STRATIGRAPHY OF THE SPARAGMITE GROUP, INCLUDING «THE SANDSTONE DIVISIONS OF FINNMARK»

(Eocambrian of Brøgger, Sparagmitian of T. Vogt)[1].

By Olaf Holtedahl

This sedimentary complex which stratigraphically comes between the Jotnian (in Norway the Trysil sandstone, with intrusive diabase) and the fossiliferous Lower Cambrian (characterized by species of *Holmia* etc.) makes up large parts of both southern and northern Norway. It dominates especially in eastern districts, and can from eastern southern Norway be followed northeastwards into Sweden. Towards the northwest the rocks become increasingly metamorphic.

Southern Norway.

The term "sparagmite" was instituted by J. Esmark 1829 for slightly metamorphic feldspar-rich sandstones occurring in the Østerdalen district. The word is derived from the Greek "sparagma" (= fragment). T. Kjerulf took up for a more comprehensive study the sparagmite districts, where besides feldspathic sandstones there are quartzites, conglomerates, shales, and carbonate rocks. He introduced the term "Sparagmite formation" and made it clear that this sedimentary complex is older than the adjacent fossiliferous "Silurian" (Cambro-Silurian) strata. In 1900 W. C. Brøgger in print proposed the term "Eocambrian", thereby stressing the close stratigraphical

[1] As to the problems of nomenclature, they have more specially been dealt with by the author in a paper: "The Sparagmite formation" (Kjerulf) and "Eocambrian" (Brøgger) of the Scandinavian Peninsula, written as a contribution to the Cambrian Symposium of the Mexico Congress 1956.

The manuscript was sent in the spring of 1956, but has unfortunately not yet (December 1959) been printed. It is hoped that the paper will appear in print before the 1960 Congress where the Precambrian-Cambrian boundary problem will be discussed. A series of short papers dealing with this problem and read in Paris 1957 at a meeting arranged by Prof. P. Pruvost, have been printed in the publication "Les relations entre Précambrian et Cambrien. Problèmes des séries intermédiaires" (Colloques internationaux du Centre National de la Recherche Scientifique, LXXVI). Here are ontributions by B. Asklund and O. Holtedahl dealing with the Scandinavian Peninsula.

connection with the fossil-bearing Cambrian. The term "Sparagmitian" was first used by T. Vogt in 1924.

We shall here briefly consider the stratigraphy as it can be seen in the more southeastern districts. Even here the complicated tectonic structure with folding, horizontal displacement and faulting, makes the deciphering of the depositional history difficult. We meet with two very different types of stratigraphical development: in certain areas strata belonging to the upper part of the sequence rest directly on the pre-Sparagmitian basement, while in others there occur a thick mass of sediments conformably underlying the younger oner (Pl. 6).

The classic area for the complete succession, as we might call it, is the *district around the northern part of lake Mjøsa,* where the stratigraphy since the time of Kjerulf has been studied mainly by Münster (1901), Goldschmidt (1909), and Vogt (1924). In recent time many, as yet unpublished data have been brought together by S. Skjeseth. The oldest member (the base not seen) is the *Brøttum sparagmite,* a dark grey rock with intercalations of arenaceous shale. In the district east of the lake there is a thin zone of limestone and red shale, the *Brøttum limestone and shale,* on top of the sparagmite.

The next member of the sequence is the *Biri conglomerate* which, besides sparagmite zones, have often very compact layers of well rounded pebbles and boulders, the diameter often exceeding 1—2 dm. The rock types are mainly quartzite, granite, gneiss; less common are sandstone and fine-grained limestone of various types (in some pebbles oolitic). The last mentioned, non-metamorphic rocks no doubt are derived from older Sparagmitian strata which have been subject to denudation. In some northwestern localities the Biri conglomerate has a less well stratified, more unsorted character, and the question of a glacial origin has been raised by Oftedahl (1945).

With transitional strata of sparagmite alternating with limestone-layers the conglomerate is overlain by the *Biri limestone.* This formation is partly made up of a more or less compact, relatively light-coloured limestone containing arenaceous layers and beds of intraformational limestone-conglomerate (or breccia), partly of dark limestone and blackish shale. Oolitic varieties are known from the district and from the southern Gudbrandsdal area. In Gausdal, to the northwest, the Biri limestone contains boulders of limestone and also of granite, a striking feature which is matched in the no doubt corresponding Hede limestone of Härjedalen in Sweden (Stålhös 1956).

Fig. 33. Moelv conglomerate (tillite) in railway cutting just south of Moelv station. Light coloured rock in sharply angular boulders: limestone. (After O. Holtedahl 1934.)

With shaly beds at the base then comes the *Moelv sparagmite,* a coarse, often conglomeratic reddish rock with thick compact layers, upwards passing into a light grey sparagmite with a good deal of calcite in the groundmass. This sparagmite with no sharp boundary passes into the reddish brown *Moelv conglomerate,* a massive rock of unsorted character. The rock fragments are of very varying size; especially the smaller ones are often angular in shape. The majority are made up of granite, gneiss, and quartzite, but also fine-grained limestone occur in considerable quantity. Also the groundmass may be calcareous. The probably glacial character of this and similar south Norwegian rocks (which reminded strongly of the glacial conglomerates of Finnmark) was pointed out by the present writer in 1922, without, however, glacially striated boulders having been observed. From a stratigraphically no doubt corresponding unsorted conglomerate in northern Jämtland in Sweden glacial striae have more recently been reported (Kulling 1948). The rocks of this type are now in Scandinavian geology generally just called *tillites.*

Higher up comes the red and green *Ekre shale* and then again thick psammitic series: the *Vardal sparagmite* in the lower part, the

Ringsaker quartzite in the upper. In Norwegian literature the old term "the quartz sandstone" is commonly used for the whole psammitic formation, quartz rocks being the dominating ones. Of great interest is the find recently made by Skjeseth of typical *Scolithus* structures in the upper part of the quartzite. As will be known, such structures are characteristic of sandstone formations of Sweden and Scotland, generally referred to the Lower Cambrian, and they also occur in younger systems. As far as the writer knows they have not been reported from what has been regarded as undoubted Precambrian.

Separated from the quartzite by a thin quartz conglomerate there comes arenaceous shale etc. with typical Lower Cambrian fossils.

The sequence described above is found *eastwards* to the big Rendal fault, on the east side of which members of the upper Sparagmitian rest directly on crystalline rocks. A recent report on these eastern districts has been published by Holmsen and Oftedahl (1956). The petrographical character[1] of the sparagmites here has been studied by the latter, who found the quartz-feldspar relation to be about 70 % quartz and 30 % feldspar. The dominating feldspar is microcline or microperthite. The amount of plagioclase may, however, in some rocks be as much as 30—40 % of the total feldspar.

In a locality west of southern Rendal the massive tillite, according to P. Holmsen, passes upwards into a red shale with scattered boulders, and the overlying Ekre shale has there a very distinct "varve"-like lamination.

Also further to the northeast, in the eastern part of the district between Rendal and the other fault-line valley, Engerdal with the lake Engeren, we meet with a sequence very like that at Mjøsa. The Biri limestone is here represented by the *Elta* limestone which is in part dolomitic. Silicified oolites, and also stromatolitic structures, occur. Like further west there is no marked boundary between the tillite layer, which locally is very thick, about 100 m, and the red sparagmite below it. In one area there is a transitional zone with beds of rounded, waterworn boulders.

In sharp contrast to the "complete" sequence now dealt with we have the other one, where *the formations below the tillite are missing.*

[1] Detailed petrographic studies on *Swedish* Sparagmitian rocks have been carried out by various Swedish geologists, especially Kulling (1942) and Stålhös (1956 and 1958).

Fig. 34. Vertical tubes of *Scolithus* type from upper part of Ringsaker quartzite near Høsbjør, east of Mjøsa (found by S. Skjeseth). ⅔ nat. size.

Tillite (here we call it "basal tillite"), the Ekre shale, or the "quartz sandstone" lie directly on a fairly even crystalline basement. This is the case, on the east side of Rendal (already mentioned), on the east side of Engerdal, and in western districts: south of the thrust front at Mjøsa where according to Skjeseth quartz sandstone is the basal post-Archean sediment (cut through by a boring), and still further to the west, as seen at a locality east of the northern part of the Randsfjord, where a conglomerate of tillite type overlies the gneiss basement. It is a rather striking fact that also in the Archean windows to the north, in the northern Østerdal—Rendal region etc., tillite is often the basal Sparagmitian rock, overlain by thrust schistose sparagmites. Locally the tillite rests on an arkosic rock, which represents a weathering product of the granite below it.

Also the allochthonous metamorphic sparagmites of the northern areas contain carbonate rocks, in part represented by dolomites. Of particular interest is a (schistose) conglomerate with scattered dolomite boulders occurring in connection with dolomite rocks, e. g. in the Koppang district of Østerdalen (probably belonging to an equivalent of the Kvitvola nappe). We have here a parallel to features found in parts of eastern Finnmark.

Finnmark.

The non-metamorphic sedimentary rocks of this northern region (by T. Dahll at an early time believed to be of relatively young, post-Silurian age) attracted considerable interest among geologists when Reusch in 1891 reported from the Varangerfjord district the occurrence of conglomerates of undoubted glacial origin. Well preserved striae could be seen on boulders and also on the surface of a quartzitic sandstone underlying such a conglomerate.

Later investigations have been carried out mainly by O. Holtedahl and S. Føyn. Through the find of Middle Cambrian fossils in a sedimentary series conformably overlying the tillite-bearing one in the Tanafjord district Føyn could definitely prove that we are dealing with a complex which in age must correspond more or less to the sparagmite group of southern Norway. Very recently, in 1959, new fossiliferous horizons have been discovered in the same district, by H. Reading.

Also in Finnmark we have the interesting feature that while locally, viz. to the south, the upper part of the complex (the present writer's "tillite-bearing sandstone division") rests on the crystalline basement, it is elsewhere underlain by older sediments (the "dolomite-bearing sandstone division"). The two divisions are separated by a rather slight *unconformity,* which is due to a pre-tillite tilting, probably towards the NE, with subsequent erosion. The existence of a distinct, angular unconformity and furthermore the *quartz* sandstone dominance also in the pre-tillite psammitic rocks are points in which the Finnmark complex differs from the south-Norwegian one.

The stratigraphy of the *Tanafjord district* can be seen from the table Pl. 6. Just a few remarks shall be added. The younger member og the older division, dolomite with shale, has escaped erosion in pre-tillite time to the north only, where it occurs with a very moderate thickness below the unconformity. This dolomite must be regarded as an equivalent to the very thick and massive so-called Porsanger dolomite well exposed in more western districts, especially at the Porsangerfjord, from where beautifully developed stromatolite[1] and other probably biochemical structures of various types have been described (O. Holtedahl 1918)[1].

[1] On the base of these observations the present writer objected to the use of *generic* names like *Gymnosolen, Collenia,* and *Cryptozoon,* and proposed to use the general term "stromatolites", introduced by Kalkowsky in 1908 for structures in Lower Triassic limestone from Germany. Especially in more recent time this view has been supported by various writers (cp. O. H. Schindewolf: Über präkambrische Fossilien. Geotektonisches Symposium zu Ehren von Hans Stille. Stuttgart 1956, p. 466).

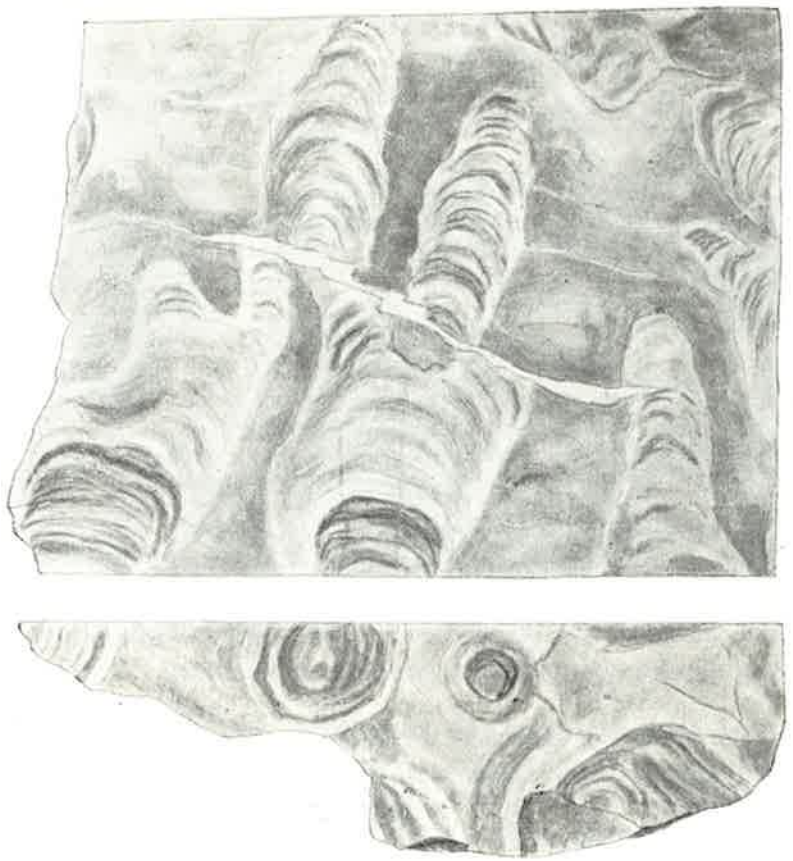

Fig. 35. Stromatolite structure (of type *Gymnosolen* Steinmann) in Porsanger dolomite. Hestnes, east side of Porsangerfjord. (After O. Holtedahl 1918.)

Two tillite horizons have been followed by Føyn over a very considerable area. The upper one has a more regular thickness than the lower one and the boulders are largely made up of Archean crystalline rocks, while dolomite normally dominates in the lower tillite. The colour of the tillites varies, from red-brown to grey or greenish. The

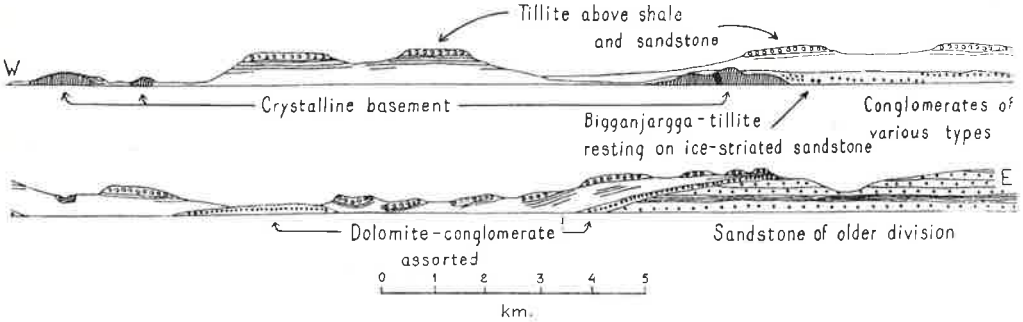

Fig. 36. Section from the district at the head of Varangerfjord and (lower figure) eastward along the north coast of the fjord. Height exaggerated and the unconformity between the older and younger sandstone division therefore too marked. Below the bedded dolomite conglomerate occur here also tillite-like rocks. Cp. Pl. 6. (After O. Holtedahl 1918.)

sandstone-shale series between the tillites (a suitable name would be the *Nyborg formation* after a locality at the Varangerfjord where the strata in question were studied at an early time) is distinctly more coarse-grained to the south, near the Archean boundary.

The sequence between the upper tillite and the formation where the Cambrian fossils have been found, is characterized by an alternation of largely bright coloured argillaceous, or silty sediments and quartzitic sandstones. A point of great interest is the occurrence of vertical tubes, of "pipe-rock" type, in the upper part of the *Digermul* quartzite. Reading (personal communication) points out that between the latter and the grey shale and sandstone where Føyn found Middle Cambrian fossils, there is a transitional series of sediments consisting of thin-bedded quartzite and shale. Here fragments of trilobites and brachiopods were found. The fossils have, preliminarily, been studied by G. Henningsmoen. They point to an age near the Lower-Middle Cambrian boundary. Anything more definite cannot as yet be said. In the lower part of the dark, largely black shale formation there are well preserved Middle Cambrian trilobites, inter alia *Paradoxides paradoxissimus*. Also in the upper part trilobites are found, according to Henningsmoen evidently of a somewhat younger age, Upper Cambrian or basal Ordovician. In the overlying thin-bedded dark sandstone formation, which also contains shale horizons, *Dictyonema flabelliforme* has been found, besides several species of trilobites. We have here basal Ordovician strata.

Fig. 37. The Bigganjargga tillite with glacial striæ on underlying quartzitic sandstone. (After O. Holtedahl 1918.)

The stratigraphical position of the Lower Cambrian Hyolithus series of more southwestern districts in the Tanafjord sequence is an unsolved problem. A fact of interest is that according to recent investigations by Føyn the thickness of the formations above the upper tillite decreases markedly southwestwards from the northern Tana district.

As can be seen at several places at the head of the *Varangerfjord* and further westwards the younger division near the southern border of the sedimentary area rests directly on the crystalline basements. It is an interesting fact that the surface of the basement, at the time of deposition, had a distinctly uneven, hilly character.

On the south side of a peninsula at the upper end of the Varangerfjord occurs in a series of light coloured quartzitic sandstone the famous Bigganjagga tillite, first described by Reusch and later on discussed by a number of writes, (Strahan, Dal, Holtedahl, Rosendahl, v. Gaertner). We are here dealing with a glacial deposit of local character, with a maximum thickness of 3—4 m. The boulders are mainly made up of quartzitic and granitic rocks, amongst others red coarse-grained granite of a type known from the basement in the

adjacent area. On the surface of the (conformably) underlying bed of sandstone ice-scouring with dominating direction NW—SE, can be seen very distinctly. Also the upper boundary of the old boulder-bed mass is here sharply marked. Contrary to the opinion of Rosendahl, the writer believes that also the sediments below the tillite belong to the younger sandstone division. Largely because the orientation of the (longer axis of the) tillite stones does not correspond with the main direction of the striation of the floor, v. Gaertner (1943) has suggested that we have before us an originally frozen mass of ground moraine transported by an ice-berg.

Somewhat higher in the sandstone succession comes a thin layer of tillitic character and furthermore a dolomite conglomerate with rounded pebbles.

Still higher occurs more or less well bedded conglomerate which fills depressions in the sandstone mass (Fig. 38). The writer has suggested that we have here glacifluvial deposits laid down in erosion-channels.

On the north coast of the Varangerfjord, about 20 km from the head of the fjord, conglomerates, with at the base tillite-like types and higher water-transported ones, rest with a slight angular unconformity on the grey and brown sandstones of the older division.

Far to the *southwest,* in a district east of the Kvænangenfjord, P. Holmsen (1956, 1957) found a conglomerate of tillite-type resting directly on the Precambrian floor, at the base of the Hyolithus series. The conglomerate thins out and disappears northeastwards. In one locality about 30 km west of Masi, the stratigraphy is as shown in Pl. 6. Still farther to the southwest beds of (in part red-coloured) arkosic sandstone occur between the tillite and the basement. We may possibly here have a thin equivalent to the Nyborg formation of eastern Finnmark. Of great interest is furthermore the observation that in an evidently allochthonous series of sediments (transported from the northwest) and coming above typical Hyolithus zone shale, there occurs tillite with mainly dolomite boulders. — Tillite, at the base of the Hyolithus zone, has previously been reported from northernmost Sweden.

In the *Alta district* a tillite layer with thickness about 10 m and containing ice-striated boulders (illustration in Holtedahl 1918) occur in the so-called Bossekop quartzite which unconformably overlies the Precambrian Raipas complex. The base of the tillite is sharply marked

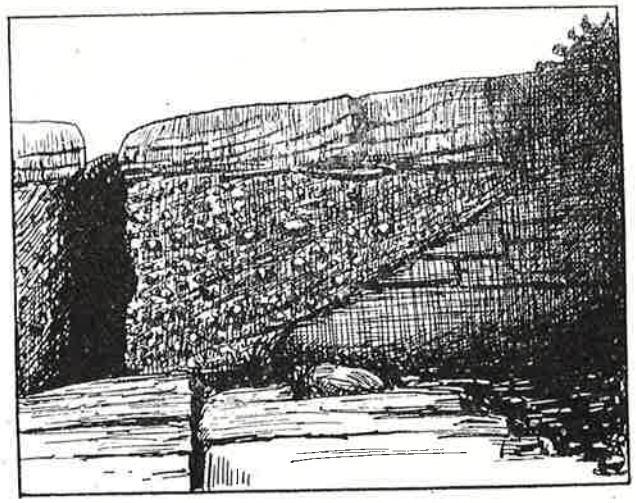

Fig. 38. Poorly sorted water-transported conglomerate filling erosion-channel in sandstone series above the Bigganjargga tillite. (After O. Holtedahl 1918.)

while upwards there is a transition, through shaly material with scattered boulders, to a series of largely red coloured shale and sandstone. Føyn suggests that we have here a thin equivalent of the (Eocambrian) formations overlying the upper tillite of the Tanafjord section. — Bossekop quartzite, with a tillite layer, has by the late Swedish geologist Zenzén been reported from the inner Kvænangenfjord district.

Finally it should be mentioned that a metamorphosed conglomerate of tillite type occurs at Duksfjord in Magerøy, near the North Cape (Holtedahl 1944).

Some general remarks.

The large masses of arkosic sediments in the *South Norwegian* sparagmite region tell of the existence of uplands where granitic rocks were subjected to long-lasting mechanical weathering under a more or less arid climate. The mother-rock of the Moelv sparagmite must have been very coarse-grained (the diameter of the feldspar grains may be as much as 4—5 mm). It is a point of interest that in the Trysil district and northwestwards coarse granites seem to be the dominating rocks of the crystalline basement. Running water transported the material, which generally shows a quite good sorting as to size, into

subsiding depressions. The fact that there are two main sparagmite series with a limestone-shale formation between them, indicates repeated crustal uplifts. The rather uniform character of the clastic rocks in W—E direction shows that there can be no direct genetic connection with the NNW—SSE-striking deformation of the Jotnian (Trysil sandstone) complex to the east, a deformation that marks the end of pre-Sparagmitian diastrophism in this part of the country.

In *eastern Finnmark* the non-metamorphic psammitic rocks of the older division have a more ordinary (quartz) sandstone character and represent deposits of a less continental character[1]. They are of much the same type as the sandstones of no doubt corresponding age, met with in the geosynclinal zones of Spitsbergen and eastern Greenland (see e. g. correlation table in Holtedahl 1938, a more recent one in Katz 1954). Here too we have a thick sandstone series underlying a dolomite formation which is the youngest (known) member of the pre-tillite sedimentary complex. Considering this very wide distribution of carbonate rocks, largely dolomites, in the various northern Caledonian districts, there can be no doubt that we are dealing with marine sediments.

The same must, at least to a large extent, be said of the tillite. As to the upper tillite of eastern Finnmark, it lies as a distinct layer between well bedded strata, and must be regarded as a deposit dropped from drifting ice-bergs. For the lower tillite, of the Tana district, a more direct glacial origin must be considered. In one locality there is at the base a breccia made up of fragments of the underlying shale of the older division. However, the way in which also the lower tillite generally passes upwards into bedded sediments tells of the existence of a water body at a corresponding time. Locally there is at the base a zone of bedded material. The assumption of an ice-mass similar to the Antarctic shelf-ice of the present day, in some places moving on the floor, in others floating and calving, would, as suggested by Føyn, give us the best explanation.

Turning now to the problem of the *direction of the ice-movement* in the E. Finnmark region we have first to consider the general geological structure of the Tana—Varanger district. A main point is the

[1] It should, however, be emphasized that the thrust metamorphic psammitic rocks of more northwestern districts of Finnmark are to a great extent rich in feldspar and, as a matter of fact, very like the schistose sparagmites of South Norway.

absence of the older division to the south, where the younger sediments rest on the basement. As far as it can be judged from the exposures seen and from the topography, it looks like the older mass of sediments ends more or less abruptly against the Archean rocks to the south. This might be most naturally explained by assuming that a dislocation along a W—E line has taken place in pre-tillite time with a subsequent slight tilting of the older division. In any case there must have been an important *crustal uplift to the south* before the time of the first glaciation. It is already from this viewpoint a reasonable conclusion that the ice-mass had its main distribution in southern districts with movement northwards. For the upper tillite Føyn reports for practically the whole region a dominance of crystalline rocks in the boulders, and, furthermore, the occurrence of especially big angular blocks (up to 1.5 m in length) to the south, — facts indicating a southern origin of the material. Also for the "interglacial" Nyborg formation a similar assumption can be made: the grain of the rocks increases toward the south, where also a good deal of feldspar appears in the sandstones. An interesting detail is the common occurrence of garnet, since further to the southwest in Finnmark there is a large complex of garnet granulites (see geol. map), which strikes southeastwards into Finland.

Now as to the lower tillite, dolomite of types known from the older division is the most common rock, except to the far south where crystalline material dominates. If we assume that after the southern uplift had taken place, a cover of old-division sediments, amongst others dolomite, existed there above the Archean basement, we would here have a possible source of the dolomite of the boulders, transported northwards by the ice. At the time of the second glaciation the sedimentary cover might to a large degree have been removed, and erosion could then mainly work in crystalline rocks.

Though certain suggestions thus can be made, the question of ice-movement is not yet quite settled. An important point to be taken into consideration is that far to the north dolomite was exposed when after a period of wide denudation the first glaciation started, so here too we have a possible source area for the dolomite material.

Concerning the Moelv type of tillite of *southern Norway* the layer-like character with conformable contacts both below and above, speaks against a normal ground moraine origin. For the "basal tillites", the

boulders of which often mainly consist of the rock types of the local underground, a more direct glacial deposition might be assumed; also in this case, however, the transition to bedded sediments upwards tells of a cover of water.

In the more eastern parts of the South Norwegian Sparagmite district the tillite often contains a considerable amount of porphyry rocks of types similar to those of the Trysil—Engerdal district to the east. Most probably there was here a transport to the west which would match a transport to the north in east Finnmark: in both cases from the more central Fennoscandian cratonic region into regions of subsidence.

Also for the South Norwegian area the writer has assumed that pre-tillite *faulting* has been more or less responsible for the striking difference in the stratigraphical development of areas now not very distant from each other. It should, however, be emphasized that such conclusions are to some extent hypothetical as long as we do not know to what extent the thick rock masses with the "complete" stratigraphical sequence have been horizontally displaced in Caledonian time.

An important problem is the correlation between the southern and northern regions dealt with above. Rosendahl (1945), and also to some extent other Norwegian geologists, have emphasized that the Moelv sparagmite might be regarded as an equivalent to the Nyborg formation of Finnmark. The Moelv tillite, and the basal tillites, would then correspond to the upper tillite of the north. In some western South Norwegian districts there seems to be a marked (erosional?) boundary between the Biri limestone and the Moelv sparagmite and in the Femund district red sparagmite, probably corresponding to the Moelv sparagmite, rest on crystalline basement (G. Holmsen 1935, 1937).

Based on some structural characteristics of the limestone boulders in the Moelv tillite the suggestion has recently been made (Spjeldnæs 1959) that the Biri limestone and the Moelv sparagmite are separated by a period of orogeny. However, the regular way in which the two formations generally occur together, points against any marked *folding* having taken place.

The near relation of the sedimentary series, especially of Finnmark, to those of Spitsbergen and E. Greenland has briefly been mentioned (concerning Scotland cp. Holtedahl 1952). Other deposits which naturally have been, in a general way, correlated with those of eastern

Finnmark are the sedimentary rocks occurring in the *Fisherman's* (Rybachi) *Peninsula,* on the north side of the Kola Peninsula and in the *Kildin Island* still farther east. Thanks to investigations by Russian geologists, especially in more recent time, the stratigraphy of the two areas is now fairly well known (Ljutkevich and Kharitonov 1958, stratigraphical tables by Agapiev, Voronko a. o.). The stratigraphy of Fisherman's Peninsula is given in concentrated form in Pl. 6.

As to the formations below the unconformity, there can be no doubt that they belong with the older division of Finnmark. The thick grey and brown sandstone series may be correlated with (in part somewhat feldspathic) sandstones occurring in the southeastern part of the Varanger Peninsula, while the multicoloured dolomite-bearing strata probably correspond to similar rocks known from the north coast of the said peninsula (cp. Holtedahl 1918). Very striking is the enormous amount of largely arkosic and conglomeratic rocks above the erosional unconformity. They most probably represent a parallel to the younger, tillite-bearing division of Finnmark. The statement of the occurrence of sometimes very big blocks is of course very important. The accumulation of such enormous masses of coarse clastic rocks at the northern border of the old crystalline block of the Baltic shield is a most interesting feature. — The uppermost part of the sequence may well correspond to the fossiliferous part of the Tana section.

In Kildin the rocks are mainly sandstones and arenaceous shale of varying colour. In the lower part (base not known) there are intercalations of carbonate rocks, both limestone and dolomite, with oolites and stromatolite structures ("Collenia"). We evidently have the lower Finnmark division represented. (Stromatolitic *limestone* occurs on the north coast of the Varanger Peninsula.)

The strata of the Fisherman's Peninsula and Kildin show no very marked folding, but a fairly regular, very moderate dip (10—25°) towards NE. The previous supposition of an important thrust towards SW in the first mentioned area, has been found not to be correct. On the other hand, there is a very marked fault in NW—SE direction, with downthrow on the ocean side, also an interesting point.

REFERENCES

(Stratigraphy of Sparagmite group.)

Asklund, B. and *Marklund* 1954.. Aktuella skandinaviska fjällproblem. G.F.F. 76, p. 103. (Here contributions by P. Holmsen, C. Oftedahl, and S. Skjeseth on the S. Norwegian sparagmite district.)

Bjørlykke, K. O. 1893. Gausdal N.G.U. 13.

Brøgger, W. C. 1900. Norges geologi. Norge i det 19. aarhundrede (Kristiania, Cammermeyer).

Dal, A. 1900. Geologiske iagttagelser omkring Varangerfjorden. N.G.U. 28. No. 5.

Føyn, S. 1937. The Eo-Cambrian series of the Tana district, Northern Norway. N.G.T. 17, p. 65.

Gaertner, H. R. v. 1943. Bemerkungen über den Tillit von Bigganjargga am Varangerfjord. Geol. Rundschau 34, p. 226.

Goldschmidt, V. M. 1909. Profilet Ringsaker—Brøttum ved Mjøsen. N.G.U. 49 (II).

Hadding, A. 1927. The pre-Quaternary sedimentary rocks of Sweden. II The Paleozoic and Mesozoic conglomerates of Sweden. Kgl. Fys. Sällsk. Handl. N.F. 38, No. 5 (see pp. 68—71).

Holmsen, G. 1935. Nordre Femund. N.G.U. 144.

— 1937. Søndre Femund. N.G.U. 148.

Holmsen, P. and *Oftedahl, C.* 1956. Ytre Rendal og Stor-Elvdal. N.G.U. 194.

Holmsen, P. 1956. Hyolithus-sonens basale lag i Vest-Finnmark. N.G.U. 195, p. 65.

— 1957. De eo-kambriske lag under hyolithus-sonen mellom Čarajavrre og Časkias, Vest-Finnmark, N.G.U. 200, p. 47.

Holtedahl, O. 1918. Bidrag til Finnmarkens geologi. N.G.U. 84.

— 1921. Engerdalen. N.G.U. 89.

— 1922. A tillite-like conglomerate in the "Eo-Cambrian" Sparagmite of Southern Norway. Am. J. of Sc. Ser. 5, 4, p. 165.

— 1922. Om Trysilsandstenen og sparagmit-avdelingen. N.G.T. 6, p. 17.

— 1930. Noen sammenlignende betraktninger fra et nord-norsk og et sydnorsk område. G.F.F. 52, p. 538.

— 1932. Additional observations on the rock formations of Finnmark. N.G.T. 11, p. 241.

— 1938. In Bailey and Holtedahl: Northwestern Europe. Caledonides. Regionale Geologie der Erde.

— 1944. On the Caledonides of Norway. Vid.Akad. Skr. (see pp. 23—24).

— 1952. The structural history of Norway and its relation to Great Britain. Quart. Journ. 108, p. 65.

Katz, H. R. 1954. Bemerkungen zur Lithologie und Stratigraphie der Tillitprofile im Gebiet des Kaiser Franz Josephs Fjord, Ostgrönland. Meddel. om Grønland, 72, No. 4.

Kulling, O. 1942. Grunddragen av fjällkedjerandens bergbygnad inom Västerbottens Län. S.G.U. Ser. C. 445.

— 1948. In G. Lundqvist: De svenska fjällens natur. See also S.G.U. Ser. C. 503.

Ljutkevich, E. M. and *Kharitonov, L. J.* 1958. Eocambrian deposits of the Fisherman's Peninsula, Middle Peninsula and the Kildin Island. In Geology of the U.S.S.R. 27. The Murmansk district. Edited by L. J. Kharitonov, Moscow 1958, pp. 361—370 (in Russian).

Münster, T. 1901. Kartbladet Lillehammer. N.G.U. 30.

Oftedahl, C. 1945. Om tillitene i det central-norske sparagmitområde. N.G.T. 25, p. 285.

— and G. Holmsen. 1952. Øvre Rendal. N.G.U. 177.

— 1956. See P. Holmsen and C. Oftedahl.

Reusch, H. 1891 a. Skuringsmærker og morænegrus eftervist i Finnmarken fra en periode meget ældre end "istiden". N.G.U. Aarbog 1891, p. 78.

— 1891 b. lagttagelser fra en reise i Finmarken. N.G.U. Det nordlige Norges geologi, p. 22.

Rosendahl, H. 1931. Bidrag til Varangernesets geologi. N.G.T. 12. p. 487.

— 1945. Præ Kambrium—Eokambrium i Finnmark. N.G.U. 25, p. 327.

Rothpletz, A. 1910. Meine Beobachtungen über den Sparagmit und Birikalk am Mjøsen in Norwegen. Sitz. Ber. Kgl. Bayr. Ak.d. Wiss. Mat.-Nat. Kl. 15.

Strahan, A. 1897. On glacial phenomena of Palæozoic age in the Varanger Fjord. Quart. Journ. 53, p. 137.

Skjeseth, S. 1954 Forholdet mellom Oslofeltets kambro-silur og sparagmit-formasjonen. See Asklund og Marklund p. 145.

Spjeldnæs. 1959. Traces of an Eocambrian orogeny in Southern Norway. N.G.T. 39, p. 83.

Stålhös, G. 1956. The sparagmite series and the Vemdal quartzite of the Hede region, Härjedalen. Bull. Geol. Inst. Uppsala 36, p. 297.

— Fjällrandens sparagmit- och kvartsitformationer. G.F.F. 80, p. 209.

Vogt, T. 1924. Forholdet mellom Sparagmitsystemet og det marine underkambrium ved Mjøsen. N.G.T. 7, p. 281.