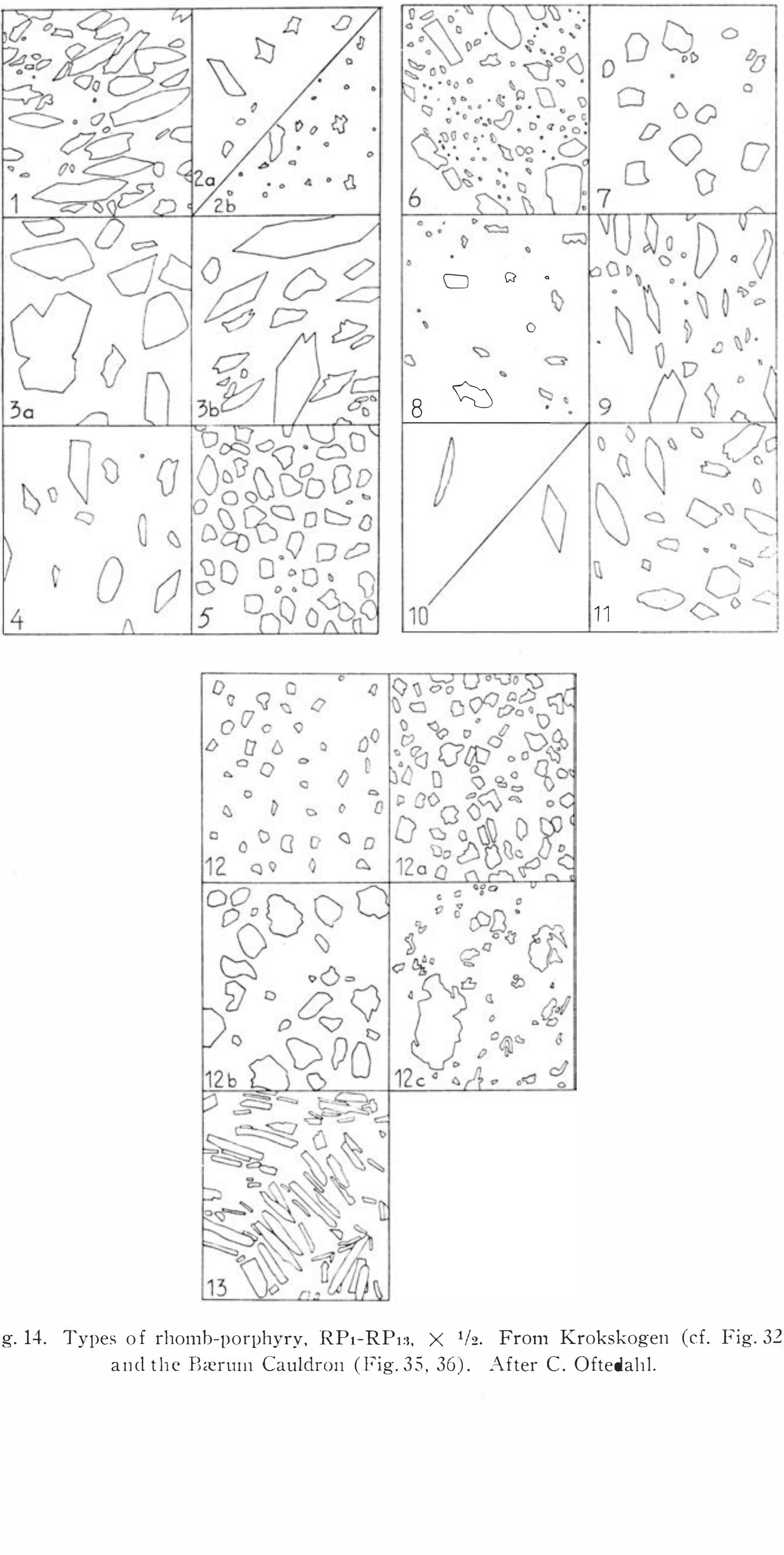

Fig. 14. Types of rhomb-porphyry, RP_1-RP_{13}, × 1/2. From Krokskogen (cf. Fig. 32) and the Bærum Cauldron (Fig. 35, 36). After C. Oftedahl.

than a dozen different flows of trachyandesite (latite) have been distinguished and mapped. Due to the more or less rhomb-shaped cross-section of the phenocrysts in a number of the flows the name *rhomb porphyry* was applied to them. (This name was originally given to a dyke rock with such crystals, by Leopold von Buch in 1810). The flows are called rhomb-porphyry lavas Nos. 1, 2, 3, etc. with map abbreviations RP_1, RP_2, RP_3 etc. After the formation of RP_9 the activity suddenly switched to basalt with formation of the second basalt, B_2. Then more rhomb porphyries followed and above RP_{12} a huge unit of basalts of various types, B_3, accumulated. Lavas of more intermediate composition followed B_3 and on the map four such higher flows are distinguished. The effusive activity continued for even longer and a number monzonitic lavas of the rhomb-porhpyry type are found north of the map area.

The various lava flows differ in thickness. Thus the bottom basalt, B_1, is locally only about 10 meters thick and the same is the case with some of the rhomb porphyry flows such as RP_3 and RP_{12}. Most of the RP-flows, however, are much thicker. 30 to 100 meters are frequent. The thickest is RP_1 which is more than 100 meters, perhaps as much as 200 meters. The areal extension is considerable; thus RP_1 originally probably covered a major part of the Oslo Region, at least 10 000 km^2.

Each of these lava flows is very uniform and seems mostly to have been formed during a single extrusion. Formation of single flows more than 100 meters in thickness is known for basalts but has hardly been described for trachyandesites.

The mode of extrusion for all the rhomb-porphyry lavas is supposed to be fissure eruption (Oftedahl, 1952).

Chemical and Mineralogical Composition. A series of chemical analyses of all the lava types was published by Brøgger (1933). The mineralogical composition of the basalt types of B_3 in the Bærum Cauldron has been described by Sæther (Oslo-series 1945). These basalt varieties occur also within the other basalt flows and thus the descriptions by Sæther cover B_1, B_2 and B_3. From their macroscopical appearance the basalts may be divided into four types:

1. Augite basalt carrying short prismatic crystals of titaniferous augite in a ground-mass of plagioclase laths and small augite grains.
2. Non-porphyritic basalt composed only of plagioclase and augite.
3. Plagioclase basalt carrying phenocrysts of plagioclase in the form of thick tablets up to two centimeters across in the ordinary groundmass
4. Porphyritic basalt with both augite and plagioclase phenocrysts. The The plagioclase has a composition very close to 50 An. The less basic types have usually a low per cent of orthoclase. Thus these basalts are not truly what should be called basalts but trachybasalts.

The rhomb porphyries have been briefly described by Oftedahl (Oslo series 1946). Their composition is essentially monzonitic, and the variations are so small and incidental that there is no systematic difference from one type to another in the series. They carry phenocrysts of plagioclase with a composition mostly around 30 An but varying from 20—40 An. The phenocrysts have a more or less pronounced rhombic section depending on the development of the crystal faces (110) and $(\bar{2}01)$ in relation to the ordinary faces (001), (010) and $(\bar{1}01)$. The phenocrysts are often somewhat resorbed and have a margin of alkali feldspar. The groundmass feldspar is essentially an altered alkali feldspar, the composition of which is close to the so-called eutectic composition. The chief dark silicate is an ordinary augite, often altered to aggregates of chlorite. Mineralogically many of the rhomb porphyries are peculiar in carrying nearly half of the feldspar as plagioclase in the phenocrysts and the other half as alkali feldspar in the groundmass.

Plutonic Rocks.

In the central northern part of the map area plutonic rocks dominate. Egil Sæther has here carried out detailed work for the present map; unfortunately the description of these rocks has not yet appeared, only a short summary (Sæther N. G. T., 1945), where Sæther presents the main facts about the relative age relations as determined by contact relationships. The oldest rock-complex is that of the Oslo-essexite occurring in the volcanic neck of Ullernåsen-Husebyåsen as described in detail by Dons (Oslo series, 1952) (see excursion No. 57). This neck can be regarded as a feeding channel for one of the basalt-lavas, most likely B_3.

The next group is represented by the coarse-grained monzonitic rocks. In the map legend they are called kjelsåsite and larvikite. The large massif of these rocks shown on the map was originally called kjelsåsite by Brøgger. This rock type is only slightly more basic and has more rectangular texture to the feldspar crystals as compared with the more ordinary larvikite in which the large feldspar crystals have a more rhombic or boatshaped cross-section. There seems to be little reason to have a special name for this rock and it might as well be called larvikite. The sørkedalite is a dioritic rock with andesine and olivine as the chief minerals. It is extremely coarse-grained with porphyritic and hybrid structures.

The third group comprises many rock types ranging in composition from monzonites to quartz-syenites. The texture varies from coarsely crystalline to felsitic. A somewhat fine-grained monzonitic rock with rectangular feldspar crystals was called akerite by Brøgger (1890). This name is now used for fine-grained rocks as well as for rather coarse-grained. Close to the northwestern corner of the map such rocks occupy a large area. The fine-grained rocks grade into felsites, which often carry numerous fragments of oldermainly lava rocks. As fragments in these (igneous) breccias also occur

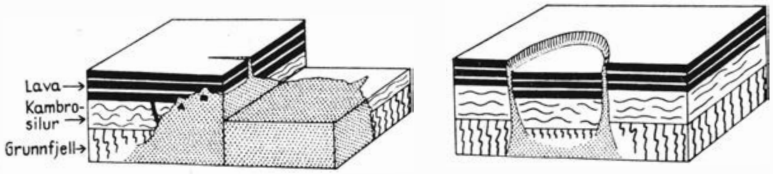

Fig. 15. Generalized block diagrams (by O. Holtedahl) illustrating mode of occurrence of igneous rocks of the Oslo district, to the right connected with cauldron subsidence (Grunnfjell = Pre-Cambrian).

coarse-grained larvikites, and Sæther concludes that the whole complex of finer grained intrusive rocks is younger than the larvikites. On the other hand they seem to be older than the syenitic plutonic rocks because they never contain fragments of such rocks.[1]

The syenitic group of plutonic rocks consists of a number of types. The older types carry ordinary dark silicates such as amphibole and biotite. Their main feldspar is alkali feldspar characterized by eutectic composition (Or_{60} Ab_{40}). It is usually a microperthite, occasionally grading into a cryptoperthite. One type carries both alkali feldspar and plagioclase (ordinary syenite). Other types carry only alkali feldspar and should be termed alkali syenite. The youngest type carries soda-bearing dark silicates, mostly ægirite. These rock types have either sharp or gradational contacts — the latter is shown by the open stippling on the map. There is also a gradation into the ægirite-granite (ekerite).

All the syenitic rocks were called nordmarkites by Brøgger in 1890. In modern nomenclature this usage of the term nordmarkite is a "sack" name. The designations used above are not completely in accordance with the definitions of Sæther (N. G. T. 1945), Barth (Oslo series, 1945) and Oftedahl (Oslo series, 1948).

The youngest plutonic rock body is that of the Drammen granite.

Chemical and Mineralogical Composition. The chemical composition of more than a hundred plutonic rock species is tabulated by Brøgger (1933a). In all, 64 of these have been mineralogically described by Barth (Oslo series, 1945) with tabulated modes. About a dozen of these are from localities within the map area.

Recently Dons has presented a thorough description of the rocks of the Ullernåsen-Husebyåsen volcanic neck, the mineralogical composition of which is highly variable. Varieties of syenodioritic rocks predominate, followed by the monzonitic akerites and akerite porphyry.

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[1] The entire group is now considered by Oftedahl to represent supracrustal rocks. The akerite porphyry and the syenite porphyries are considered to represent tuffs, perhaps to some extent lavas. The felsite porphyries, transitional into breccias, are considered as ignimbrites, — welded tuffs grading into agglomerates. Cf. a forthcoming paper in the Oslo series. (Added in proof, Feb. 1957.)

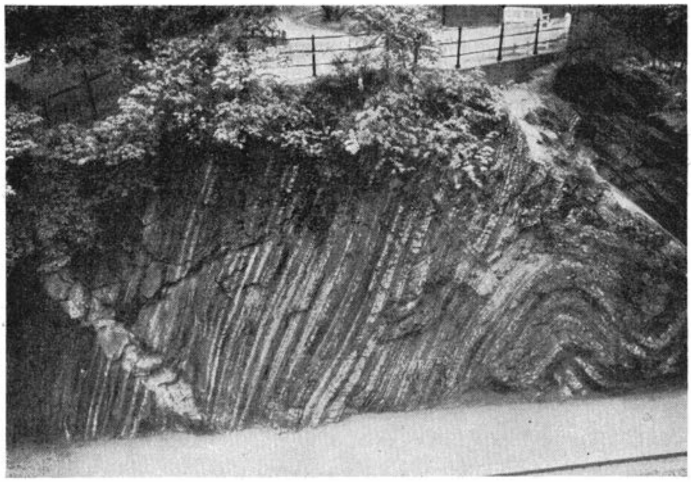

Fig. 16. Folded Ordovician strata of shale and impure limestone (4aβ), to the left cut by a Permian dyke. Uranienborgveien, Oslo. After O. Holtedahl.

The kjelsåsite occurring in the massif NE of Kjelsås is a syenodioritic rock with 10 per cent augite as an important dark mineral. The larvikite is more typically monzonitic, with the same content of dark minerals. Around Kjelsås extraordinary rock types occur. Thus sørkedalite is an olivine diorite with as much as 23 per cent olivine occurring as drop-like grains in large tablets of andesine, apotroctolite (Barth, Oslo series, 1945) is the corresponding olivine-bearing monzonite. This latter rock is not distinguished from sørkedalite on the map.

The rocks of the next group have been partly described by Oftedahl (Oslo series, 1946). They range in composition from monzonitic to quartz syenite. The monzonitic rocks, with a mineral content similar to the larvikite, are represented by akerite and akerite porphyry. Some of the rocks in the Bærum cauldron grade into ordinary syenite. The felsitic rocks are syenitic to quartz syenitic and some of them are characterized by an unusually high amount of alkalis, eg. K_2O: 6,80 %, Na_2O : 2,68 %.

The syenitic rocks, the "nordmarkites" contain from 85 to 90 % feldspar, a cryptoperthite, or more often, a stripy microperthite. Tablets of plagioclase are present in one variety. The quartz content is usually below 5 %. The dark silicates, 5—10 %, are hornblende + biotite, or arfvedsonite + ægirite, though transitions exist.

The ekerite is a granite with up to 10 % ægirite and/or arfvedsonite. The Drammen granite contains some oligoclase besides the microperthite tablets. A few per cent biotite is the usual dark silicate.

The Dyke Rocks.

Igneous dykes occur especially in the Cambro-Silurian sediments adjacent to the plutonic bodies, with a heavy concentration in certain areas around volcanic necks.

A considerable amount of work has been conducted on the petrography and geological problems of the dyke rocks. A number of papers by Brøgger are solely devoted to them. Brøgger distinguished a great number of new types, many of which were first described by him. In the recent years extensive mapping has been done around the Ullernåsen-Husebyåsen volcanic neck by Dons and immediately west of this area by Sæther (Oslo series, 1947). The sills are generally older, and the fissure dykes the younger rocks. The age succession is the following: mænaite, bostonite, lindøite (all mostly as sills), then rhomb-porphyry and akerite-porphyry, syenitic dykes, quartz-aplite and sphaerulite-felsite, kullaite and windsorite. Diabases and related rocks cover a wide range of time, the majority being very young.

The chemical and mineralogical composition of a great number of dyke rocks have been published by Brøgger. Modern nomenclature and descriptions are given by Sæther and Dons.

Literature: 1, 3, 5, 6, 8, 9, 32, 37, 38, 39—52.

Contact Metamorphism.

By

Ivar Oftedal

The hornfelses surrounding the large intrusive bodies of the Oslo Region are recrystallisation products of Cambro-Silurian sedimentary rocks and — less frequently — Permian lavas. They are largely products of "isochemical" and static metamorphism. As a result of his comprehensive studies some 45 years ago, V. M. Goldschmidt (1911) arrived at the conclusion that the mineral association of a given hornfels is completely determined by the composition of the original material. Considering a series ranging from pure argillaceous to highly calcareous rocks (clay-marl sediments), the resulting hornfelses will exhibit a corresponding range of definite and predictable mineral compositions. On this basis Goldschmidt defined his 10 hornfels classes. Class 1 comprises the hornfelses resulting from pure argillaceous shales; it is characterized by highly aluminous silicates (andalusite, cordierite). Similarly the highest classes are characterized by lime silicates (grossularite, diopside, wollastonite, &c.). All the hornfels classes represent mineral associations stable within a definite temperature-pressure interval characteristic of the "inner contact zone". In the mineral facies classification developed later by Eskola this interval corresponds to the pyroxene hornfels facies.

Goldschmidt estimated the temperature of the inner contact zone at perhaps above 1000° C, but added that this was mere conjecture. He also found in some hornfelses (from Sølvsberget in Hadeland) orthoclases resembling sanidine in their optical properties, but at that time no definite conclusions could be drawn from this fact.

Quite recently T. H. McCulloh (Oslo series, 1952) has studied hornfelses, mostly from xenoliths in nordmarkite, in the Grefsen-Grorud area. In some of them he discovered true sanidines as well as felspars intermediate between sanidine and orthoclase. Thus some of the contact rocks have obviously recrystallized in the sanidinite facies. Utilizing recent data McCulloh concludes that the nordmarkite magma emplaced itself at a probable initial temperature higher than 1000°C. As this is much higher than the temperature of principal crystallisation the magma was obviously superheated. A number of other observations indicate that Oslo magmas were superheated. Thus E. Sæther (Oslo series, 1946) found in the Nittedal area that the intruded magmas must have cooled considerably prior to crystallization.

In the Grefsen-Grorud area most hornfelses seem to belong to the classes 7, 6, 5, i. e. the sediments of the area were on the average moderately calcareous. Some of the class 6 (plagioclase-diopside-hypersthene) hornfelses, mostly from xenoliths, were shown by Goldschmidt to represent recrystallised basalt ("essexite lava"). They differ from normal (sediment) class 6 hornfelses mainly by being much richer in magnetite and ilmenite. A number of small copper deposits (chalcopyrite, bornite) occur in this basalt hornfels.

As the sediments of this area did not include thick beds of limestone no typical "skarn" deposits occur. However, locally there are many vestiges of contact metasomatism or pneumatolysis. Thus Goldschmidt studied in detail some lime silicate xenoliths in the Årvoll valley and found a number of interesting minerals due to such processes: axinite, scapolite, vesuvianite, prehnite, molybdenite, sphalerite, &c. Actually Goldschmidt's great work on the contact metamorphism developed from these mineralogical studies in the Årvoll valley.

In the Nittedal area E. Sæther has studied the contact metamorphism in Cambro-Silurian sediments as well as in basalts. Pyroxene hornfelses were found only locally close to the intrusive contact. Most of the contact metamorphic rocks were found to be in the amphibolite facies and the epidote-amphibolite facies (outer contact zone). Between these and the unmetamorphosed rocks there is a zone of rocks in the actinolite-greenstone facies.

In Bærum there is some contact metamorphism in connection with the Bærum Cauldron. Metamorphosed lavas within the cauldron and metamorphosed sedimentary rocks just outside it belong to the epidote-amphibolite facies, according to E. Sæther (Oslo series, 1945). Similarly most of the Downtonian sandstone in Vestre Bærum is contact metamorphic. It is surprising that the sandstone is metamorphic (quartzitic) nearly everywhere in the wide valley between Kolsås and Tanumås, except in the layers just below the lava beds. We obviously have to assume an intrusive body not far below the bottom of the valley.

In Asker a very broad contact aureole surrounds the granite.

Literature: 20, 41, 45, 48.

Faults.

By

Olaf Holtedahl

Block-faulting is a structural feature very characteristic of the map area. A number of faults younger than the lava-series have been described by Kjerulf and later on Brøgger (1886) made a very detailed study of the principal fault zones bordering the fjord. He demonstrated the existence in some parts of the fault scarps of two zones or layers, of tectonically highly broken rocks (cp. also Gleditsch, 1944) viz. an inner layer with a fine-grained quartzite-like rock, a micro-breccia (mylonite), and an outer layer of younger age, a macro-breccia with fragments of the rock just mentioned and also of dark shale etc. Quartz-veins are common in both types of breccia. There evidently have been dislocations at two well separated periods. It has been suggested that the first brecciation is of Pre-Cambrian age, but it is also possible that we are dealing with an early phase of younger dislocations.

The vertical movements along the faults on the west side of Nesodden and the east side of Bunnefjord must have been, at a minimum, more than 500 m (the thickness below sea-level of the Cambro-Silurian present in islands near the fault-lines plus the height a. s. l. of the Pre-Cambrian block to the east). Further south along the east side of the Oslo-fjord (e. g.. at Moss) the dislocation exceeds 2000 m. In some cases there has been an important horizontal component in the movement (cp. e. g. the Ullern district, p. 56).

The majority of fault lines in the Oslofjord district, both in the area of the new map and further south, are more or less straight and with directions about N-S (the direction of the "Mittelmeer-Mjøsen Zone" of H. Stille, 1925). In the northern part of our map area, however, conditions are more irregular, with largely other directions and also curving fault lines, a feature that no doubt has close connection with the mechanics of plutonic intrusions. A typical example of "Cauldron subsidence" tectonics is seen in the "Bærum Cauldron" with the border of the subsided mass marked by a ring dyke of nordmarkite porphyry. The thickness of the dyke generally is between 30 and 100 m. This dislocation therefore most probably belongs to the period of nordmarkite intrusion. It has taken place after the consolidation of the kjelsåsite-larvikite rocks. The downthrow is in the southern part at least 6-700 m and to the north much more.

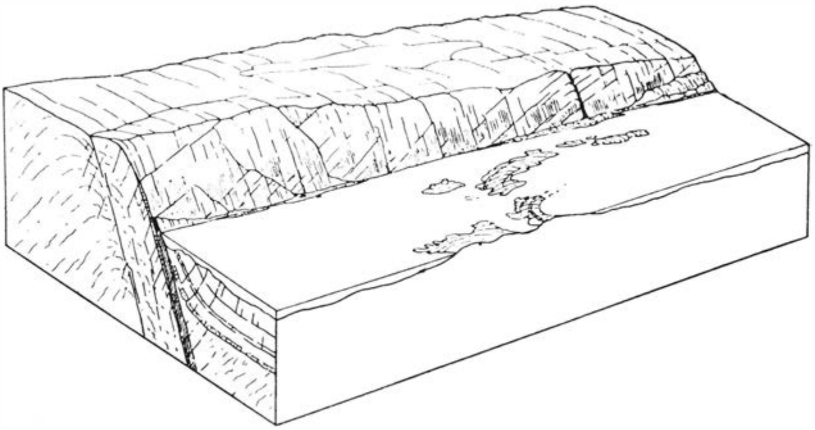

Fig. 17. The fault zone on the west side of Nesodden Peninsula (Pre-Cambrian) with Ildjernet Islands (Ordovician, notice deviation of the ordinary SW-NE strike near fault). After H. Cloos.

The Alnsjø area of volcanics etc. with its nicely curved border line (of intrusive contact) towards the nordmarkite to the south probably represents a part of a subsided, originally more or less circular crust block the northern part of which has been replaced by plutonic masses which in an irregular way cut into the Alnsjø rocks. The nordmarkite belt to the south may be regarded as a sort of parallel to the ring dyke along the margin of the Bærum Cauldron. Of considerable interest is the straight N-S-running eastern border of the Alnsjø area, also with intrusive contact, because it lies in the continuation of the northern part of the Bryn-Grorud fault.

This fact may have some significance regarding the age question of the Oslo faults in general and point toward the conclusion that the main faulting took place at the period of intrusion of the younger plutonic masses. The marked concavity of the Bryn-Grorud fault and the NW-SE direction of a number of faults in the Nittedal area, parallel to the boundary of the plutonic rocks, indicate that there is a close relation between faults and magmatic phenomena. The dip of the rock complex of the Nittedal area and of the Permian rocks in Grefsenåsen (Fig. 38) towards the large nordmarkite body, accentuates this relation between magmatism and tectonics.

The fact that in the Nittedal district some of the rhomb-porphyry lavas are locally missing while they are present in near-by sections may, as emphasized by Sæther, indicate that some faulting took place already during the RP extrusion.

Literature: 1, 4, 10, 11, 16, 32, 33, 34, 39, 41, 45, 49, 51.

Some Remarks on the Land Forms.

By

Olaf Holtedahl

Many prominent topographical lines are due to the Permian faulting. The fault topography is quite especially marked when the hard Pre-Cambrian rocks of Nesodden, Ekeberg etc. rise abruptly above the remains of Cambro-Silurian sediments in the (relatively) subsided areas.

The close connection between the relief and the geological structure can be most strikingly demonstrated in the map area. Each of the main group of rocks, viz. 1. Pre-Cambrian, 2. Cambro-Silurian, 3. Permian lavas, 4. Permian plutonic bodies, has its own characteristic land form.

The Pre-Cambrian area is of medium elevation (altitudes in the east up to about 350 m) and is characterized by a rather broken relief, with long, narrow depressions in the direction of the strike of the rocks (to the east about N-S) or along fracture lines in other directions.

The easily eroded (non-metamorphic) Cambro-Silurian sedimentary rocks are present in the low land and in the fjord areas. The SW-NE strike is very distinctly marked in the minor topographical features (also in the submarine relief of the fjord). Cross-cutting dykes sometimes rise as low narrow ridges above the adjacent sediments (e. g. rhomb-porphyry dyke in the Frogner-Gaustad district, syenite porphyry dyke on the western slope of Ullernåsen).

The western lava district largely shows altitudes between 300 and 500 m. Commonly we find a plateau-like surface, in places broken by deep ravines some of which have been eroded along important fault lines. Typical are the escarpments of the massive lava rocks above the less resistant sediments.

The plutonic rocks make up the greater part of the high ground to the north of the Oslo depression, with extensive areas lying between 400 and 600 m . The topography is mostly characterized by rounded land-forms (providing excellent skiing slopes in winter time). However, there are many quite deep fissures carved out along lines of weakness.

Quaternary Deposits.

By

Olaf Holtedahl

The map is principally of the solid rocks and the cover of loose deposits is mainly marked only for the land lying below the "marine limit", the highest stand of the shore-line after the ice masses had disappeared.

This height differs somewhat in different parts of the map area, for two reasons. Firstly because the uplift of the Fennoscandian landmass was

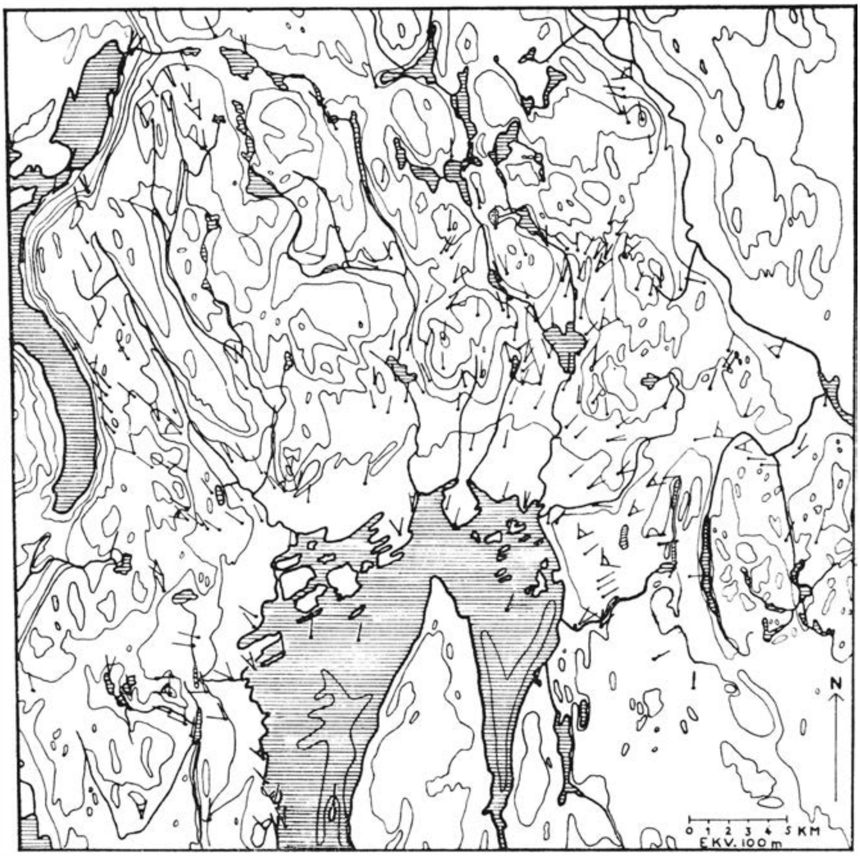

Fig. 18. Glacial striae in the map area and somewhat west and east of it. The majority of striae date from the time just before the ice disappeared in the district and shows a confluence of the ice masses towards the fjord basin. At a somewhat older period the ice movement was more N-S (less influenced by the topography because of greater thickness of the ice). After J. Gjessing.

greater in the central than in the peripheral part. The result of this, for the Oslofjord-district, is that the shore-line of any one time lies higher in a northern than in a southern locality. Secondly, the land was rising during the retreat of the ice-fronts, which means that the marine limit does not correspond to exactly the same time all over the district. Taking for example the Maridalen-Grefsen area, the Maridalen valley could not, because of the existence of an ice-tongue there, be invaded by the sea at the same time as the Oslo valley. The height of the marine limit west of the southern part of the Grefsenås is at least 217 m while at Skar i Maridalen it is only 214. The highest marine limit known from the map area is 221 m, marked by shore gravel with *Mytilus edulis* (Fig. 21) in Skådalen between the southern parts of Holmenkollen and Vettakollen respectively. Here the

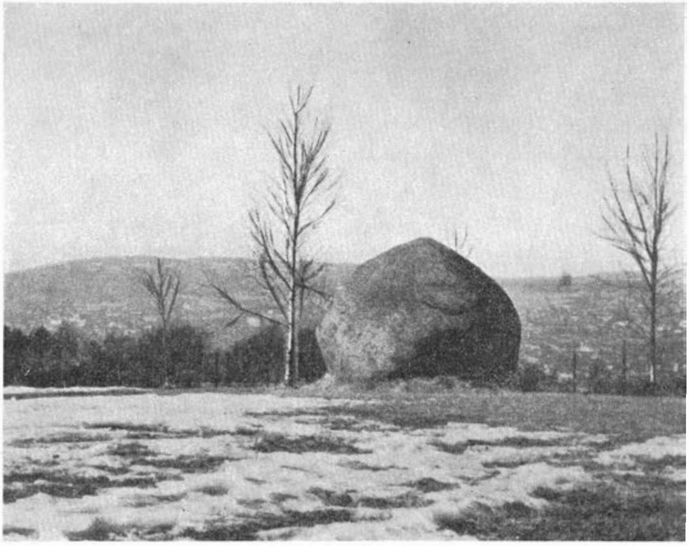

Fig. 19. Ice-transported boulder of gabbro on the northern part of the Ekeberg plateau (at "Ekeberg" of Fig. 40). J. A. Dons photo.

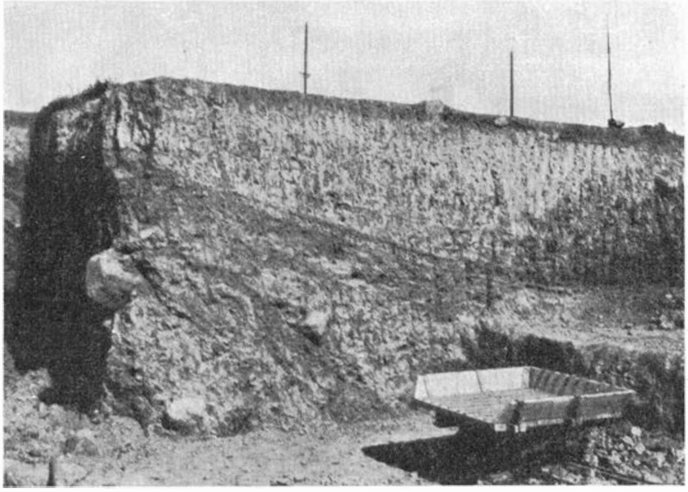

Fig. 20. Till of terminal moraine east of Disen (south of Grefsenåsen), covered by "late-glacial" marine clay. Exposure no longer seen. O. Holtedahl photo.

coastal area evidently became ice-free at a relatively early period. For considerable parts of the map area the marine limit lies at about 210 m.

We have, in the previously submerged area, a number of terminal moraines, formed below sea-level along the ice-fronts. The lakes Bogstadvannet, Sognsvannet and Maridalsvannet are dammed by one or several moraine ridges. The material is in part typical unassorted till, in part stratified drift, largely of fluvioglacial origin. Typical is a gravelly surface layer, often

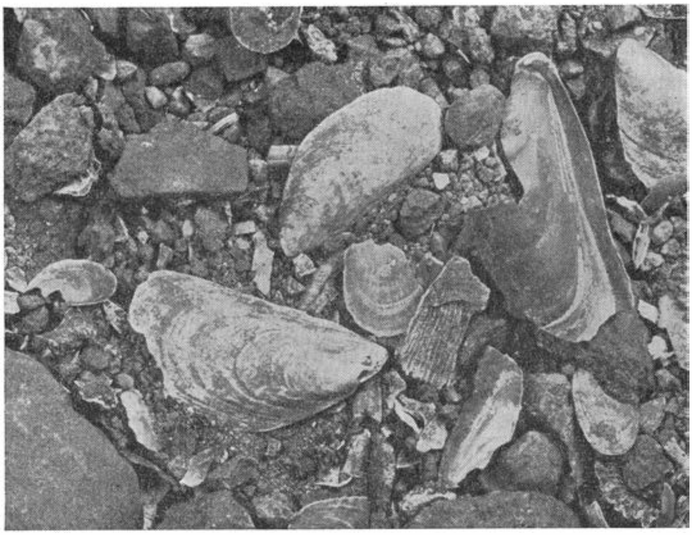

Fig. 21. Shells of *Mytilus edulis* and fragments of a barnacle in gravel found at the marine limit 221 m a. s. l. in Skådalen. B. Mauritz photo. (Geologisk Museum.)

with big blocks, formed when the moraine was washed by the waves during the rise of the land.

The older "late-glacial" marine clays (the Arca-clay etc.) were deposited at the time when ice-masses existed in the more northern part of the map area or in neighbouring districts to the north (largely during the time when the moraines just mentioned were formed). After the ice had disappeared and the land had been considerably uplifted, a "post-glacial" clay with fossils of a more temperate character was laid down at intermediate and low levels covering the "colder" clays. The land is still rising at Oslo, probably 3-4 dm during the last hundred years.

A considerable part of the area lying above the marine limit is covered by ground moraine. The material of stones and boulders may in places be of a dominantly local origin (and with largely angular blocks), in others there is a very considerable quantity of far-transported boulders, such as Eocambrian quartzite and sparagmite and Pre-Cambrian gneiss and granite. In the bottom of many valleys better assorted material, formed through the work of running water, is of importance.

The ice-scouring (according to Gjessing 1953) tells of an older phase of ice-movement (during the last glaciation) with N-S direction dominating while at a later period the movement was more influenced by the local relief (Fig. 18). At one time there probably existed a curved ice-front, concave towards the south, and calving into the fjord area.

Literature: 1, 7, 15, 22, 28. Printed 1956: J. Gjessing and T. Fjellang, Om løsmateriale og isskuring i strøket Akerdalen-Sognsvann-Maridalen. Vid.-Akad. Oslo. Mat.-Naturv. Kl. 1956.

Selected Excursions.

1. Røyken.

By

Chr. C. Gleditsch

1a. Slemmestad-Hogstad-Bårsrudvann-Nærsnes. Bus (No. 33) from Rådhusgaten to Slemmestad and southwards towards Morberg (cp. coloured map). Just south of the area of Cambrian sediments and Permian sills (exc. 4) rather massive granitic or quartz dioritic rocks prevail. In the road-cuts further south along the road there are good exposures of leptite with zones of granite where the road curves just before we reach the fields of Morberg farm (where the SSW-striking dyke of rhomb porphyry marked on the map passes below the houses). It should be emphasized that in the district now dealt with the Archaean rocks are often more or less mylonitized along zones of considerable width, due to faulting.

At Morberg we take for a short distance the road to the west, and then follow a narrow local road southwards towards the Hogstad farms. About half-way there is a small quarry to the left where there is an alternation between light coloured foliated rocks of leptite character and darker rock rich in biotite. Near the houses of one of the Hogstad farms we notice in the rock underground at the road granitic or pegmatitic rocks with inclusions of leptite. Somewhat further south there are, on the left side of the road, brecciation phenomena with innumerable quartz-veins (with quartz crystals) indicating a breaking up of the rock-mass through faulting.

South of the Hogstad farms there is no road (only paths which often are only slightly marked), yet we can still easily find our way southwards towards Aukesåsen (marked 211 in the map) following the high ground just west of the slope towards the Bårdsrudvann-valley. As before we have leptite (with bands of amphibolite) alternating with granitic zones. However, southwards the relative quantity of granite increases and in the summit-area a compact coarse-grained granite dominates, with leptite in relatively small masses of irregular form. Just north of the summit and close to the eastern acclivity there are basic inclusions in the granite. They have diffuse borders and the rock mass may here have a "nebulitic" character. South of the summit the massive granite is even more the dominating rock type. It should be emphasized, however, that there also occur granitic rocks with a slight foliation.

From the summit, or better, from the ground just north of it, we can find our way down the slope to the valley just north of Bårsrudvann. The

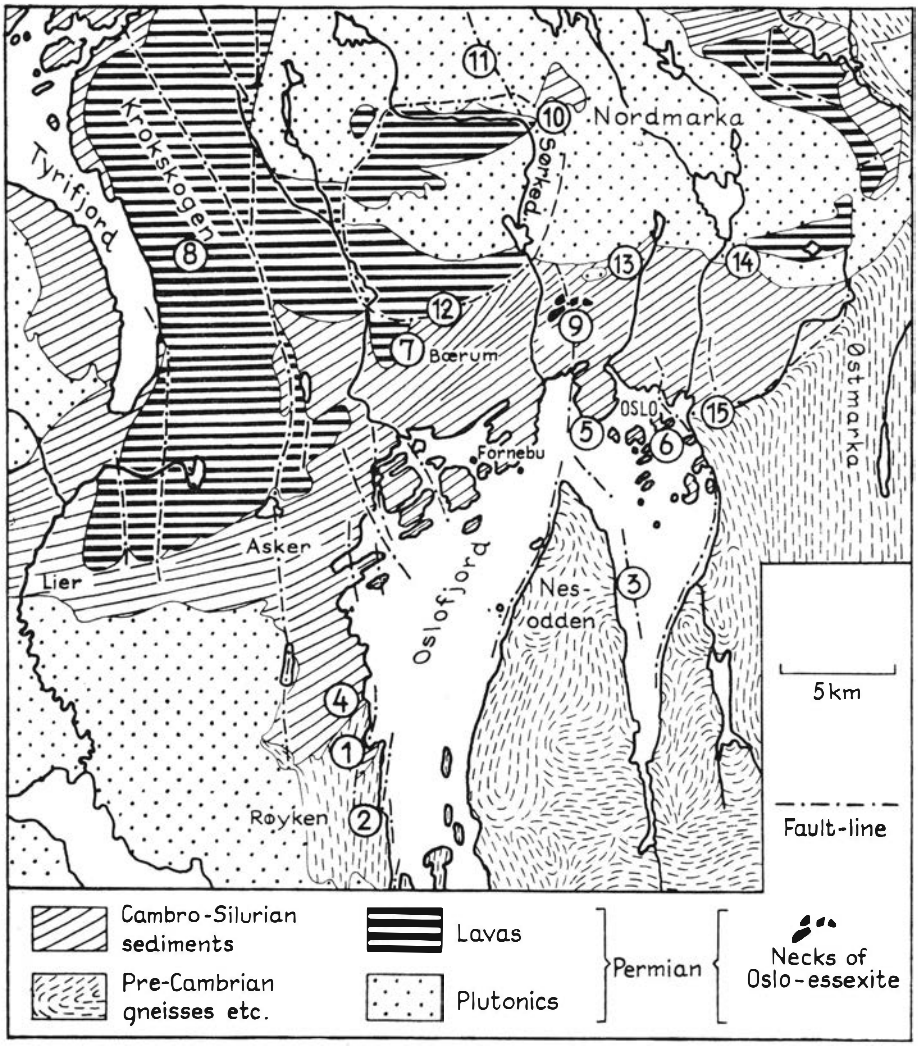

Fig. 22. Key map for excursions 1—15.

rock-mass shows a marked jointing in a NW-SE direction, and small ridges and clefts in this direction are therefore characteristic of the topography, a feature that must be taken into consideration during the descent. We pass the fault line and proceed along a local road (private) towards the inner part of the Nærsnes-Bay, in the area of Cambrian alum-shales, with sheets of rhomb-porphyry and mænaite. Having reached the main road near the shore we follow it for some distance to the right. In various places there occur in the generally forested slopes, just south of the road, patches of the Cambrian basal conglomerate, resting on the peneplaned Pre-Cambrian granitic rocks. At the place where a road to the Nærsnes pier branches off and the main road turns E and SE the conglomerate can be seen in the road-cut on the right. There is no sharp boundary between conglomerate and the crystalline rock beneath it, but a sort of grading downwards into a rather coarse massive rock mainly made up of feldspar. There must have been a surface zone of mechanically weathered granite when the sea invaded the area.

From Nærsnes we may take a bus or boat to Oslo or walk back to Slemmestad. If, after having followed the main road westwards for some distance, (from the locality just mentioned), we take a small road leading down to the shore and proceed northwards to Grundvik we may study the Permian fault-zone in detail. Here are beautiful breccias to be seen in the wall to the left. It is possible from Grundvik to climb the slope to the west and reach the Slemmestad road at Morberg, but it is best to return southwards to the main road and follow it northwards up to the slope to Morberg (and further to Slemmestad). There are, especially on the left side, excellent exposures in leptite with granitic veins, the rock mass, however, often mylonitized or brecciated. Just south of Morberg there are well marked breccia-zones (or plates) in the main fault-line direction of the district, about N-S, as well as a breccia crossing this direction.

1b. Slemmestad-Hogstad-Auke-Hallenskog railway station. From a point just north of the summit of Aukeåsen we follow a path to Auke farm. Here occur relatively dark, biotite-rich leptite-like rocks which locally contain kyanite. Proceed further westwards to Åsgård, in the downfaulted area of Cambro-Ordovician rocks. After having crossed the N-S-running Åros River (and the fault line) follow the main road for some distance towards the south, and then take a farm-road leading to Skryset, Here occurs granite with fragments of leptite, as in Aukeåsen. We proceed along a small road (about 600 m) westnorthwestwards to Nordlihaug (name not in the map) where east of the road the Pre-Cambrian has been cut through and broken up by the Drammensgranite, with the formation of typical igneous intrusion breccias. Go for ½ km southwards along the main road and then northwards to Hallenskog railway station (in Drammen granite).

Literature: 16, 17, 18, 19, 33.

2. Røyken (just south of the map area).

By

Chr. C. Gleditsch

Hurum bus (No. 33) to Follestad (Fig. 23). In small cuttings at the road-junction can be seen fine-grained porphyritic leptite with zones of basic rocks. One follows the road northwards to the rocky outcrops at V.(Western) Hov where massive saussurite-gabbro can be seen. A couple of hundred meters east of the farms, in low ridges along the east side of the fields at Sundby and Hov there are fine outcrops of saussurite-gabbro and variable leptite types. Here are also found rocks intermediate between gabbro and

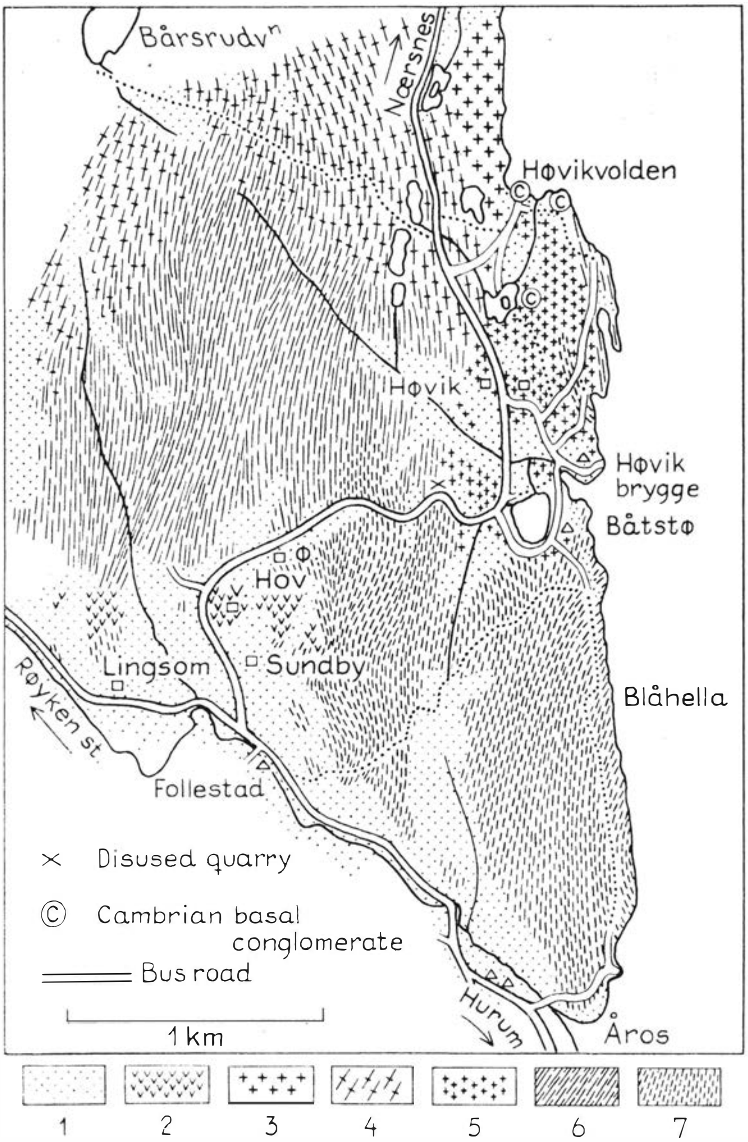

Fig. 23. Map to excursion 2. 1. Cover of Quaternary deposits. 2. Massive saussurite-gabbro. 3. Granite with both biotite and muscovite. 4. Gneiss-granite, usually without porphyritic structure. 5. Fine-grained granite with symplectic (micrographic) structure 6. Fine-grained gneiss-granite and leptite-gneiss with distinct traces of porpyritic structure. 7. Leptite, commonly distinctly porphyritic, often very fine-grained ("hälleflinta").

leptite. Near the massive gabbro the leptite often has a considerable content of dark minerals and shows innumerable layers of basic rocks.

Paths through the woods make it easy to walk (south of the road) to the east, over markedly porphyritic leptite, down towards Båtstø. The border towards the granite is sharp. This granite is a massive, mica-poor, fine-grained rock wih a pronounced symplectic (micrographic) structure. Along the shore southwards from Båtstø towards Blåhella fine outcrops of porphyritic leptite can be seen.

Instead of going through the woods between Hov and Båtstø one can walk along the highway. In outcrops north of the fields of Ø. Hov relatively coarse, weakly porphyritic leptite gneisses can be seen, while on the south side of the road, eastwards to a disused stone quarry, there is mainly fine-grained, markedly porphyritic leptite till the massive, fine-grained granite mentioned above is met with.

This same granite is seen in the crags north of Høvik landing stage. (From here there is boat connection with Oslo in the summer season.) In places the granite shows a (not very strongly marked) porphyritic structure. About 200 meters north of the landing stage, on the shore, there are outcrops of ultra fine-grained flinty-looking leptite. This zone can be crossed if one follows the paths as near the coast as possible, northwards to Høvikvolden. Some small faults with quartz-breccia are also seen.

At Høvikvolden there are several outcrops of basal Cambrian conglomerate. The best outcrops are to be seen right down at shore-level. From Høvikvolden one can walk up to the main road and take the bus to Oslo or walk northwards to Nærsnes passing through a gneiss-granite territory. Alternatively one can take a pleasant woodland path southwards via the small lakes Høvikdammene back to Høvik landing stage.

At the main road just south of Åros (southerly part of detail map) the contact between leptite and Permian granite (Drammen-granite) is beautifully exhibited.

Literature: 17, 19.

3. Northeastern part of Nesodden.

By

Ivar Oftedal

The NE shores and hillsides of Nesodden are made up of an interesting rock complex, comprising leptites, mica-schists, staurolite and kyanite gneisses, various other plagioclase gneisses, and dyke-like masses of amphibolite. The adjacent rock (to the S and W) is a gneiss granite of somewhat varying character. For detailed mapping and description see O. A. Broch (1926).

Those who want to see exposures of these rocks without spending more than a few hours, may take one of the Bunnefjord boats[1] to the stop Fjordvangen (Flateby, Fig. 24), which is near the southern boundary of the complex. Here nearly all the main rock types are found within a few hundred meters of the pier, — see figure, which is a simplified reproduction of a small part of Broch's map.

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[1] The detailed routes and time tables of the Bunnefjord boats may be found in "Rutebok for Norge".

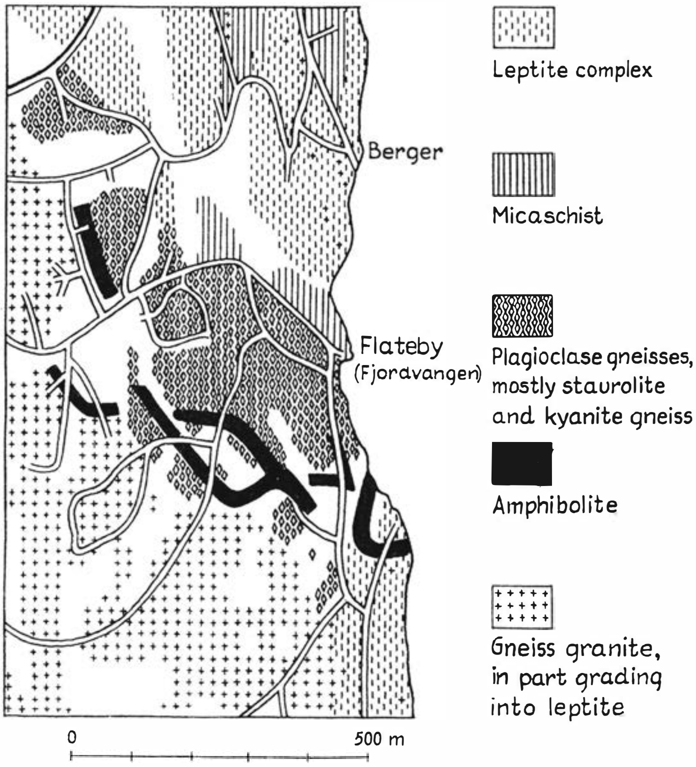

Fig. 24. Map to excursion 3.

The mica-schist close to the pier is partly garnetiferous. To the north, towards Berger, we find the leptite, which contains smaller and larger lenses or layers of mica-schist and numerous pegmatitic veins and bodies. To the west of the pier (up the hillside, Flateby forest) and to the south the rocks are mainly staurolite and kyanite gneisses. The large amphibolite bodies here are complicated in shape, and locally contain very large idioblasts of garnet. Further south there is a small area of leptite and mica-schist, which grades into the adjacent gneiss granite by way of a migmatite zone rich in pegmatitic dykes and ptygmatic veins.

Literature: 2.

4. Slemmestad.

By

Leif Størmer

Bus (No. 32) from Rådhusgaten to Slemmestad (Fig. 25). The place of arrival at "Torget" is situated in a SW-NE depression, the Bø valley, marking the border between the Pre-Cambrian gneisses to the SE and the Cambrian alum shales to the NW.

The sub-Cambrian peneplane dips NW at an angle of 15—30°. A road section (1) shows a strongly weathered Precambrian surface, actually an

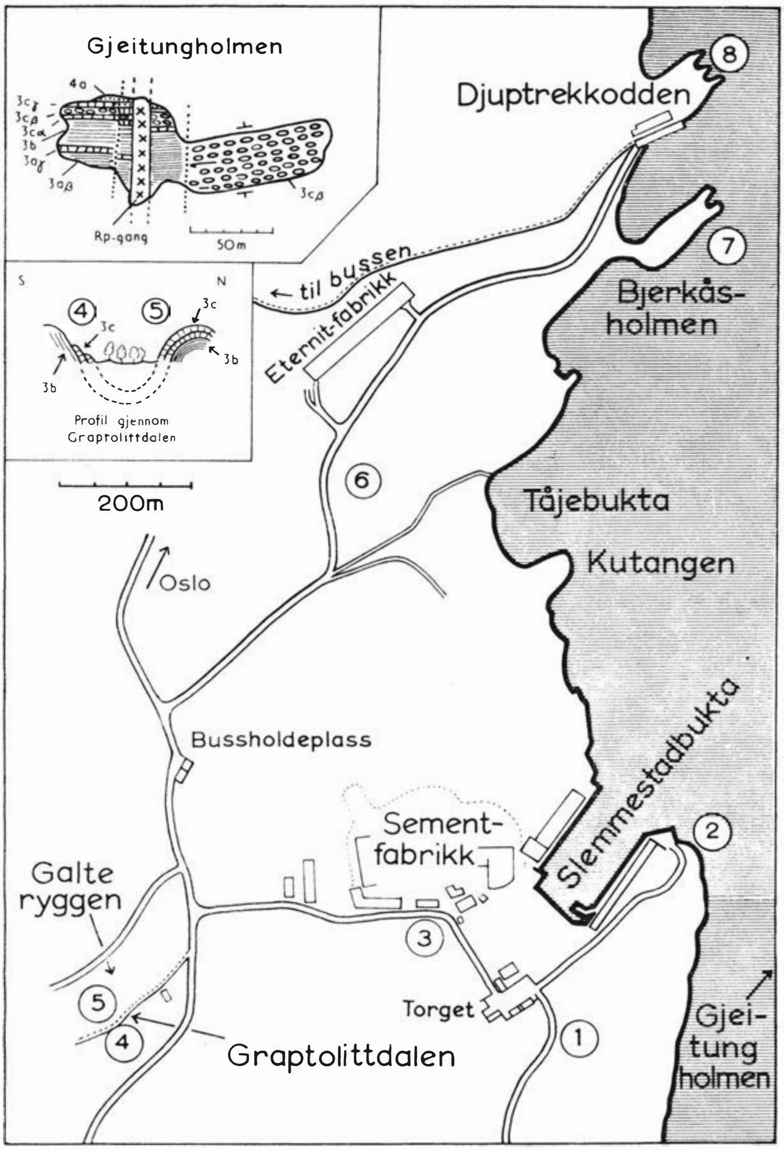

Fig. 25. Map to excursion 4.

arkose, overlain by Middle Cambrian conglomerate, black limestone and alum shale. Only a few quartz pebbles are seen in this section, but 2-3 km further SW a well developed basal conglomerate is exposed. The about 40 cm thick black limestone ("stinkstone") contains *Paradoxides paradoxissimus, Ptychagnostus gibbus, Solenopleura* spp. a. o. belonging to the Middle Cambrian (zone 1cβ). Considerable variation in the development of basal sediments has recently been found by Spjeldnæs (1955). In the section and along the road NW to locality (2) Permian mænaite sills are seen intruding the

Middle Cambrian alum shales. At (2) there is a good view of the Oslofjord situated in a graben bordered by N-S Permian faults. The Geitungholmen island composed of sediments of Tremadoc and Arenig age, pierced by a rhomb porphyry dyke (Fig. 25) belongs to a relatively subsided area.

Returning to "Torget" one follows the road towards the Cement factory. Along the road (3) Upper Cambrian alum shale contains limestone lenses (stink limestone) with *Peltura scarabaeoides, Sphaerophthalmus* sp. a. o. (Fig. 3) indicating zone 2d.

Turning left about 400 m further up and following a path to the right about 60 m from the turn, one reaches the "Graptolite valley" (4). To the left is a good exposure of the Lower Didymograptus Shale of the Arenig. The black shale, dipping about 60° NW is very rich in graptolites with *Phyllograptus angustifolius elongatus, Didymograptus* spp., *Tetragraptus* spp. indicating the Lower Didymograptus Shale (3b). Further on the Orthoceras Limestone (3c) succeeds the shale. Most of the limestone was once removed for cement production, now the factory gets a purer Silurian limestone from the Holmestrand district. The Graptolite valley is part of a syncline (section in Fig. 25), the NW-limb (5) with the Endoceras Limestone (3cγ) containing numerous specimens of *Cyclendoceras* sp. on the weathered and corroded surface.

Turning back to the main road and following this N to the bus stop and further to the Eternit factory, a section through the Upper Didymograptus Shale 4aα_{1-2} is seen along the right side of the road just in front of the factory gate (6). *Didymograptus geminus* and *Climacograptus* sp. occur.

The peninsula Bjerkåsholmen (7) has a good section through the Tremadoc-Arenig (cp. also Fig. 12). Along the E shore the Ceratopyge Limestone (3aγ) contains *Ceratopyge forficula, Niobe insignis* a. o. In the lower part of the succeeding Lower Didymograptus Shale (3b), there are grey beds with barite crystals as pseudomorphs after gypsum. Along the SE shore, to leeward of the peninsula, numerous erratic boulders occur.

At Djuptrekkodden (8) there is a section through vertical beds of the Orthoceras Limestone (3c), in which the Asaphus shale (3cβ) contains *Asaphus expansus, Megalaspis limbata, Illaenus sarsi* a. o. In the Endoceras Limestone (3cγ) *Megalaspis* cf. *rudis* and *Asaphus striatus* are found besides *Cyclendoceras* sp.

A path leads to the bus stop on the main road. Bus back to Oslo.

Literature: 3, 4, 33, 36.

5. Bygdøy.

By

Gunnar Henningsmoen

The main locality of interest to be visited is at Huk to the extreme south of the Bygdøy peninsula. This may be reached by taking a No. 30 bus (Bygdøy) from Rådhusgaten. Alight at the terminus, Huk (18 min.), and walk down to the beach (Fig. 26). To the left lies a small peninsula called Hukodden, crossed by a narrow ridge of *Orthoceras Limestone* (Lower Ordovician). At A on the map tilted beds of massive *Endoceras Limestone* (3cγ) rise two feet or so above the beach. They belong to the upper part of the Orthoceras Limestone, and are rich in cephalopods, especially species of *Cyclendoceras* (Fig. 5, No. 14-15). Cross sections show that the siphuncle of the latter usually rested downwards on the sea bed and that the upper part of the cone often had been dissolved before being embedded. The sections may thus be used for orientating the beds.

The steep wall behind the Endoceras Limestone consists of the underlying *Asaphus Shale* (3cβ), a marly shale with limestone nodules. Fossils are rather plentiful, including complete specimens of trilobites (*Asaphus expansus, Illaenus sarsi,* etc.), which are usually best collected in the loose stone debris at the foot of the wall. Continuing along western shore of the peninsula, one passes down through older beds of the Asaphus Shale and into the underlying *Megalaspis Limestone* (3cα), which shows discontinuities (erosion surfaces?) and bands of pyrite nodules.

Some of the fossils which may be collected from the Orthoceras Limestone (3cα-γ) are shown in Fig. 5.

Continuing the section, Megalaspis Limestone is seen to rest on crushed *Lower Didymograptus Shale* (*Phyllograptus Shale*) (3b), yielding few and poorly preserved graptolites. A fault separates it from the northern limb of a small anticline (see section C-B). In the southern limb the beds are slightly inverted and the younger (3cγ) squeezed out and missing in some places. The low-lying outer part of the peninsula consists of still younger beds, the *Upper Didymograptus Shale* ($4a\alpha_{1-2}$), in a crushed condition. Only poorly preserved graptolites may be found.

After visiting the Hukodden peninsula, return to D in Fig. 26, where an outcrop of *Ogygiocaris Shale* ($4a\alpha_{3-4}$) may be studied. Well preserved fossils occur in the dark limestone concretions; compressed trilobite specimens etc. as well as graptolites may be found in the shale itself, which also contains nodules of pyrite. Among the most common fossils are *Ogygiocaris dilatata sarsi* and *Pseudomegalaspis patagiata* (these and other fossils from the same beds are shown in Fig. 5).

Further north the *Ampyx Limestone* (4aβ) is exposed. It consists of alternating layers of shale and limestone nodules, but is not very fossiliferous

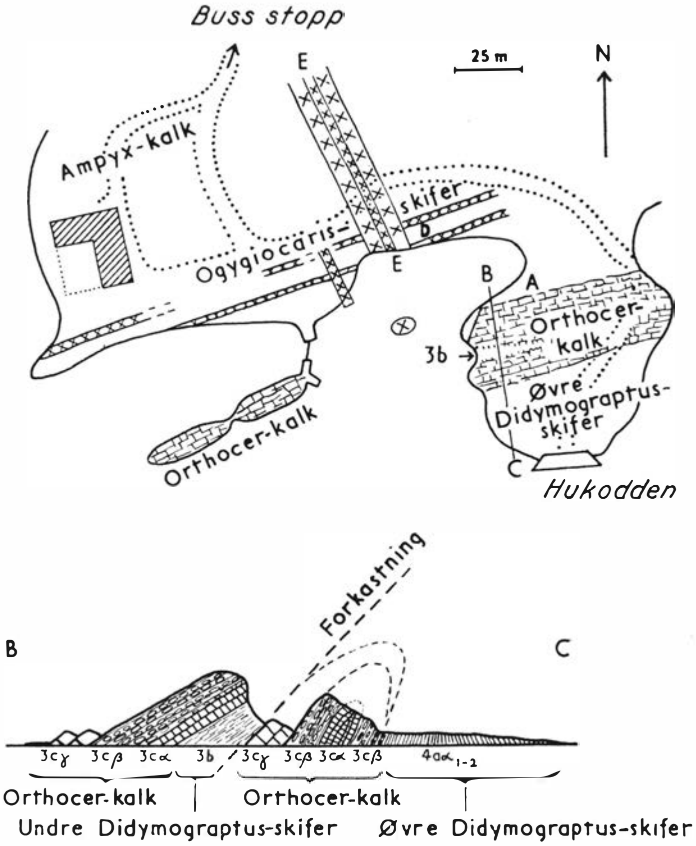

Fig. 26. Map of Huk and section through Hukodden (excursion 5).
E-E composite dyke.

here. Most common are trilobites of the raphiophorid group (e. g. *Lonchodomas rostratus,* Fig. 6, No. 3), and asaphids (e. g. *Asaphus* sp., cf. *platyurus,* Fig. 6, No. 1).

Several Permian dykes cut the Ordovician beds at Huk, including a large composite dyke (EE) consisting of mica-syenite porphyry with a central layer of diabase. The surface is nicely ice-polished and striated.

Return to the bus terminal and take the bus to Huk Aveny near the Viking Ship Museum (walking distance 1.3 km). Several small sections through the Middle Ordovician *Chasmops beds* (4b) are passed on the way. From the cross-roads at the Viking Ship Museum continue along Langviksveien. At the junction with Museumsveien a small section through beds of the so-called *Calcareous Sandstone* (5b), marking the top of the Ordovician sequence in the Oslo Region. Some beds are conglomeratic. Rugose and other corals from the underlying *Gastropod Limestone* (5a) occur as pebbles.

Continue along Museumsveien northwards to the bus stop called Folkemuseet (0.1 km) and take a bus No. 30 (Grorud) back to the city. Alternatively, first follow Museumsveien southwards and then Huk Aveny down to the fjord, where ferries (either Skillebekk or Rådhuset-City Hall) depart every 15 minutes during the summer. Huk Aveny cuts through the Calcareous Sandstone, in which cross-bedding, small folds and overthrusts are common.

Literature: 3, 5, 36.

6. Hovedøya.

By

Nils Spjeldnæs

Hovedøya is an island situated within the harbour area of Oslo. Cambro-Silurian sediments (zones 4a-6a) are folded into a complicated anticline, the southeasterly limb of which is inverted. The structure is cut by several Permian dykes, mainly diabase and syenite (Fig. 27).

There are two ridges in the island, following the strike direction, SW-NE, and consisting of Upper Ordovician limestone and sandstone. The ground between them is occupied by soft shales (with nodular limestones) of Middle Ordovician and Lower Upper Ordovician age.

Many rare plants originate from the days of the old monastery, ruins of which are still preserved (Kloster ruin).

Take the ferry from Vippetangen (frequent service in summer time).

(1) Shale and nodular limestone, zones 4bα and 4bβ (Middle Ordovician).

(2) Large Permian sill of syenite in Middle Ordovician beds form a prominent feature of the landscape.

(3) Folded Upper Ordovician shales, nodular limestones and calcareous sandstones occur along the shore as far as (4).

(4) Coarse boulder-conglomerate in zone 5b, the uppermost zone of the Ordovician. It was deposited in an erosion channel and is intraformational. Boulders up to 5 feet in diameter are present.

(5) Arenaceous shale (Silurian) with siltstone bands sometimes show graded bedding. Zone 6a. The faults (see map) are easily found because of the juxtaposition of the Ordovician and Silurian beds.

(6) Inversion of beds with zone 5b overlying 6a. A large dyke of diabase with jointing. This rock was quarried for the construction of the Akershus Castle.

(7) Narrow cleft eroded along a prominent fault-zone.

(8) Steeply dipping Upper Ordovician beds with increase in dip to the north.

(9) Zones 6a and 5b in normal succession. The wedge of conglomerate between them (Fig. 28) may indicate an angular unconformity.

Literature: 5, 30.

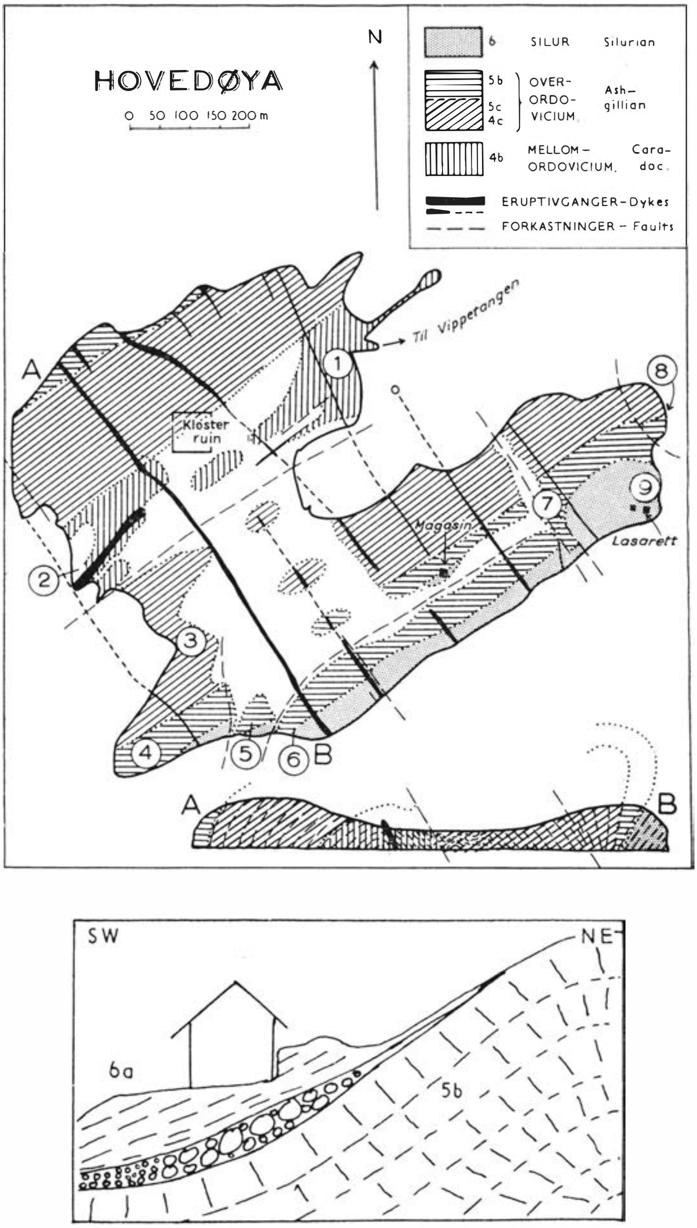

Fig. 27-28. Map to excursion 6 with, below, section along the shore at (9) showing slight unconformity between 5b and 6a.

7. Kolsås.

By

Johannes A. Dons

Take Kolsås-banen (from Nationalteatret) to Gjettum. In a road-cut in Gjettumveien, south of the station, Upper Llandoverian limestone (stage 7) dips to the north (Fig. 29). Large corals may be found such as *Halysites, Favosites, Heliolites,* etc.

Follow the road by the side of the railway track and then turn right. At Hauger station, the lower part of Downtonian sandstone of continental type occurs. It is reddish and greenish in colour and is also found along the road and path from Topås up to a small ledge beneath the scree. Current-bedding, ripple-marks and mud-cracks may be observed. Fossils have been found at Ringerike.

At Hauger crossing glacial striae and transverse marking (crescentic gouges) (Fig. 31), also of glacial origin occur. Their localities are indicated by arrows on the excursion map.

Kolsås is situated in a gentle syncline of Caledonian origin but the angle of unconformity which the Lower Paleozoic and Downtonian make with the Permian is not very marked here. The latter is represented by easily weathering layers of red arenaceous shale seen in the ledge and upwards along the rising path. Sandstone and quartz conglomerate with pebbles of pegmatite quartz and quartzite follow above.

At other localities such as Semsvik the sedimentary sequence continues with greenish, grey or red shales succeeded by layers of sandstone, tuffaceous and conglomeratic beds containing pebbles of the basaltic lava B_1. Lower Permian fossils were found in 1931 in the shales as well as in a sandstone above the lava debris.

The basalt lava, B_1, on Kolsås rests directly on the quartz-conglomerate (Fig. 30). It is of the non-porphyritic type with labradorite, titaniferous augite, subordinate olivine pseudomorphs, iron-ore in a matrix of orthoclase, chlorite, carbonate. In the upper part laths of plagioclase occur and the topmost layer is vesicular. A bed of sandstone in some places separates basalt B_1 and the succeeding rhomb-porphyry lava, RP_1, but it is not developed on Kolsås. The contact of the two lava beds is not exposed on the path just below "Kringsjå Kafe" but may be studied some 50 meters to the east in the face of the cliff. Here its vesicular character is displayed.

RP_1 (cp. Fig. 14) is the oldest in a succession of approximately 20 lava streams of rhomb porphyry, all of which have about the same mineral composition, viz. 36 % plagioclase phenocrysts (An_{20-40}) often with a marginal zone of alkali feldspar. Turbid alkali feldspar and accessory chlorite, carbonate and iron-ore make up the matrix.

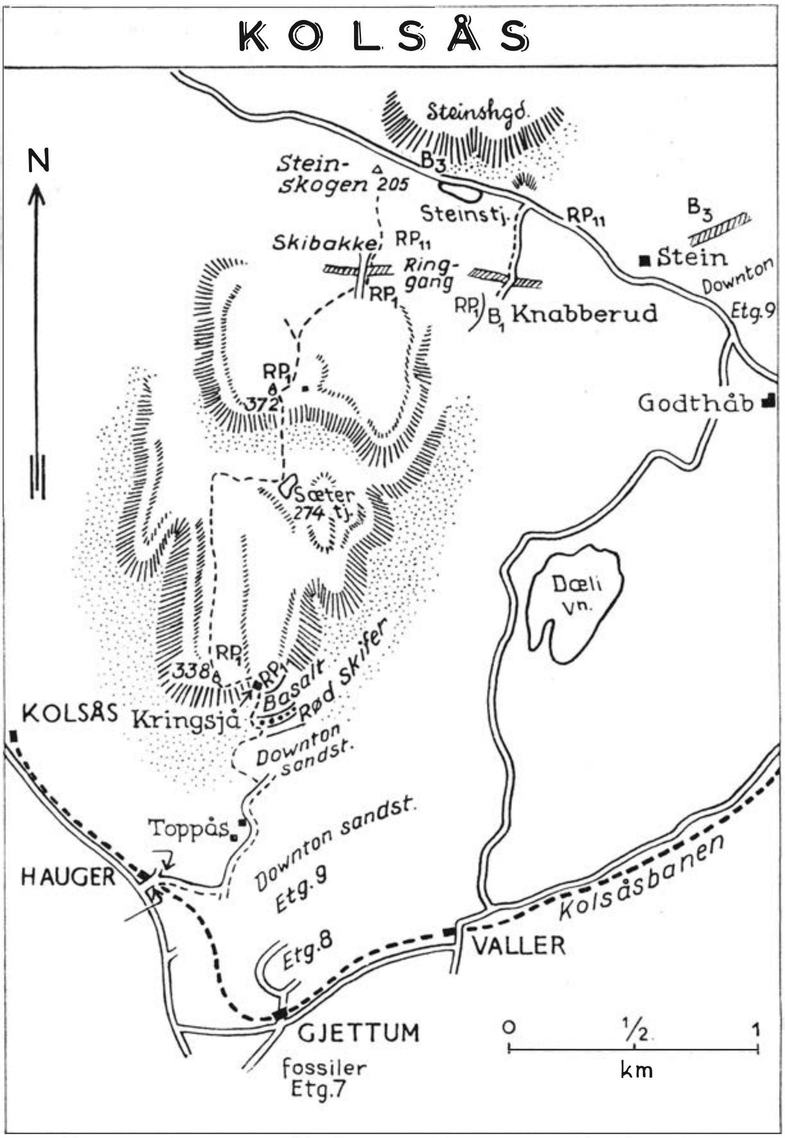

Fig. 29. Map to excursion 7.

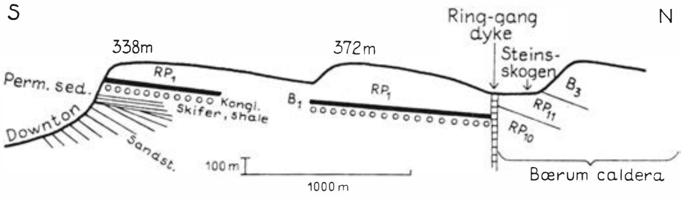

Fig. 30. Section through Kolsås and northwards.

Fig. 31. Ice scouring on a sloping sandstone surface at Hauger station. Ice movement towards SE, upwards in the picture. J. Gjessing photo.

In the magnificent view from the southern point of the Kolsås plateau, bastion-like hills of lava may be seen to the west. Further south lies Vardåsen with a rounded profile typical for granite. In the distance to the south and east may be seen the gently undulating surface of the Pre-Cambrian, (roughly corresponding to the sub-Cambrian peneplane?), broken by Permian fault-lines. In the low-lying foreground, islands and peninsulas of Cambro-Silurian sediments occur. They are folded on axes ENE-WSW. The Permian faults have a general NNE direction. To the east hills of nordmarkite may be seen with their characteristically rounded and dome-shaped topography.

Proceed northwards along one of several footpaths, approximately along the western side of the ridge, then eastwards down to Sætertjern, a small lake well hidden in the wood. From the northwestern corner of this lake follow a path northwards and up to the northern summit of Kolsås. The path follows in its higher part a dyke of diabase which has weathered out leaving a cleft in the rhomb porphyry. From the upper part of the cleft turn to the right and go up to the top of Northern Kolsås where an even more splendid view may be obtained.

Descending the hill in a northerly direction to Steinskogen the path follows the right side of a ski-jumping hill (ski-bakke) and crosses the ring-dyke of nordmarkitic composition which borders the Bærum cauldron. The sidence amounts to 2000 meters. Rhomb porphyry, RP_{11}, is found on the inner (northern) side of the dyke.

From Steinskogen follow the road down to Godthåb. Basalt B_3 (melaphyre and labradorite porphyrite) are visible along the road-side, especially in a quarry situated about 100 meters east of the small lake Steinstjernet. Here also occur dykes of akeritic and diabase composition. One of the akerite dykes shows intense epidotization related to the very unevenly developed contact metamorphism affecting the basalts of the district. This is believed to be due to an acidic rock situated under the cauldron at rather moderate depth. The ring-dyke is not exposed along the roadside but basalt and an exposure of RP_{11}, further Downtonian and Upper Silurian marine sediments may be seen.

From Godthåb there is a frequent bus service to the city.

Literature: 13, 14, 24, 41.

8. Krokskogen.

By

Christoffer Oftedahl

The highway from Oslo to Hønefoss runs through the lower half of the sequence of lavas forming the Krokskogen district. Eleven different lava flows may be inspected, mostly in excellent roadcuts, along this highway. An excursion through this part of the sequence is most easily arranged by taking the Hønefoss bus (No. 36, from Skansen near the City Hall) to Nes bus stop (Fig. 32), and by walking back along the highway to Sollihøgda, from where one can return to Oslo by bus.

As one starts uphill from Nes, locality (1), the roadcuts show various beds in the uppermost part of the Silurian sediments, consisting of steeply dipping limestones with some shales.

Locality (2) is a crag situated along the farm road to Sønsterud, about 30 m from the highway, on the left hand side of the farm road. Here the lowermost part of the rhomb porphyry, RP_1 (Fig. 14), is exposed in a little slope. Below its base a bed of sandstone with lava fragments, about 1 m thick, may be seen. In front of it the basalt, B_1, penetrates the moss cover. The base of B_1 is not exposed due to a fault which brings the Silurian limestone in contact with the basalt.

B_1 is a black, fine-grained basalt, very vesicular in its top layer. Mostly it is non-porphyritic, but some beds contain pyroxene and small red olivine pseudomorphs. RP_1 shows long sharp-edged rhombshaped plagioclase phenocrysts in a fine-grained groundmass. The lengths of the phenocrysts may be up to three centimeters.

RP_1 is best inspected in the huge blocks at (3), along the highway opposite the entrance to the farm road. In some blocks the phenocrysts have a parallel arrangement and show a sligthly curved flow structure. Some of the phenocrysts are twinned according to the Carlsbad law on (100); this gives the twinned crystals a tooth-like appearance.

Locality (4) is a huge rock-face of RP_1 which in its lower parts exibits some excellent structures. Round blocks of lava, one meter in diameter, are set in a matrix of light weathering rhomb porphyry and quartz-bearing shale or quartzite. Such structures, resembling pillow lava, are observed in a few other exposures of rhomb porphyries, but mostly these lavas are very massive without any stratification. Each type seems to represent one single flow, even though it may be two hundred meters thick, as is the case with RP_1.

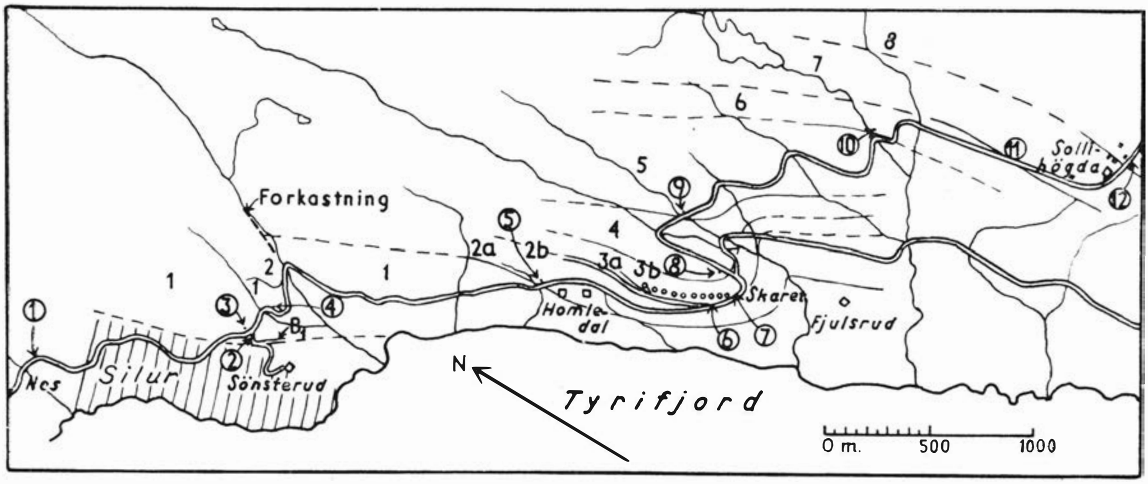

Fig. 32. Map to excursion 8. (Forkastning = fault).

At Homledal farm (5) the overlying rhomb porphyry RP$_2$ is exposed in a roadcut. The top of RP$_1$ is topographically very well expressed. It forms an irregular plateau which slopes gently down from north, easily seen from the higway one hundred meters north of Homledal.

The lower type of RP$_2$ carries scattered small and irregular feldspar phenocrysts. This type (RP$_{2a}$) is characterized by its twinned phenocrysts. Every other crystal is twinned in some way, and star clusters contaning up to twelve twinned individuals are fairly frequent. The Baveno twin law plays an important role.

The upper part of RP$_2$ (RP$_{2b}$) has still fewer and smaller phenocrysts. The contact at (6) between the two flows is marked by the very rotten top layer of RP$_{2a}$, with a bed of conglomerate a few meters thick above it. The RP$_{2b}$ flow is only ten meters thick. Its top is also characterized by a bed of conglomerate, about 30 centimeters in thickness.

The overlying lava flow RP$_{3a}$ is a most conspicuous type. It carries very abundant and large crystals, the largest seen in any rhomb porphyry of the Krokskogen district. It is only about ten meters thick and is overlain by a bed of coarse conglomeratic sandstone. This bed, one meter thick, comes down the large roadcut close to the beautiful viewpoint of Skaret (7). The pebbles of the sandstone consist of the underlying rhomb porphyries, essentially RP$_2$ types.

The succeeding lava flow RP$_{3b}$ is a very typical rhomb porphyry in that the huge phenocrysts are very sharp-edged and many good rhombic sections are easily seen. This flow occupies the roadcuts on both sides of the highway at Skaret. It is less than twenty meters thick.

The next flow, RP$_4$, is first exposed in the roadcut above Skaret café (8). It is fairly similar to RP$_1$.

The contact between RP_4 and RP_5 (9) is marked topographically by a little depression. The top layer of RP_4 is very rotten and transitional into a conglomerate with pockets of red sandstone. RP_5 is a very conspicuous type, distinctly different from the types previously seen. It contains very abundant, small, round or rectangular phenocrysts. Its very massive appearance is striking. The thickness is about 100 m. The upper part is characterized by a rotten zone with pockets of sandy and shaly sediments.

The contact with RP_6 is not exposed, but the lower part of RP_6 is strongly weathered and conglomeratic with pockets of sediment. This can be seen in shallow roadcuts at (10). A little farther on some deeper roadcuts exhibit a fine example of fresh RP_6, characterized by two generations of phenocrysts: large, scattered crystals and small ones in greater number. This flow is fairly thin, and its top is well developed in the topography as a flat terrace at a sharp curve of the highway.

The overlying flow, RP_7, forms a conspicuous vertical rock-face which approaches the highway gradually (11). The turn to the left up to Sollihøgda has excellent roadcuts in this rock. It is not very noteworthy as a type, carrying fairly abundant irregular or more round crystals.

The first roadcuts on both sides of the highway past Sollihøgda hotel show the succeeding flow RP_8 which is very similar to RP_{2a}.

Bus back to Oslo from Sollihøgda.

Literature: 6, 39, 44, 50.

9. Ullernåsen.

By

Johannes A. Dons

Take Kolsås-banen (from Nationalteatret) to Åsjordet station (Fig. 33). Between Montebello and Ullernåsen stations a high bridge carries the line over the Mærradalen valley (1). The latter marks a fault-zone along which an oblique displacement with a horizontal component of 200 meters and a vertical component of 50 meters has taken place. The eastern block (Husebyåsen) has subsided relative to the western one (Ullernåsen). The fault zone should be considered in relation to the Nesodden fault line to the south and the fracture line in the Langli valley to the north.

At the platform at Åsjordet station (2) a red dyke of mica-syenite porphyry is cut by a dark dyke of diabase. A dyke swarm of mica-syenite porphyries can be traced at intervals for a distance of 17 kms, from the west side of Nesodden, passing through Bygdøy, Ullernåsen, Røa and disappearing east of Voksen farm into akerite. In the field the dyke is conspicuous by its smooth surface and glacial striae on small hillocks free of vegetation.

Follow Hoffsjef Løvenskiolds vei northwards observing the occasional exposures of Ogygiocaris Shale, Ampyx Limestone and Lower Chasmops Shale cut by several Permian dykes. Dykes and sills cover 17 % of the

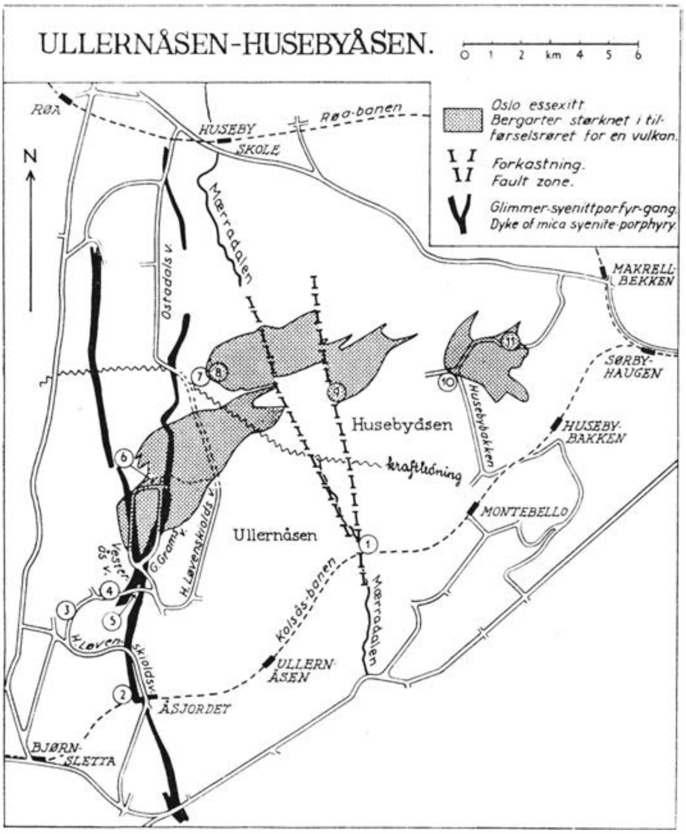

Fig. 33. Map to excursion 9. (Kraftledning = power transmission).

Ullernåsen-Husebyåsen area. 47 % are light coloured mænaite dykes almost entirely composed of plagioclase. (It is not advised that samples be taken from garden walls!). An extremely complicated association of dykes may be seen near the gate of Hoffsjef Løvenskiolds vei 31, (3).

At the road junction at Hoffsjef Løvenskiolds vei 50 a volcanic breccia can be studied (4). No volcanic matrix is visible here or in corresponding breccias at Øraker and Jar 1-2 km to the SW. The only matrix is a powder of the same material as the fragments, viz. Pre-Cambrian gneisses, Cambrian alum shales, Ordovician limestone and shale and undetermined Permian igneous rocks. Their age is uncertain but must be younger than the Oslo-essexite. In the mode of formation the breccias probably correspond to the Schwäbischen Tuffschloten described by H. Cloos.

Along the left side of the road the dyke of mica-syenite porphyry is again met with (5). A gradual transition can be studied from the red central part (phenocrysts of light coloured oligoclase-andesine and red orthoclase) with $SiO_2 = 60$ % and $FeO + Fe_2O_3 = 1.9$ % to the bluish black border zones (labradorite-bytownite, biotite, magnetite) with $SiO_2 = 45$ % and FeO +

$Fe_2O_3 = 10\,\%$. The more basic marginal zones along the dyke are probably due to thermo-diffusion (convection currents, Soret effect etc.) which took place in the dyke during the solidification.

Along Vesterås veien to the left as far as Gregers Grams vei. Here the dyke bifurcates and cuts a body of Oslo-essexite. It seems likely that during magmatic differentiation successive intrusions took place giving the following Oslo-essexite rocks: olivine gabbro (in very small quantity), kauaiite, three types of akerite and akerite porphyry. Transitional types exist between the different akerites, and diffuse borders occur between the akerites and akerite porphyry. The body became gradually enlarged southwards by the intrusions.

Akerite, sometimes xenolith-bearing, can be seen in a road-cutting (6) near Gregers Grams vei 8. Specimens of the akerite porphyry are now difficult to obtain.

The junction between the akerite and kauaiite (dotted line at (6)) indicates a "lit-par-lit" injection with diffuse borders and an absence of chilled margins.

Kauaiite, the dominating rock seen when continuing northwards, is a medium-grained massive, equigranular rock of syeno-dioritic composition with alkali feldspar, plagioclase (zoned), augite, biotite etc. The border zones are often more rich in biotite.

Continue northwards to the electric cables (the pylons founded on metamorphosed sediments) and proceed 100 meters in a northeasterly direction to a small ridge (7). Here may be found metamorphosed lime-bearing sediments. They have a more northerly strike than usual due to their being thrust aside and lifted by the igneous magma now represented by the Oslo-essexite body situated on both sides of the Mærradalen valley Tectonic analysis has shown that the metamorphic sediments in contact with the body were raised about 100 meters. The fault along the Mærradalen valley has later dislocated the body.

The first rock of Oslo-essexite met with is a coarsely tabular syenodiorite with large plagioclase phenocrysts (An_{30-40}) orientated to give a platy flow structure (8). These are, in either single or more layers, parallel with the borders of the essexite intrusions.

The planes indicated by the phenocrysts mostly dip at high angles towards the centre of the body forming a funnel or inverted cone. This supports the assumption that the necks of Oslo-essexite represent feeding channels to the old volcanoes. It is as yet uncertain if any of the basalts B_1, B_2, B_3 in the Oslo area originally poured out of the Ullern volcano.

A coarse, pegmatite-like rock with long needles (2-5 cm) of amphibole (barkevikite) is often contiguous to the syeno-diorite. Several other types are found, one grading into another. The type locality for husebyite (a nepheline syenite) is also in this body.

If the shooting range in the Mærradalen valley is in use it is advisable to proceed westwards to Ostadalsveien and to the Huseby skole station on the Røa line. If shooting is not in progress the excursion may be continued eastwards across the valley to the third body of Oslo-essexite forming Husebyåsen. At (9) just behind the shooting range most remarkable types of Oslo-essexite can be seen. The best exposures are in road-cuttings where kauaiite at (11) and windsorite at (10) may be seen. Windsorite contains 15 % quartz, 20 % plagioclase, 51 % alkali feldspar, biotite etc. Husebyite can hardly be found now but its existence is of great theoretical interest by indicating a differentiation to a nepheline-bearing rest-magma, whereas the windsorite in the same body shows a contrasted trend of differentiation, to a quartz-bearing rest-magma.

Follow the road eastwards to Makrellbekken station where a train may be taken to the city.

Literature: 9, 49.

10. Sørkedal — Svartor — Blankvann — Voksenkollen st.

By

Johannes A. Dons

Bus No. 41 (Sørkedalen from Rosenkrantzgaten) to Sørkedalen school (Skole, Fig. 34). Exposures of Sørkedal-porphyry occur at (1), RP_{12} at (2) and RP breccia and felsites between (2) and (3). They belong to the Bærum cauldron, the northern border of which is marked by brecciated rocks. Coarsegrained kjelsåsite is found on the outer side of the cauldron at (3).

The Blankvann area is composed of folded Ordovician and Silurian contact metamorphic sediments and Permian rocks of various origin completely surrounded by plutonic rocks. Near Svartor farm (5) a dyke of rhomb-porphyry occurs: it probably had a connection (before the emplacement of the nordmarkite) with the RP dykes in the Vettakollen area (see excursion 13).

The small lake Blankvann (which limnologically is of considerable interest) is 55 m deep. It is possible that plutonic rocks (nordmarkite), because of erosion of the sedimentary cover, occur on the bottom.

South towards Tryvann three different types of "nordmarkite" may be studied though the true type is not seen here. Exposures of fine-grained biotite-granite occurs along the track to Voksenkollen station.

Literature: 35, 37, 39, 40.

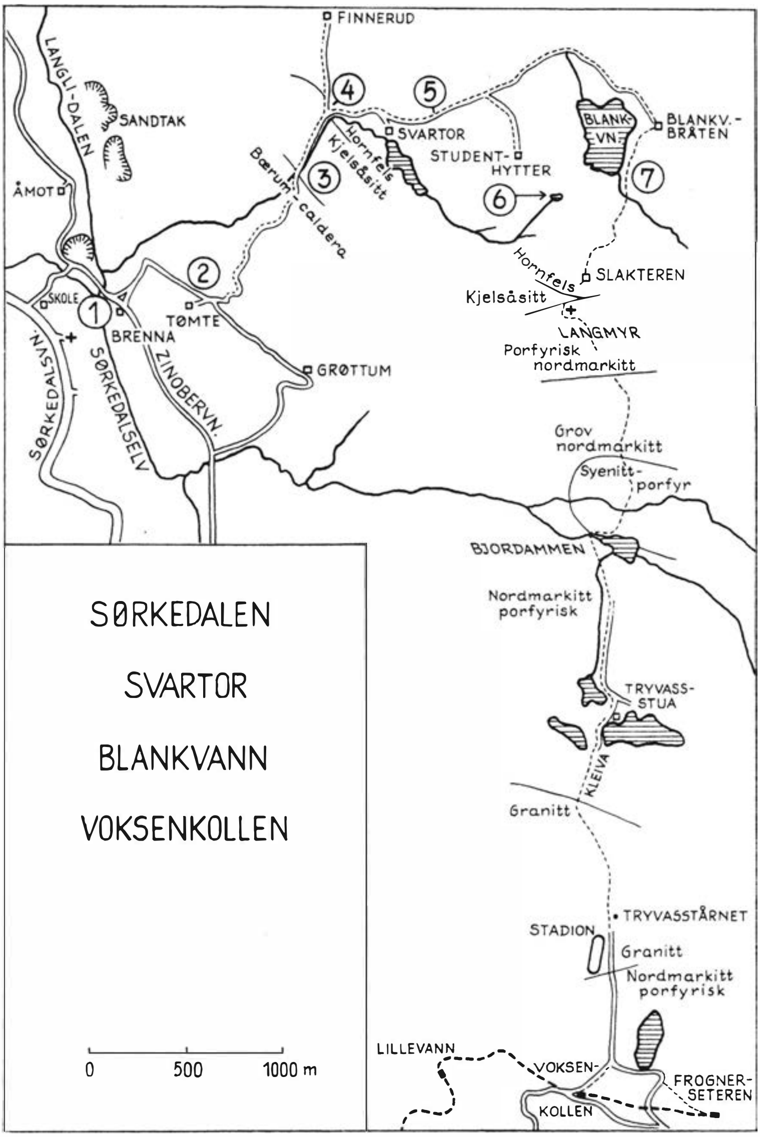

Fig. 34. Map to excursion 10.

11. Northern Sørkedal.

By

Christoffer Oftedahl

Bus No. 41 to Skolen bus stop (Fig. 35).

1. Exposures and cliffs of the lava flow RP_{12b}.
2. First road exposure of RP_{13}, the "rectangle porphyry".
3. Typical RP_{13}, with large, relatively thin plates of plagioclase. Continuous exposure to
4, where the lava is amygdaloidal, and to
5, an exceptionally fresh exposure for hand specimens.
6. Intrusive felsite porphyry, exposed about 60 m along the road.
7. RP_{13} again for 15 m.
8. Another intrusion of felsite porphyry, 30 m along the road.
9. Good exposures of vesicular RP_{13}. Further north poor exposures; at
10, the lava is strongly shattered and brecciated, close to the ring fault.
11. The cauldron ring dyke, a relatively coarse syenite porphyry with distinctly red microperthite phenocrysts.
12. Exposures at the turn of the road; strongly shattered RP_{13}. This lava is variety with smaller phenocrysts.
13. Is opposite good exposures of the ring dyke, and shows location of a path leading to
14, dumps from a long water tunnel, with fresh material from all the interesting rocks to the north. May best be visited and sampled on the way down again. Known as locality for polymignite, a rare mineral rich in rare earths. It occurs as black, thin worms in the coarsest rocks, producing a red halo in the feldspars.
15. Exposures of coarse sørkedalite (olivine diorite). For general description, modal composition and analyses of this and following rocks, see Barth, 1945, p. 56-67.
16. Exposures of basic, fine-grained dyke (?).
17. Two thin, vertical dykes in coarse sørkedalite.
18. Very coarse sørkedalite, strongly altered.
19. Especially interesting exposure in rock cut below cattle grid. The rock appears gneissic, with a bed, one meter thick, of a fine-grained sørkedalite (19A). Feldspar crystals, attaining a length of 5 cm, have grown in the overlying layer (19B), which carries the same minerals as the fine-grained rock.

Thin section of 19A (sørkedalite) shows the following minerals, with estimated per cents: 66 % plagioclase; fresh, twinned andesine; 18 % olivine, 0.5-1.0 mm grains and smaller, often with serpentine border zone; 6 % biotite in scattered flakes and grown on ore grains; 6 % iron ore; 4 % apatite, often in clusters with biotite and small olivine grains.

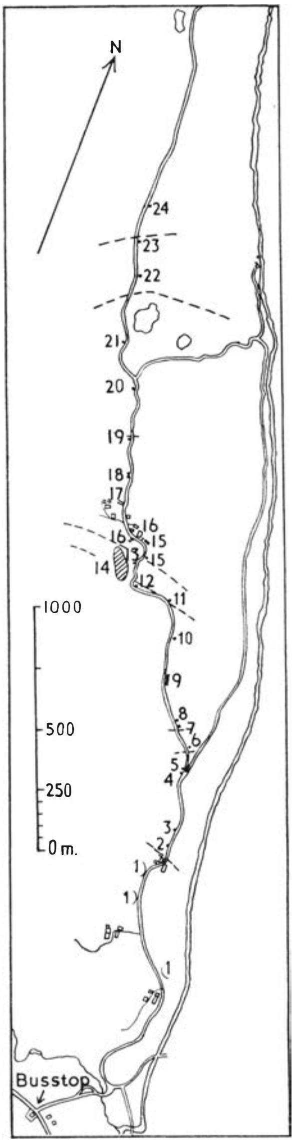

Fig. 35. Map to excursion 11.

Thin section of 19B: The same minerals, only less biotite.

20. Vertical wall, showing beautifully the structure of abnormally coarse, altered apotroctolite (olivine syenodiorite).

21. Good exposure of possibly still coarser rock (altered apotroctolite).

Thin sections show: The grey feldspar is clear to cloudy andesine. The whiter feldspar is a heavily altered, often nearly opaque alkali feldspar; one clear patch is recognizable as a soda-rich cryptoperthite. Clusters of dark minerals contain iron ore, apatite, and a strongly green chlorite, alteration product after olivine.

22. Road cut at the lower end of a long slope; "akerite" of the map; belongs to the marginal zone of the larvikite massif.

Thin section: 79 % feldspar; somewhat cloudy oligoclase and strongly altered alkali feldspar, intergrown as antiperthite or with the second feldspar enclosing large crystals of the first feldspar; 10 % amphibole, green, dirty; 5 % biotite, dark brown; 3 % quartz; 3 % ore.

23. Contact to coarse, weathered larvikite; the akerite seems to become gradually more fine-grained against the contact, situated exactly at the top of the hill.

24. Fresh, nearly black larvikite, a variety without the more or less rhomb-shaped or boat-shaped feldspar crystals occurring in the most typical variety.

Thin section: Oligoclase in large tablets (25—30 An), antiperthitic, containing 20-30 % of irregular patches of alkali feldspar; clusters of dark minerals, 25 % in all; augite in clusters and minute grains; serpentine and chlorite in mixture; iron ore and calcite.

Return to bus stop at Skolen.

Literature: 39, 40, 44, 50, 51.

12. Øverland — Muren — Brunkollen.

By

Christoffer Oftedahl

Bus No. 38 (Godthåb or Lommedalen from Rådhusgaten) to Øverland (Fig. 36). Return to the same bus stop.

The area traversed by the excursion has been carefully mapped and described by E. Sæther (1945).

1. Road cuts at the bus stop, with beds of shale and limestone, belonging to upper Wenlock (zone 8c).
2. Steep wall formed by middle to upper Ludlowian limestones, dipping faintly westwards.
3. Northeast of the road intersection an area with talus and large erratic blocks of sedimentary rocks, which have been sheared close to the ring fault of the cauldron. At location 3 there is a little knob, less than one meter high, made up of highly folded and sheared shale, in which is situated a block of rhomb porphyry. The block is about 0.5 m in size. It belongs probably to RP_7; thus it has been kneaded into the sediments adjacent to the ring fault during the subsidence.
4. A little wall, 1 m high, at the road side consists of "igneous breccia"; the rock occupies a zone,, 2 m wide. It probably represents a block, torn loose during the subsidence.
5. The ring dyke is strongly weathered to red and brownish colours. The rock is a syenite porphyry, with rectangular phenocrysts of alkali feldspar, 2-6 mm long, in a fine-grained to felsitic groundmass.
6. A diabase dike, standing up as a wall and cutting the ring dyke.
7. First roadside outcrops of the basalt B_3 within the subsided block of the cauldron. The basalt is strongly sheared and epidotized. A few meters north of the basalt a white felsite is seen in the outcrop. Most likely the felsite is part of a earlier intrusion, because it does not look like the ring dyke.
8. Continuous outcrops of B_3, here mostly a basalt with augite phenocrysts (2-5 mm across) and abundant plagioclase laths (up to 5 mm in length). According to Sæther (1945, pp. 27-29) the basalt of B_3 is a complex made up of numerous small surface flows as well as small near-surface intrusions. The various types are described in great detail (Sæther, 1945_1, pp. 9-22).
9. Assemblage of large blocks of various types of basalt.
10. Roadcut mostly in non-porphyritic basalt. In nothern extension of the cut the irregular contact between a non-porphyritic and a porphyritic type is seen. Strong, irregular epidotization.
11. Continuing northwards many exposures of various types of basalts are seen in the road and at the roadside. Thus at 11, 100 m from 10, there is a little cut in a type with abundant plagioclase phenocrysts of fair size.

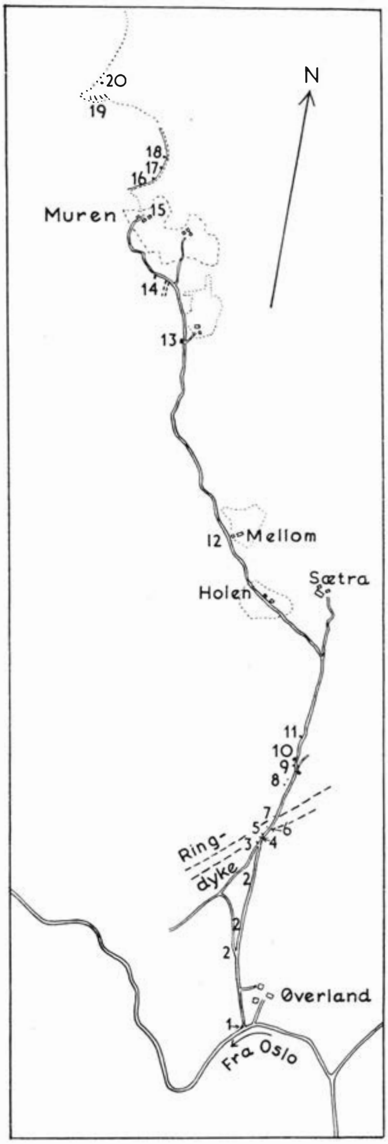

Fig. 36. Map to excursion 12. Distance Øverland—Muren about 3.5 km.

12. At Mellom a fine view of the hills to the north, made up of intrusives into the lava series, prior to the subsidence.
13. On left side of the road low exposures of basalt of agglomeratic appearance.
14. Solid outcrops and large blocks of igneous breccia. Some exposures is a felsite porphyry with marked fluxion structure and microperthite phenocrysts as small, white dots. The porphyry mostly carries inclusions of rhomb porphyries, in place so abundant that the groundmass is not distinguishable.
15. At Muren non-porphyritic basalt. Continue path uphill to Brunkollen.
16. After passing a ski-jump a wall of igneous breccia is approached. Inclusions are not easily visible in the felsite porphyry which has rectangular phenocrysts of alkali feldspar, 1-2 mm in size.
17. Locality where inclusions show up beautifully in a felsitic groundmass. The size of the inclusions is up to 30 cm. They consist of various fine-grained to felsitic rocks of syenitic composition.
18. Road cut showing same type of breccia.
19. Exposures of fine-grained rock of monzo-syenitic composition belonging to the huge intrusive body of akerite porphyries, etc.
20. Excursions may be terminated at the little log cabin with beautiful view southwards to the lowland. Then return to bus.

Other varieties of akerite porphyries may be seen by following the path past Haslumseter (topographic map "Oslo omegn III", 1 : 25 000). The overlying lava RP_{12a} occurs at the foot of Barlinddalshøgda. Between RP_{12a} and RP_{13} occurs a thick bed of breccia (tuffitic agglomerate), cropping out in the southern slope of Tjæregrashøgda which is made up of RP_{13}.

Literature: 41, 44, 51.

13. Vettakollen — Sognsvann.

By

Nils Spjeldnæs

Take Holmenkollbanen from Nationalteatret to Gaustad station (Fig. 37, those interested mainly in petrology may continue to Skådalen station and proceed from there, beginning at locality (8)).

Just SE of Gaustad station (1) a large dyke of rhomb porphyry cuts Ordovician strata. For a width of about 1 m the shale and nodular limestone have been altered into hornfels. Northwards along Slemdalsveien a section through fossiliferous, unmetamorphosed Ordovician mudstones (with marl concretions) of zone 4b is exposed (2).

At Ris station follow Trosterudveien to the right. At the junction with Halvor Torgersens vei (3) the rhomb porphyry dyke isa gain exposed. The sedimentary rocks here are somewhat metamorphosed by the plutonic rocks occurring to the north.

Where the road divides into three, take the middle one (Gråkamveien) and outside No. 12, just west of the gate (4), a thick-bedded limestone may be seen below the silty shale. This is the border between the Ordovician (5b) and the Silurian (stage 6). Some poorly preserved fossils may be found in the limestone.

At Gråkamveien No. 18 the rhomb porphyry dyke is again visible (5). Turn along Stjerneveien to the right. Here the sediments are strongly metamorphosed and very hard. At No. 4 the rhomb porhyry dyke is again exposed. It is here cut by a younger quartz-porphyry dyke (6).

From Stjerneveien follow a path northwards to Bonntjernveien (Ankerveien). Just north of the junction (7), where furthermore, a path from the north comes down, there is a small disused mine, worked for iron ore. In the overgrown dumps one may find magnetite, pyrite, chalcopyrite, garnet wollastonite, fluorite etc. It is a contact pneumatolytic mineral deposit in the Upper Ordovician Limestone.

Take Bonntjernveien either northeastwards, directly to (13), see later, or descend southwestwards and then follow Huldreveien to the right as far as Vettaliveien. The latter road comes from Skådalen station and those starting from there (see above) can first see a large dyke of rhomb porphyry, metamorphosed sediments and akerite in the railway cutting at the station (8).

Opposite the western gate of Vettakollen Turisthotell, two thin rhomb porphyry dykes are seen (9). These belong to the same dyke as seen at localities (1), (3), (5) and (6).

Continue along Vettaliveien to the north on akerite. In a sharp curve of the road rhomb porphyry lava (RP_1) is met with. In the hillside north of the road the junction between two lava beds (RP_1 and RP_2), with a thin layer of tuff between, is exposed (10).

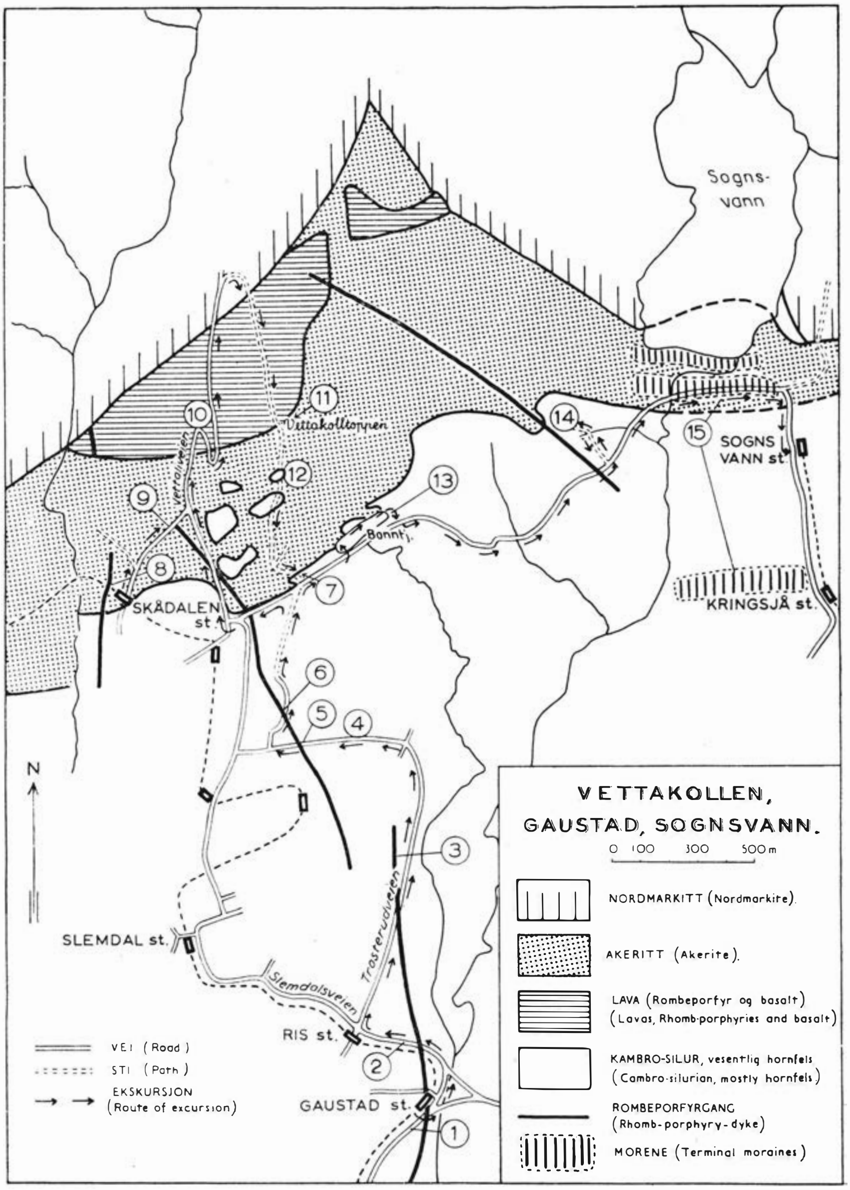

Fig. 37. Map to excursion 13.

The route goes northwards over lavas with several dykes of akerite and diabase, and then passes into nordmarkite. Just northwest of the border follow a path marked "Vettakolltoppen" to the right. This brings one back over the lava again.

At Vettakolltoppen (11) the border between rhomb-porphyry lava and akerite is visible. A fine view of the Oslo depression may be obtained from this point.

From the summit take the path southwards. After about 400 metres several xenoliths of hornfels are met with "swimming" in the akerite but having the same strike and dip as the sediments outside the akerite. Proceed to Bonntjernveien (7) and eastwards to Bonntjern. On the northwest side of Bonntjern the contact akerite-hornfels is well exposed (13). Assimilation processes seems here to have taken place.

Continue further east on Ankerveien (easterly continuation of Bonntjernveien) across metamorphosed sediments with many dykes. An old mine (14) occurs, similar to that at (7). At the southern end of Sognsvann three terminal moraines may be seen. One dams the lake; the W-E road runs along the second; the third (and largest) lies west of Kringsjå station (15).

Just north of Sognsvann station *Mytilus edulis* and other late Pleistocene molluscs were found (195 metres above sealevel).

Return to town from Sognsvann station.

Literature: 14, 39, 44.

14. Grefsenåsen — Stig — Storhaug.

By

OLAF HOLTEDAHL

Take the Kjelsås-line tram (No. 4) from Dronningens gate or Storgaten to Sanatoriet station (1 in Fig. 38). From here take Dr. Smith's vei southeastwards to Kjelsåsveien, and follow this road uphill (to the northeast). Continue along Grefsenkollveien until the relatively flat ground close to the steeply ascending rocky mass of the Grefsenås is reached.[1] This flat ground has been levelled during sand- and gravel-quarrying operations some time ago. The area is occupied by the southern (distal) part of the Grefsen moraine, which has a rather complicated structure. Layers or irregular masses of clay and sand containing locally fossils (e. g. *Mytilus edulis*) occur in the boulder clay and indicate oscillations of the ice front (cp. Isachsen 1941). A typical feature is a top layer of washed gravel and stones, the result of wave-action during the rise of the land mass. To the right of the road, at (2), just below the steep rocky slope, there are the narrow remains of a terrace which possibly marks the highest "marine limit" in the Grefsen district. Its height is 217—218 meters a. s. l.

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[1] Bus No. 56 (Solemskogen) from Ankertorget stops here.

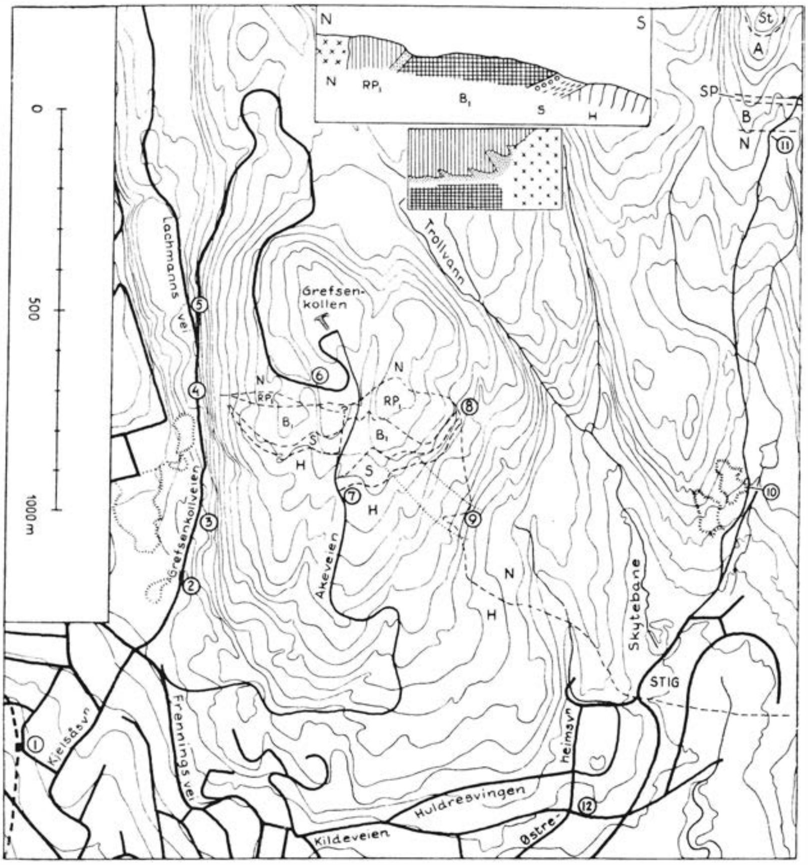

Fig. 38. Map to excursion 14. Upper section SW of (6). Lower section SW of (8), direction SW-NE, length about 20 m. H — hornfelsed Ordovician strata, S — basal Permian sediments, B₁ — basalt, RP₁ — rhomb porphyry, N — nordmarkite, B — basalt of Alnsjø area, SP — syenite porphyry, A — argillite and greywacke, St — summit of Storhaug (with conglomerate).

From this locality and upwards (northwards) along the Grefsenkollen road the rocks are very well exposed on the right hand side. They are folded Ordovician hornfels-rocks, contact-altered strata belonging to stage 4. There is an alternating succession of dark- and light-coloured hornfelses, representing original beds of shale or (mudstone) and impure limestone. The hornfelsed limestone occur as either continuous layers or rows of nodules. According to McCulloh (Oslo series, 1952) these hornfelses range in composition from biotite- and orthoclase-bearing hypersthene-plagioclase types (of clay origin) to diopside-wollastonite types (of marly limestone origin).[1]

The hornfels mass is cut by a number of dykes, the majority of which has a dip of about 45° towards the northeast, thus towards the nordmarkite

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[1] About 180 m southeastwards from (2) vertical strata of a light coloured rock largely made up of finely fibrous wollastonite are well exposed. They represent contact metamorphic calcareous sandstone of stage 5b.

body of Grefsenåsen and the subsided Alnsjø area still further north. This system of dykes, which evidently has a "cone sheet"-like character, also cuts the nordmarkite adjacent to the hornfels, as seen on the right side of the road between (4) and (5) as well as in old quarry walls below the road just south of (4)[1]. The dyke rock varies somewhat from one dyke to another. In most cases we are dealing with light coloured, sometimes distinctly reddish, types with a finely porphyritic texture. Professor I. Oftedal has kindly studied thin sections from a considerable number of dykes and has found the phenocrysts to be perthitic alkali feldspar. The ground mass is mainly made up of feldspar. In some types alkali feldspar predominates, in other albite. Texture in some cases trachytoidal. There is very little of dark minerals. Quartz may be present in small quantities. In general we can speak of syenitic dykes, some closely related to nordmarkite rocks.

Interesting structural features are seen in an old (hornfels) quarry, at (3). Here (Fig. 39) tectonic movements have taken place, in a nearly horizontal direction, after the emplacement of the dykes. In this particular quarry, at the north end, there is a conspicuous dyke made up of a fine-grained pinkish rock, very rich in alkali feldspar. The branching dyke seen to the left in Fig. 39 differs both as to mode of occurrence and petrographical character from the other dykes mentioned. The rock is more coarsely porphyritic, relatively dark, greenish, with a considerable quantity of dark minerals (mainly pyroxene and ore) in the ground mass. The dyke to the right in Fig. 39 is a syenite porphyry with small phenocrysts (1-3 mm long) of alkali feldspar.

The main nordmarkite body of Grefsenåsen is met with about 250 meters north of the quarry, at (4). It is a pink, medium-grained rock, which besides alkali feldspar contains phenocrysts of a greyish-weathering potash-oligoclase (McCulloh) which gives the rock a porphyritic aspect. Dark minerals and quartz are present in very small quantities only. A clear and simple contact between the nordmarkite and the hornfels is not well exposed at the road (but below it). At the foot of the very steep rockface occur down-fallen blocks, mostly of dyke rocks. The whole rock-mass has evidently been strongly fractured; fluorite occurs locally as fissure fillings.

Further along Grefsenkollen road there are plenty of good exposures of nordmarkite. On the right hand side, at (5), about 120 meters north of the junction of Grefsenkollen road with Lachmanns vei, a vertical diabase dyke with a N-S strike cuts through the plutonic rock.

The road then swings southwards in a marked curve, approaching the area of Permian supracrustal rocks stretching across the upper part of Grefsenåsen. In places, as at (6), the nordmarkite contains numerous small, dark inclusions, the original character of which is rather uncertain. Professor

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[1] In August 1956 the Permian rocks of parts of Grefsenåsen were mapped (in scale 1: 1000) by Mr. Hans-Olaf Pfannkuch of the Technische Hochschule of Aachen.

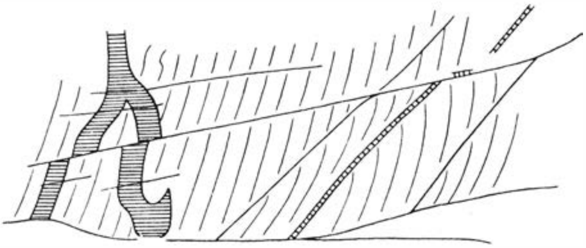

Fig. 39. Dykes in hornfels at (3). Thrust-displacement in left part of the section 1.5-2 m.

Oftedal kindly studied a thin section of such an inclusion a couple of cm in diameter, and makes the following remarks: "The inclusion contains a porphyroblast of plagioclase 4 × 5 mm, set in a very fine ground-mass. The minerals of the latter seem to be mainly cordierite and biotite, with needles of andalusite and some apatite. The inclusion in all probability represents a hornfels of Goldschmidt's class 2." Commonly the borders of these inclusions are not sharp and we get the impression that assimilation processes have taken place.

The Permian supracrustal complex to the south can be reached by, e. g., walking southwards from the main road a little west of (6). At a number of places there can be seen the contact between nordmarkite and the rhomb porphyry lava RP_1, the latter being the youngest supracrustal Permian rock now exposed in Grefsenåsen. The nordmarkite has a very fine-grained, evidently rapidly chilled marginal zone. Below RP_1 comes a thin (1-2 m thick) zone of a light-coloured, fine-grained quartzitic sandstone of which we have no equivalent in the Kolsås sequence, but which is represented in the Nittedal area. Further down comes B_1, the very dark massive (trachy-) basalt, probably 15-20 m thick. Typical of this rock is a lighter coloured zone of weathering, 1-2 mm thick.

Finally come the basal Permian sediments, at least 15 m thick with, in the lower part, psammitic and (hornfelsed) pelitic beds,[1] and, in the higher part, a zone of quartz conglomerate. This series of supracrustal rocks shows a marked northerly dip (25—30°) with local steepening near the nordmarkite-contact (upper section in Fig. 38). Especially in the rhomb porphyry there is evidence of mechanical strain, the feldspar phenocrysts being in places more or less squeezed out.

A visit to the restaurant at the top of the hill can be recommended. From here an extremely fine view is obtained of the whole Oslo depression.

Parts of the four main Permian zones can very easily be seen on the east side of Akeveien east of a N-S fault line. The more fine-grained part

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[1] At this level occurs in the western part of Grefsenåsen a sill of a light coloured fine-grained porphyritic rock with small perthitic phenocrysts and a ground mass very rich in albite.

of the basal zone of sediments crops out well, and a short distance further south (7) we meet the tilted hornfels floor of the sub-Permian peneplane on which the sediments were, unconformably, deposited. The strata of the hornfels stand more or less vertical, with strike NE.

The excursion may be continued in one of two ways. Either one can follow Akeveien downhill into Frennings vei, follow this road to the south and southeast, via Kildeveien, Huldresvingen etc. to the shooting-range (skytebane) at Stig. Or one may go east from Akeveien in order to study some rather remarkable structures on the eastern slopes of Grefsenåsen In the latter case Akeveien is left just south of the boundary between the Permian sediments and Ordovician hornfels, and a path is followed leading NNE for about 150 meters. One then turns east and crosses the upper part of an open skiing slope which runs in a southeasterly direction. Here can be studied the Permian conglomerate strata in small exposures and in loose blocks. Having passed the open field, obliquely downwards, one turns northeastwards to locate a narrow, shelf-like, ledge eroded in the quartzite zone below the rhomb porphyry. This ledge can be followed for about 150 meters towards the NE till the nordmarkite, which cuts through the Permian supracrustal rock and the hornfels below them, is reached (8).

What is of particular interest is the character of the boundary between the rhomb porphyry and the quartzite in this eastern area. This boundary shows very marked undulations of fold character, with overfolding towards the south, the fold structure being especially well marked as the nordmarkite border is approached (cp. lower section, Fig. 38). The quartzite is very strongly jointed, with the main joint direction more or less parallel to the axial plane of the folds. That this structure is the result of mechanical forces acting after the cooling of the RP-lava, is indicated also by the fact that the adjacent rhomb-porphyry rock has commonly a more or less mylonitic character. An other point is the occurrence in the quartzite of an evidently strongly deformed dyke-like mass of a labradorite porphyry. This may be explained as a tectonically deformed and horizontally somewhat moved (upper) part of a dyke which is seen to cut the B_1-lava on which the quartzite lies. Conditions seem to tell of a compressional structure which probably (like the marked northern dip mentioned from the more western district), has some close relation to processes connected with the emplacement of the plutonic body.

Just east of (below) the eastern extension of the Permian rocks a path can be found leading southwards (on nordmarkite) till, after having passed into hornfels rocks, the middle part of the skiing slope is reached. In the open non-forested area here one can study the rather irregular boundary between the nordmarkite and the hornfels (there is a dyke-like offshoot uphill). Down the slope one can notice (9) some xenoliths, several meters wide, of hornfels in the plutonic rock. If the strike of the bedding of the inclusions is compared with that of the main (bed rock) hornfels-mass it is found that there is a marked difference, of varying magnitude. From the foot of the skiing-slope a comparatively well-marked path can be reached running on the east side of the brook shown on the map, either by following a path leading in a NE-direction, or a path leading southwards, from which after some 2-300 meters, a branch leads down to the brook mentioned.

From Stig the excursion continues northeastwards, east of the shooting-range until, after about 500 meters, several quarries are seen to the left where mainly Ordovician hornfels and Permian lava have been worked. These rocks occur as inclusions in the nordmarkite and represent xenoliths which must have fallen down into a magma of low viscosity from the "roof" of the magmatic chamber, during a process of stoping. Xenoliths of all sizes, up to diameters of several hundred meters, are very typical of the nordmarkite zone south of the Alnsjø area, and their arrangement (cp. the coloured map) gives an indication of the original character of the roof in various parts of the area under consideration. (A very big inclusion on the eastern side of Årvollåsen, made up of both lavas and Permian sediments, is of particular interest because the series lies inverted. The block must have rotated during the subsidence into the magma).

In the quarries north of Stig is at present (1956), just east of the rock-crushing house of the northern quarry (10), an exposure that shows B_1, quartzite and RP_1 in a continuous series, here with a moderate northerly dip. All the rocks are of course highly metamorphic. As was locally the case in Grefsenåsen the rocks have been exposed to strong mechanical strain. The feldspar phenocrysts of RP_1 have frequently been squeezed out, and along certain zones of movement the rock has been completely mylonitized. This process probably took place just before the xenoliths subsided into the magma.

Another characteristic feature is that the rhomb porphyry rock shows more or less round patches, some few centimeters in diameter, where it has been strongly altered. Professor I. Oftedal has studied the phenomenon and written the following note:

"The ordinary rhomb porphyry in this locality is nearly blackish grey and very fresh. The patches are visible in a small area, some square meters only, on the rock surface. One or two of them have been examined in some detail. They exhibit a central nucleus some centimeters in diameter, made up almost entirely of a crystalline aggregate of a greenish-black common hornblende. This is immediately surounded by the rhomb porphyry, which is, however, discoloured for a distance of a few centimeters. In particular the rhomb feldspars stand out clearly, light grey in colour. The alteration processes within this discoloured zone include formation of some minerals and corrosion of others. The most conspicuous newly formed mineral is a green epidote, which occurs abundantly near the nucleus boundary, and occasionally within rhomb feldspars.

As the nordmarkite contact is not more than a few meters distant, hornblende, epidote, etc. can hardly have formed during the period of normal contact metamorphism. We have to imagine some kind of hydrothermal metasomatism at a somewhat later stage. This is supported by the occurrence of a number of narrow, light-coloured veins in the close vicinity of the patches. The clean boundaries of the hornblende nuclei suggest that they may have developed in pre-existing vesicles in the rhomb porphyry lava."

North of the nordmarkite zone now dealt with, we have the Alnsjø area of Permian supracrustal rocks (with some dykes), a large subsided fragment of the crust which may be regarded as a part of a cauldron-subsidence block. This area can easily be approached, in the Storhaug district, by continuing from the quarries northwards along a well marked path. There is here very little of moraine deposits. One may walk for considerable distances practically directly on a sloping floor of nordmarkite with often fine ice-scouring. The surface commonly follows marked joint planes in the rock. West of a little bog and just before the main path turns northeastwards (11) the northern boundary of the nordmarkite is crossed and we enter a zone of a fine-grained, partly porphyritic basaltic lava, belonging to the Alnsjø supra-crustal complex. This lava zone belongs stratigraphically far above RP_1 and may possibly be compared with the zone B_2 which in Bærum and Nittedal comes above RP_9.

One now continues directly north, up the southern slope of Storhaug. After a quite thick E-W dyke of syenite porphyry, the argillite or greywacke of the Alnsjø series is met with. The colour of this rock changes, from south to north, from dark grey to purplish, the change being due to the effects of contact metamorphism. The rock is very massive, but in places a bedding can be seen. The dip is to the north, decreasing northwards, until the youngest stratigraphical member of the Alnsjø series, the Storhaug conglomerate, is met with, ocupying a marked synclinal position. The conglomerate is mostly a fairly well-bedded rock of varying coarseness, with sandy layers. The pebbles (and sand grains) are made up of porphyritic and fine-grained igneous rocks. One meets with both basaltic types and relatively acid felsite-like rocks which possibly may be of effusive origin. Considerable masses of volcanic rocks must have been exposed to denudation before or during the deposition of the Storhaug conglomerate.

McCulloh has pointed out that the contact metamorphism along the border between the nordmarkite and the Alnsjø rocks is far less strong than along the southern margin of the nordmarkite, where it is in contact with the Cambro-Silurian sediments. A considerable cooling of the magma therefore seems to have taken place between the time of nordmarkite-emplacement and the subsidence of the Alnsjø block.

From Storhaug one follows the same path back southwards to Stig and takes a bus (No. 31) e. g. from the bus stop at (12), back to the city.

Literature: 14, 20, 25, 28, 37, 39, 48.

15. Ekeberg.

By

OLAF HOLTEDAHL

Take the Ekebergbanen tram from Stortorget to Sjømannskolen station (Fig. 40).[1] During the later part of the ride the line rises from the low ground of the city with its superficial Quaternary deposits, up the northern slope of Ekebergåsen along the Kongsveien road. On the left may be seen much crushed Cambrian alum shale with contorted intrusive bodies of the mænaite type. The latter represent sheet, or sheet-like, intrusions characteristic of the horizon just above the sub-Cambrian peneplane (cp. Slemmestad and Akershus, p. 45, 77). Both the shale and the intrusives have been dragged down along the northward-dipping fault-zone bordering Ekeberg. About 250 m from the foot of the slope Archaean rocks appear, they are much fractured and brecciated near the fault-zone.

Alight at Sjømannskolen and walk to the western front of the building (1) where a fine panoramic view may be obtained. Southwards the fault-zone runs along the western side of Ekeberg (described in detail by Brøgger, 1886), with downfaulted Cambro-Silurian in the islands and in the peninsula just south of Bekkelaget station. To the west, under the fault-slope, are more, islands (e. g. Hovedøya, see p. 50) made up of folded shale, limestone etc., with ENE strike. Beyond appears the pointed northerly extremity of Nesodden where uplifted Archaean occurs. Further distant still the Cambro-Silurian forms the low-lying ground of Asker and Bærum; lava-capped hills of Skaugumsås, Kolsås (p. 52) rise behind.

To the north-west lies the Akershus peninsula (p. 77) with the Archaean basement on its western, far side. Here runs a north trending fault, presumably a northerly continuation of the western Ekeberg fault. About 7 km distant the forested area of Ullernås with its hard core of Oslo-essexites, rises sligthly above the surrounding low ground.

In the slope SW of the building are several exposures of the prevailing Archaean rocks of the district. These include 1. gneisses, relatively compact in some zones but more banded in others; 2. amphibolite-bands of varying thickness; 3. pegmatite veins cutting 1 and 2, the strike of which generally is NW.

Before crossing the tram-line again, attention is drawn to a fenced-in place just below the Kongsveien road and opposite the more southerly platform of Sjømannskolen station. It is of both geological and archaeological interest since it contains an ice-striated rock surface with rock carvings of Late Stone-Age man.

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[1] Alternatively take the tram marked "Gamlebyen" to the terminus and walk from there to Sjømannskolen. The exposures, however, are not accessible because of the tramline.

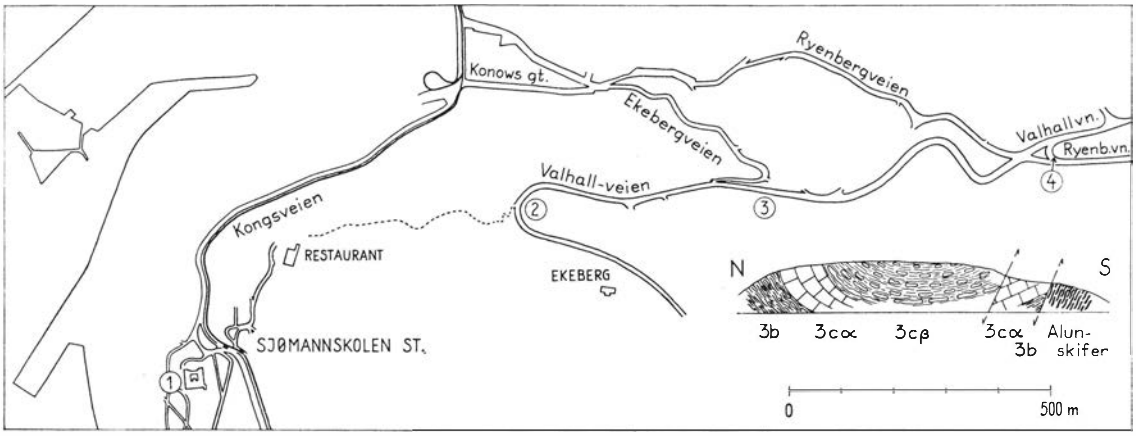

Fig. 40. Map to excursion 15. Section at (4).

Cross the lines and proceed northwards to the restaurant and on up the slope to the curve on Vallhallveien facing westwards. In places may be observed a thin cover of ground moraine with local concentrations of stones or blocks, the majority of which consist of nordmarkite.

In the same curve of the road good exposures show fracturing of the Archaean rock: slickensides tell of dislocations in varying directions and of varying degrees of steepness. Calcite has been deposited on some fractures. A thin pegmatite vein, dipping slightly southwards is seen to have been stepfaulted, with the downthrow to the north towards the main fault-zone, but most probably this faulting is of Pre-Cambrian age.

At this elevation (120-130 m above sea-level) Ekebergåsen has a cover of marine clay over quite wide areas.

Just east of the curve a splendid view may be obtained. Down-faulted Cambro-Silurian rocks occupy the lowland at the foot of the steep slope below the road but are largely hidden by thick masses of marine clay. To the north rise the forested masses of Grefsenåsen (p. 68), Årvollåsen, Røverkollen etc., mainly consisting of hard syenite rocks. Further west the distal part of the Grefsen moraine occurs and for long distances the approximate upper limit of the Quaternary marine deposits is well marked topographically at a height of about 200 m.

Downwards along Vallhallveien are good exposures in gneiss. Further on the main zone of dislocation is approached and on the right hand side of the road (3) badly crushed alum shale (with nearly vertical cleavage) and irregular, tectonically deformed and broken bodies of Permian intrusives of the mænaite type can be seen. The Archaean rocks are often brecciated, and steeply inclined fault-planes, striking along the road, display slickensiding in the border zone. These movements were obviously not restricted to one plane of dislocation.

Vallhallveien follows the fault-zone for some distance before swinging to the left where it enters less deformed rocks belonging to higher stratigraphical horizons. The steep fault escarpment rises a short distance away to the right.

Just above the houses 63-69 on Vallhallveien a projecting mass of hard rock represents the northernmost part of a vertical rhomb porphyry dyke. This cuts only the Pre-Cambrian and stretches southwards for a long distance (passing east of Gjersjøen, cf. coloured map). It does not continue northwards into the Cambro-Silurian, probably because the fissure along which the magma was intruded did not reach above the relatively rigid and easily jointed Pre-Cambrian basement. (Cf. the large Modum dyke on the western margin of the Oslo region).

At the intersection of Vallhallveien and Ryenbergveien a syncline in Ordovician limestone 3cα with adjacent older and younger shales is exposed (section Fig. 40). In the south part of this exposure two faults occur, the more southerly one bringing black, steeply inclined alum shale into contact with the above mentioned limestone. A few hundred meters further east along Ryenbergveien, Archaean rocks of the border zone, frequently brecciated, are quarried.

From the intersection of Vallhallveien and Ryenbergveien take the latter road down to the west, where several exposures of Ordovician shale and nodular limestone can be seen. They dip steeply northwards, having been dragged down during the faulting.

Proceeding along Konows gate crushed alum shales (with sheet-like intrusives) occupy the steep slope to the left. The shales here were quarried and burnt for alum during part of the period from 1737-1815.

Literature: 1, 4, 5.

Some Places of Geological Interest within the City.

By

GUNNAR HENNINGSMOEN

Pre-Cambrian — Cambrian.

Akershus castle. An interesting section (Fig. 41) is seen close to the railway line along the quay-side, south of the City Hall. Steeply dipping Pre-Cambrian rocks, gneisses and amphibolites (1 in Fig. 41), are exposed at the entrance to an air-raid shelter and southwards. A layer of conglomerate and arkose (2-3), one metre thick, is seen to overlie the Pre-Cambrian just above the entrance. Further north occur (4) black shales (alum shales) which probably are of Middle Cambrian age. No fossils have been found. Permian sills of mænaite porphyry (5) are seen above the alum shales.

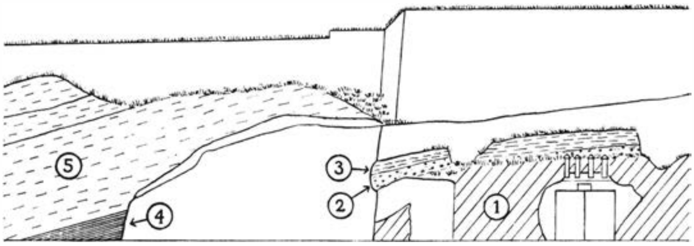

Fig. 41. Section below Akershus castle. 1. Pre-Cambrian gneiss etc., 2. Conglomerate, 3. Arkose, 4. Alum shale, 5. Permian sills.

Rådhusgata. On the northern side of Rådhusgata, near Rosenkrantz gate, a similar section is exposed through dark unfossiliferous alum shales and light-coloured Permian sills.

Gamlebyen. Upper Cambrian alum shales underlie large areas of the city centre and also occur at Tøyen and Gamlebyen. The shales are rarely exposed, except by casual digging in streets and on building sites. They may, however, be studied in the abandoned alum shale quarry on the south side of Konows gate, on the northern slope of Ekebergåsen. (See above). *Peltura, Parabolina* and other Upper Cambrian trilobites are here often numerous in the black limestone concretions (stinkstones) in the shale.

Middle Ordovician.

Several good sections can be seen in the town. They show a marked banding due to frequent alternations between layers of dark shale and impure limestone or limestone nodules, with a more light coloured weathered surface. The beds are often beautifully folded. Good sections occur along Frederiks gate, west of the University (Lower Chasmops Shale), Drammensveien (Lower Chasmops shale with, in the western part of the section, Ampyx limestone), Uranienborgveien between Josefines gate and Holtegata (Ampyx limestone folded into an anticline and cut by a Permian dyke Fig. 16), and in Halvdan Svartes gate near the Frogner Park between Solheimsgata and Drammensveien (mainly Ampyx limestone).

Permian dykes.

Of larger dykes can be mentioned the rhomb-porphyry dyke seen in a ridge in the Frogner park just northeast of the Vigeland monolith and a dyke of related type in Stensparken (somewhat north of Fagerborg church).

Literature: 1, 14.

Norwegian Ornamental Stones in Oslo.

By

GUNNAR HENNINGSMOEN

Many of Oslo's buildings are wholly or partly faced with stones of Norwegian origin. A few of the commonest are mentioned below.

Pre-Cambrian rocks.

Migmatite from the border area between the Østfold granite and the surrounding gneisses at Hvaler in Østfold, is used in the lower part of the eastern, southern and western walls of the City Hall (Rådhuset). Also other buildings near the City Hall, and on others elsewhere in the town. The stone itself shows granite penetrating and partly assimilating the gneiss, fragments of which are sometimes preserved as relics.

Light-coloured Østfold (Iddefjord) granite is used for the staircase on the northern side of the City Hall. A single large piece is represented by the Monolith in the Vigeland lay-out; other (granite) sculptures were similarly fashioned from single blocks.

Ordovician and Silurian rocks.

Porsgrunn Limestone (so-called Wenlock Limestone) is used in Stortingsgata 30, for buildings of Fridtjof Nansens plass 7 and 8 facing out to Tordenskjolds gate, and in Storgata 21. Other fine examples of this stone are seen in Trondheimsveien 5 and elsewhere in the city. The stone is grey, richly fossiliferous limestone from beds of Wenlock age from the Porsgrunn area. It represents a near-reef facies and is crowded with fossils, especially thick encrinite stems, corals (*Halysites, Favosites, Heliolites,* rugose corals) and other reef-builders such as stromatoporoids and bryozoans.

Fauske marble, from northern Norway, is used among other places in the front of Stortingsgata 12 and in the entrance hall of Stortingsgata 28 (Odd Fellow building). It is a white, reddish or grey-blue crystalline rock, probably of Ordovician age.

Permian intrusive rocks.

Larvikite, well known in Great Britain and other foreign countries as an ornamental stone, is a light or dark blue augite monzonite from Larvik and other parts of Vestfold. It is extensively used in Oslo as a facing stone, e. g buildings in Roald Amundsens gate and Klingenberggata. The dark blue larvikite is very well seen in Klingenberggata 4, and the light blue larvikite is used on the ground floor of Stortingsgata 22. It is also used indoors for shop-counters, etc. Its beautiful labradorization when polished is dependant upon the cryptoperthitic structure of the feldspar and due to some sort of internal reflection from the boundary between the two feldspar faces of the cryptoperthite.

Tønsbergite, from Tønsberg in Vestfold is a variety of larvikite which is red-coloured, due to alteration. It is well displayed in Rådhusgata 8.

Nordmarkite, a reddish soda syenite, is named after Nordmarka, the forested hills north of Oslo. It is quarried at several places around the town, e. g. at Grorud, and is used in the lowermost part of the walls of the Parliament Building (Stortinget). It is even better seen in the walls of the Zoological Museum in the Botanical Garden (Tøyenhagen).

Drammen granite, a red biotite granite from the vicinity of Drammen, is used in the walls of the Geological Museum in the Botanical Gardens. Polished slabs are used as a facing stone in the entrance to Karl Johans gate 23.

Literature: 14.

Giants' Kettles (Pot Holes) in the Oslo district.

(Text to the maps Fig. 42.)

By

HALVOR ROSENDAHL

Map 1. Vardåsen in Asker.

Vardåsen. The kettles are situated on the top of the mountain, on the SW part of a ridge S of the small tarn, on the very edge of the steep slope downwards to the SW, at more than 300 m a. s. l. Four kettles are visible, with diameters 0.4-0.8 m.

Map. 2. Vestmarka (W of the Sandvikselv valley).

Haveråsen. One kettle, diameter about 0.8 m, S of and not far from the basis of the former fire-guard tower, 438 m a. s. l.

Ramsåsen. One kettle near Stovisæter on a small ridge W of Breidmosen, at more than 400 m a. s. l.; diameter 70-90 cm.

Svartoråsen. Three small kettles, the largest one of which is 30 cm in diameter and 40 cm deep, W of Skui farm, on the crest of the mountain ridge at 258 m a. s. l.

Map 3. Maridalen.

Dausjøen. On the SE slope of the steep rocky wall on the NW side of Grøndalen, sloping towards Dausjøen. A very large kettle, diameter 3.5 m. Some few meters to the north there is a smaller kettle, 0.7-0.8 m diameter. To find the locality, take the road to the east from the busstop "Lokalet", and follow a path to the NE through Grøndalen.

Map. 4. Sørmarka (E of S part of Bunnefjord, mainly outside the map area).

Grønliåsen. One kettle on the western slope of the northern part of the rock ridge NE of Prinsdal. Diameter 42 cm, emptied to the bottom, 1.5 m.

Fløysbotn. From the old road southwards, passing Prinsdal, a farm-road leads towards the east to Fløysbotn farm. From the point of this road, were the view opens out on to the fields of Fløysbotn, there is a kettle 100 m to the north on a little rock outcrop covered with brushwood. The diameter of the kettle is 60 cm, the depth more than 90 cm. Quite near this kettle there is a smaller one.

Stallerud. A little S of the farm, at the lane to Stallerudhytta on the W slope of the steep rock wall, two kettles are located close together, 1.2 and 1.1 m diameter, and each more than 1 m deep.

Gjersrud-Jonsbråten. On the east side of Maurtuvegen (Klemetsrud-Myrer), midway between Lower Gjersrud and Jonsbråten on the rock slope, inclined to the west, there is an oval kettle, diameters 0.9 and 1.25 m. Nearer to Jonsbråten, on the same side of the road, there is a smaller kettle.

S of Myrer, at the S-end of Maurtuvegen, there is a tarn, Myrertjernet. On the SE side of it, in the steep rock wall sloping to the W, there is a large, somewhat oval kettle, diameters 1.25 and 1.10 m. The kettle was emptied of water and gravel in 1948. The distance to the bottom is 3.5 m, and the excavation may be traced in the rock slope 3 m higher. The kettle widens downwards, and has screw sculpture.

Grytebråten. 700 m N of Siggerud chapel, E of the remains of a little house, beneath the electric transmission wire, in a steep rock wall sloping to the W. Here a large, almost circular kettle, diameter 1.8 m, visible depth 1.4 m. The boring may be traced upwards in the steep gneiss wall.

Fjeld. At Enebakvegen, on the E side of Bindingsvatnet, E of the mouth of Svartholbekken, between Fjeldsætra and Langbråten, on the almost vertical rock wall facing W, one large kettle, only partly excavated in the rock, the western side being open. N of this kettle there is a smaller one, wholly excavated in rock and filled with gravel and water.

Jevikplass (Nordby). A little S of the farm, a circular kettle, 60 cm, on a flat rock surface.

Fjellstad (on the map Fjæstad), W of Jevikplass. A little SW of the farm, on the SE side of the road to Greverud, a large kettle, 1.4 m diameter, on a rock surface sloping slightly to the W.

Also outside the map areas of Fig. 42 kettles are known. Some are mentioned below.

At the mouth of Hakloelva in Bjørnsjøen, Nordmarka, 3 small kettles.

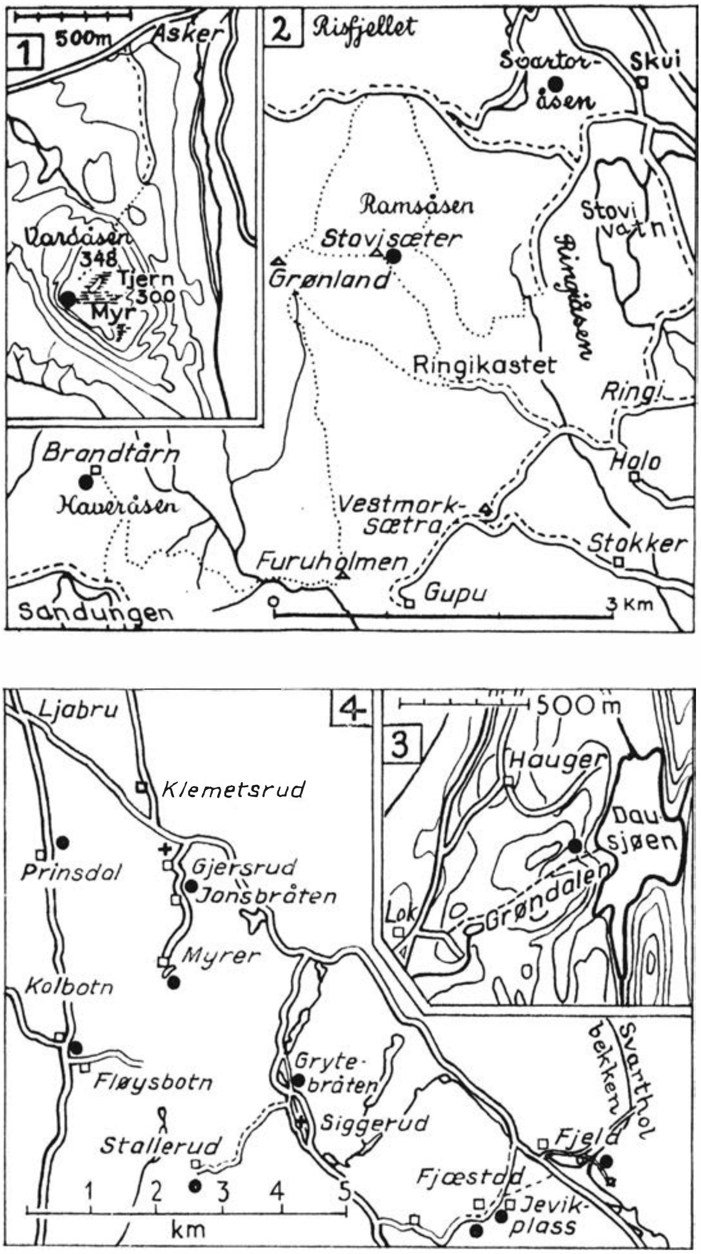

Fig. 42. Maps showing location of pot-holes.

About 200 m W of the northern end of the lake Kringla, Solemskogen, E of Maridalsvatn, a kettle with diameters 65 and 80 cm. Emptied down to 1.20 m without reaching the bottom.

The large and famous kettles at Kongshavn and Bekkelaget described by Brøgger and Reusch in 1874, the largest of them more than 10 m deep, have mostly been disturbed by the construction of the railway in 1879.

W of the northern part of the area of the coloured map: Retelsæter on the rhomb porphyry plateau, about 500 m a. s. l., SE of Sundvollen, Ringerike. Along the SW edge of the fields, to the right of the path from Retelsæter to Kleivstua, are two kettles, the largest one 70 cm in diameter, named "Sankt Olavs brønn" (The well of Sanct Olav).

The above information comes partly from my own observations, but mostly from the observations of the late Alfred Janson. The Dausjøen kettles in Maridalen have been described in a newspaper-article by Hans Andresen in 1950.

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N. G. U. = Norges Geologiske Undersøkelse (Geol. Survey of Norway).

The last 14 references listed below belong to the series "Studies on the Igneous Rock Complex of the Oslo Region", published by Det Norske Videnskaps-Akademi (Academy of Science and Letters) in Oslo. Further contributions may be expected. Reprints can be ordered through H. Aschehoug & Co. Schesteds gate 3, Oslo, or through bookstores.

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