

Ms. rec. January 9, 1945.

## **A RAPID SURVEY OF THE PRE-CAMBRIAN AREAS AROUND THE OSLO-FIORD (THE WATERS OSLO—SON)**

Preliminary Note.

BY

CHR. GLEDITSCH

With 1 Geological Map and 6 Figures.

During several years I have been mapping the pre-Cambrian areas around the Oslo-Fiord (the maps Oslo and Moss). Because of the unfortunate martial conditions in my country I have been late in working up the material collected, and, due to the same conditions, it probably still will last a couple of years before I shall be able to publish a complete geological map and petrographic description of the areas. However, some interest may be attached to the preliminary results, and since it is impossible to know when the conditions again will be such as to permit me to complete my work, a preliminary map is here offered for publication. Slight corrections and amendments may have to be introduced, however, after the completion of the petrographic analysis of the material.

I started my investigations in the Røyken area in November 1940, and up till now I have spent more time in this little area than in all the other areas taken together. It is probable, therefore, that the map more accurately presents the geology of Røyken than of the other parts. Since large areas are covered by soil it is impossible farther inland to work out the geology as accurately as along the coast.

The main part of the field work has been conducted under the auspices of Norges Geologiske Undersøkelse (Director Dr. Carl Bugge) who also has furnished me with several thin sections and with four rock analyses. Financial support has also been rendered by Nansenfondet and Det Videnskabelige Forskningsfond av 1919.

Professor Dr. Olaf Holtedahl, Director of the Geological-palaeontological Institute of the University, has shown a special interest in my work, and has given me much help and encouragement. Assistant,

Miss Ruth Smit, has given me valuable tuition and help during the drawing of the map.

Professor Dr. Tom. F. W. Barth, Director of the Mineralogical Institute of the University, has from the beginning of my investigations given to me the most welcome help, advice, and encouragement, and he has taken part in a couple of excursions to Røyken and Hurum. He has also furnished me with the best of the working facilities at the Mineralogical Institute. Without his expert help it hardly had been possible for me to carry through my investigations.

The translation of the manuscript into English has been done by Miss Tone Barth.

### Literature.

Other than the detailed work by O. A. Broch on the north-eastern tip of Nesodden practically no petrographic description of the rocks of the areas of my mapping exists.

1850. B. M. Keilhau: "Gæa Norvegica", Kristiania 1850. He has just touched on the pre-Cambrian around the Oslo-Fiord, and he mentions the contact between pre-Cambrian and younger rocks at Røyken and Hurum.
1886. W. C. Brøgger: "Über die Bildungsgeschichte des Kristianiafjordes", *Nyt Mag. f. Nat.*, vol. **30**. He has described some of the faults dissecting the pre-Cambrian. Furthermore he has written a series of papers on the younger rocks surrounding the pre-Cambrian areas.
1926. O. A. Broch: "Ein suprakrustaler Gneiskomplex auf der Halbinsel Nesodden bei Oslo", *Norsk Geol. Tidsskr.* bd. **9**. A careful and detailed description of the leptite micaschist complex on the NE tip of Nesodden (Flaskebekk—Flateby).
1939. O. A. Broch and Fridtjov Isachsen: "The Southern Fault-line Boundary of Nesodden Peninsula, Oslofjord", *Norsk Geogr. Tidsskr.* bd. **7**. This paper describes the breccia Halangspollen—Brevik, and a find of cyanite gneiss just south of the breccia.
1940. Fridtjov Isachsen: "Kvartsporfy i Åros, Røyken", *Norsk Geol. Tidsskr.* bd. **20**. A thorough description of a porphyre leptite which I on my map has designated Røyken leptite.
1943. Chr. Gleditsch: "Permiske forkastninger i Røykenfeltet", *Norsk Geol. Tidsskr.* bd. **23**. In this small paper I have described the breccias and the younger rocks in and around the Røyken area.
1945. — "Om leptitbegrepet", *Norsk Geol. Tidsskr.* bd. **24**. Paper read in Norsk Geologisk Forening.

### **Tectonics. Summary Statement.**

Almost everywhere in the Røyken area the rocks strike essentially north and south, and dip steeply ( $80\text{--}100^\circ$ ). All angular measurements are given in terms of  $400^\circ$  in the full circle. In this area folded rocks have not been encountered.

The pre-Cambrian rocks at Hurum also usually strike north and south. The dip varies more than in Røyken. Folds are very scarce on the mainland, but on the island of Mølen the rocks are strongly folded.

On the E side of the fiord the strike is highly irregular. Farthest to the north and southward along the western side of Halangspollen a northerly strike direction is usual, while large areas farther to the south exhibit a westerly strike. The dip is at most places subject to large variations. Folds are common.

The pre-Cambrian rocks are dissected by a series of breccias, at several places these exhibit an obvious relation to thrusts, but not always. The breccias have not been marked on the map, for I have not been able to survey them sufficiently at other places than Røyken; they have been mentioned in an earlier paper (1943). The breccia Halangspollen—Brevik has been described by Broch and Isachsen (1939).

Furthermore Brøgger (1886) has mentioned a series of breccias and faults. On his maps in the same paper he has indicated fault lines along the borders between the Drammen granite and the pre-Cambrian. In all probability further investigations will prove this to be erroneous.

### **Petrography.**

1. The Røyken leptites. Porphyre leptites with very fine-grained ground mass, down to an average grain size of 0.02 mm (rarely to 0.01 mm). Usually poor in mica. Insets of quartz, albite (antiperthite) which is usually dominating, and microcline (perthite) in subordinate amounts.

Røyken leptites occur in two separate areas at Røyken, as well as on S. Langåra. In the southern leptite area at Røyken the leptites in west and north shade into leptite gneisses (2), and further into coarse gneisses (12). In the northern area we meet with a similar transition in the north-east (around Slemmestad) where the leptites



Fig. 1. Schlieren of light, rather coarse granitic rock in Røyken leptite (1) (darker on Fig.). From the migmatite zone close to Tåje (SW of Slemmestad).

gradually shade into leptite gneisses and coarser rocks. But otherwise the transitional member, leptite gneiss, is missing in the northern area; the characteristical transitional member is here a typical migmatite made up of veins of coarser rocks in the leptites (Fig. 1) and of patches of leptites in the adjacent, coarser rocks (this is schematically shown on the map). This phenomenon is particularly well developed at Aukeåsen.

2. Porphyric leptite gneisses. These rocks are transitional between the Røyken leptites of the southern leptite area at Røyken, and the coarser rocks farther to the north and west. In addition to being coarser they distinguish themselves from the true leptites in carrying much mica-like minerals (muscovite, biotite, chlorite). The porphyric structure is usually less pronounced than in the leptites. The insets in these rocks are dominantly microcline, although both quartz and albite may be present.

3. Tofte leptites. Homogeneous leptites usually without definite porphyric structure with several inclusions and schlieren of amphibolite (Fig. 2). These leptites which build up the southern pre-Cambrian area at Hurum are somewhat coarser than the Røyken leptites. They usually carry some mica, mostly biotite, although chlorite



Fig. 2. Tofte leptite (light) with schlieren of amphibolite (dark) dissected by two crosscutting Permian diabase dikes (the hammer lies on the diabase). Peninsula E of Ersvik.

sometimes dominates. The feldspar is almost exclusively microcline (perthite). On Mølen the rocks are strongly folded.

4. Homogeneous leptytes, usually poor in mica. Furthermore they differ from the Tofte leptytes by but rarely carrying inclusions of amphibolite schlieren. The leptytes on Håøya are typical microcline leptytes; on this island they also are met with as schlieren in the augen gneisses. Homogeneous leptytes also occur at Røyken, particularly in the north-western area; they usually are albite leptytes.

5. Spro leptytes. These also are homogeneous leptytes without any porphyric structures. But I regard them as distinct from the other rocks because they are coarser than the aforementioned leptytes, often as coarse as to make the name leptyte discussable. They carry, generally, more mica-like minerals (biotite and chlorite) than the other leptyte types. The feldspar is dominantly microcline (perthite). They shade with gradual transitions into true granites (10).

6. Epidote leptyte with stripes of garnetiferous mica-schists. The leptytes east of North Sprodam differ from the Spro leptytes by carrying much epidote, and in places garnet. In addition

we find several stripes and schlieren of micaschists, frequently garnet-mica schists. The schists seem to carry more muscovite than biotite (and chlorite).

7. Homogeneous leptite gneisses. Non-porphyric, rather fine-grained gneisses, intermediate between Spro leptites and coarse gneisses. In places it is difficult to distinguish between these leptite gneisses and the veined leptite gneisses (9). But they are very unlike the porphyric leptite gneisses at Røyken in that they exhibit a much more pronounced gneissic structure (mica stripes).

8. The leptite-gneiss-micaschist complex. Such a complex has been described by O. A. Broch from the north-eastern coast of Nesodden (Flaskebekk—Flateby). Personally I have not investigated this area in detail. The leptites here seem to be of the same type as in other areas of fine-grained rocks on the Nesoddland; they seem to be rather similar to what I have called veined leptite gneisses (9). A similar leptite-micaschist complex with much pegmatite has been encountered in the hills south of Fjellstrand. Possibly further investigations will show that micaschist (or quartz micaschist) is the dominant rock in these parts.

9. Veined leptite gneisses. Heterogeneous gneisses with stripes of usually fine-grained, light rocks. Typical migmatites. In places some dark stripes, usually amphibolites, may be seen, in other places micaschist-layers occur. Pegmatite lenses, rich in mica, are frequent. The leptite stripes usually carry some mica, mostly biotite. The feldspar is in most places essentially microcline, but plagioclase leptites also occur. The plagioclase ranges from albitic to andesinic. It is impossible to draw a sharp boundary between these rocks and what I have designated homogeneous leptite gneisses (7) or the leptite-gneiss-micaschist complex south of Fjellstrand (8). They also exhibit gradual transitions into heterogeneous gneisses with stripes of usually coarse-grained rocks (19 and 20).

10. Fine-grained gneiss-granite. At several places we meet with a rather fine-grained, reddish gneiss-granite. In places it is massive. The mineral composition is variable, but usually it is a common biotite-microcline granite. Adjacent to the Spro leptites, and frequently as inclusions in them, we find homogeneous, grey granites, rather fine-grained (= "coarse Spro-leptite"). They are often poor in mica.



Fig. 3. Coarse augen granite (14) with inclusions of leptite; hills E of Tofte.

11. Quartz albitite. A very fine-grained, massive rock, practically without mica. It borders against the porphyre leptites at Båttstø. With gradual transitions it shades into mica-bearing rocks (2 and 12). The feldspar is essentially an albite (perthite), but odd grains of microcline do occur. Quartz can be seen, partly it forms crushed grains, partly it is syntectically intergrown with feldspar, forming kind of a micro-graphic granite.

12. Coarser gneiss-granites of Røyken. These gneisses are not similar to the gneisses at Nesodden and Hurum, for their gneissic structure is not well developed. In several places they are massive, as indicated on the map. They may be poor in mica, but usually they carry both muscovite and biotite (chlorite). Both albite (antiperthite) and microcline (perthite) occur among the feldspars, albite usually dominates. As compared with the common gneisses at Hurum and on the eastern side of the fiord they are very homogeneous. They are not veined. In Skrysetåsen they exhibit porphyroblasts of feldspar and may be called augen granite (14).

13. Plagioclase gneiss. Thoroughly described by O. A. Broch (1926).

14. Augen granite. The augen granite east of Tofte is a coarse, massive microcline-biotite granite with large augen of micro-

cline (perthite). In places it carries inclusions of Tofte leptite (Fig. 3). Another type of augen granite or porphyric granite is encountered at Skrysetåsen, Røyken, as mentioned under (12). This also is a microcline-biotite granite, but has a more fine-grained and heterogeneous structure.

15. Homogeneous, coarse gneiss. Where I on the map have indicated "variært året gneis, vesentlig grove, lyse drag", the streaks and schlieren in this gneiss consist of homogeneous gneiss of common granitic composition. Certain areas are covered by this homogeneous gneiss without inclusions of other gneiss types, only with narrow and rare bands of dark amphibolite breaking the monotony. At Nesodden Broch has called this rock "Torrvik granite". At Hurum a similar homogeneous gneiss occurs between the zone of augen gneisses and the more heterogeneous gneisses. A similar mode of occurrence is probably exhibited by the homogeneous, coarse gneiss on the east side of the fiord, but the large areas covered by soil prevent an adequate presentation of the geological features on the map. By imperceptible transitions this homogeneous, coarse gneiss shade into augen gneiss and heterogeneous, coarse gneisses (18, 19, and 20).

16. Cyanite gneiss and (17) Staurolite gneiss have been thoroughly described by Broch (1926).

18. Augen gneisses. Coarse gneisses with more or less pronounced augen structure are very common at Hurum and along the whole eastern side of the fiord. The mineral composition is granitic with porphyroblasts of microcline (perthite). The zone of augen gneisses at Hurum is very monotonous and extremely poor in dark bands or inclusions, excepting the area around Værpen—Storsand where we find some bands of amphibolite and, more rarely, streaks of fine-grained gneisses. The areas of augen gneisses on the east side of the fiord and on Håøy and Asponn are usually more heterogeneous and contain inclusions of various other rocks. At several places the augen gneisses carry abundant bands of amphibolite, for instance on Håøy and around Hvitsten. The augen gneisses usually exhibit no sharp boundary towards the other gneisses, and in those rocks that have been called heterogeneous gneisses (9, 19, and 20) large included areas of augen gneiss may occur.

19. Heterogeneous, veined gneisses with streaks of rather coarse, light rocks. In these areas we find a great variety



of rocks (Fig. 4), but the coarse, light gneisses dominate. In addition to abundant pegmatite lenses, these gneisses everywhere contain lenses and narrow bands of quartz. In several places fine-grained gneisses are mixed into the rock complex which exhibits transitions into the veined leptyte gneisses (9). Scattered bands of amphibolite also occur within this complex. An increase of the amphibolite occurrences marks the transition into the next rock type (20), (Fig. 5).



Fig. 4. Heterogeneous veined gneiss with rather coarse bands. The hammer lies on a band of augen gneiss. North of Solbergstrand between Drøbbakk and Hvitsten.

20. Heterogeneous, veined gneisses rather coarse-grained with dark bands (Figs. 5 and 6). The light bands are usually coarse, as in 19; but in places many bands are fine-grained, and the rock becomes transitional into 9. The dark bands are essentially amphibolitic (at Bunnefiord partly garnetiferous amphibolite, Fig. 6) either coarse or fine-grained. In places the dark bands are so numerous that the rock may be called a banded gneiss.

21. Epidote amphibolite and common amphibolites. In almost all rocks of the pre-Cambrian areas we find dark bands or lenses. Where broad and extensive bands have been encountered they have been marked on the map. In the Røyken area the dark rocks would seem to be mostly epidote amphibolites, in places also greenstones. The latter ones are usually devoid of hornblende and are composed of saussuritized plagioclase, epidote, and chlorite. At Hurum and on the east side of the fiord common amphibolites dominate. In certain places garnetiferous amphibolite is common. It carries conspicuous aggregates of porphyroblastic garnet crystals (Fig. 6).

22. Garnetiferous amphibolites. Described under 21.



Fig. 5. Heterogeneous veined gneiss with coarse bands containing fragmented inclusions of amphibolite. North of Solbergstrand between Drøbakk and Hvitsten.

23. Gabbro. There are two larger gabbro massives that I have seen. One is located at Sundby, Røyken, and is a rather fine-grained saussurite gabbro. The other, which still await further investigation, forms the greater part of Sonsåsen.

24. Micaschists. They occur scattered in various rocks on the eastern side of the fiord, usually associated with the leptite rocks. In a few places I have marked them on the map as individual rocks. Usually they carry both muscovite and biotite, and in several places typical chlorite schists occur. Garnet occurs in some of the mica-schists. Such a garnetiferous micaschist has been mentioned above (6). Otherwise the garnetiferous micaschists usually occur along the Bunnefjord. Quartz micaschist may also be present at various places, particularly in the leptite micaschist complex south of Fjellstrand (8).

25. Garnetiferous micaschist, mentioned under 24.

26. Younger sediments. This designation includes all sediments of Cambrian age or younger. They have been treated in a previous paper by me (1943).



Fig. 6. Band of garnetiferous amphibolite (22) in coarse veined gneiss (20). Road cut at the head of Bundefjord (Mosseveien).

27. Oslo-essexite and dikes of mænaitite. Oslo-essexites are met with at Hurum and on the islands south of Hurum. These occurrences have been described by Brøgger. The borders of the lesser of the two occurrences at Filtvet have been wrongly stated on the previous maps; this has now been corrected. Furthermore I have mapped the Oslo-essexite at Vestby, an occurrence which has been first mentioned by Olaf Holtedahl "Studies on the Igneous Rock Complex of the Oslo Region". Vid.-Akad. Skr. 1943, No. 2. Together with dikes of mænaitite there occur at Røyken other light, essexitic dikes. They have been mentioned in a previous paper by me (1943).

28. Rhomb porphyry. At Røyken I have observed a couple of dikes that have not been indicated on previous maps. In the other areas the rhomb porphyries have been drawn essentially after Brøgger's and Broch's maps. (See also my paper 1943.)

29. Drammen granite. As mentioned in my previous paper (1943) the older maps give the border between the Drammen granite and the pre-Cambrian more than one kilometer out of place at Åros, Røyken. Therefore I have mapped, and at several places especially at Hurum, rather drastically revised the border lines. It is worthy of notice that the border itself is not everywhere sharp. Especially where

the pre-Cambrian rocks strike perpendicular to the border line it seems to be a usual phenomenon that the granite metasomatically has "fused" or assimilated the leptites with the formation of a migmatic rock along the border.

Of other Permian rocks there are within the mapped area numerous diabase dikes (Fig. 2). They are not shown, however, on my map. Nor are the camptonite dikes shown around the bodies of Oslo-essexite.

Oslo, Dec. 1944.

=====



PREKAMBRIUM LANGS LEDEN OSLO - SON

