Stratigraphical consequences of the discovery of Silurian fossils on Magerøy, the island of North Cape

By
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Contents

Abstract

Crinoid stems were discovered east of Nordvågen (east of Honningsvåg) on Magerøy in 1959. In 1960 an additional find of fossils proved a Silurian age for the limestone and conglomerate beds there. Two years later the author found crinoid stems in similar rocks at Sardnes (west of Honningsvåg). In this paper the author elucidates the present state of the age problem as regards the sedimentation of (later metamorphosed) rocks in the central area of Magerøy, especially the tillite-like conglomerate at Duksfjord. A Silurian age for this rock is, with the present state of knowledge, a more reasonable one than the Eocambrian which was formerly presumed. The alteration of the view of the age implies that the glacial origin is now to be controverted.

The existence of the fossils proves that the intrusions of gabbro on Magerøy are not older than Silurian age.

An unpublished report with a map prepared by Mr. J. J. C. Geul in 1958, has been the basis for the planning of the excursions and a guide in the field.

Introduction

By the middle of the last century the geology of Magerøy was fairly well known, taking into consideration the general knowledge of the geology of Norway. *Gæa Norvegica* contains a description and a map (Keilhau 1850, p. 255 and 270, and Pl. V. Fig. 1), compiled on the basis of investigations by L. v. Buch (1810), R. Everest (1829) and Keilhau himself. During the next hundred years, contributions to the geological literature on Magerøy seem to be confined to only two papers, based on short visits by Reusch (1924) and O. Holtedahl (1944).

Holtedahl in particular describes the occurrence of a tillite-like conglomerate at Duksfjord in the north-eastern part of the island. The conglomerate shows no stratification. It is metamorphosed, the fabric of the matrix being crystalloblastic, but almost no schistosity appears. The rock fragments are mostly angular, consisting in the main of fine-grained limestone or dolomitic limestone, but Holtedahl also reports the presence of quartzite among the fragments. The tillite-like conglomerate rests on a series of garnet-bearing mica schists, quartzites, bedded conglomerates and crystalline carbonate rocks (limestones and dolomites).

The thought naturally suggested itself that the tillite-like conglomerate might be a matamorphosed equivalent of one of the Eocambrian tillites of Finnmark. Consequently, the adjoining rocks also had to be looked upon as parts of the latest Precambrian and Eocambrian sedimentary suite of Finnmark. The term Eocambrian is, in this paper, applied in the "restricted" sense, viz. from the time starting with the deposition of the lower tillite in Finnmark. When I visited the locality in 1957, 1958 and 1959, I fully agreed with this view of Holtedahl.

In the south-eastern part of Magerøy the metamorphism is of a lower grade, the argillites being phyllites and not mica schists. On the geological map of Norway of 1953 (Holtedahl and Dons), these rocks were designated as probably Precambrian, based on a lithological similarity to a part of the Raipas suite in the Alta district.

The mapping in 1958 by J. J. C. Geul

In 1958 J. J. C. Geul, a Dutch post-graduate student who wished to work in the Caledonides for a time, was employed by Norges Geologiske Undersøkelse (Geological Survey of Norway) for the summer season. The director of the Survey gave him the task of investigating the interesting, differentiated gabbro complex near to Honningsvåg on Magerøy, and of mapping the surroundings, including the sedimentary rocks of the Duksfjord area and the

Fig. 1.
Geological map of south-eastern Magerøy by J. J. C. Geul.

North Cape plateau. Geul's report represents a very valuable contribution to the knowledge of the geology of the eastern part of Magerøy. An abstract of the report and a simplified map were published in the Guide to excursion no. A 3, International Geological Congress, Norden 1960 (Reitan 1960, pp. 55-57 and Fig. 12). The abstract mainly gives a review of the petrology of four types of gabbro and of the more important sedimentary rocks. The map, Fig. 1 in this paper, has been reproduced after that in the Guide-book. Note that hornfelses, with more or less sedimentary relics, are included in the "Gabbro complex". To the abstract in the Guide-book some important conclusions from Geul's report concerning the age problems are added here:

1. The sedimentary rocks of the south-eastern part of Magerøy differ only in the degree of metamorphism from those of the central part and the Duksfjord area. Accepting an Eocambrian age for the Duksfjord "tillite", he thus dismissed a Precambrian (Raipas) age for the south-eastern sedimentary rocks.
2. The intrusions of the gabbro effected a contact metamorphism of the adjacent rocks.
3. The gabbro shows no signs of intense shearing. Most probably the intrusions belong to a late phase of the Caledonian orogeny.

Further, Geul's map and report show that intraformational conglomerates and carbonate rocks occur east of Nordvågen and are common in the area between Duksfjord and Sardnes (which is a locality at the south-western corner of the map Fig. 1 - the name Sardnes is omitted).

When, in 1958, I accompanied Mr. Geul in the field for a couple of days, he especially called my attention to this similarity between conglomerates east of Nordvågen and at Sardnes, both containing pebbles mainly of limestone or dolomite, and having a carbonate-rich matrix.

The discovery of the fossils

In 1959, Holtedahl, Reitan and I visited Magerøy, in connection with the planning of the international excursion no. A 3 of 1960. Using Geul's map we went along the shore to the westernmost of the two conglomerate localities east of Nordvågen. In an impure limestone close to the conglomerate we discovered crinoid stems (see Guide to excursion no. A 3, 1960, p. 57, and Strand 1960, p. 165).

In 1960, G. Henningsmoen and F. Nicolaisen collected more crinoid stems from the limestone bed, and also from limestone pebbles in the conglomerate. In addition they found a few poorly preserved, straight monograptids in a shale slab. During the Congress excursion the same year one of the excursion

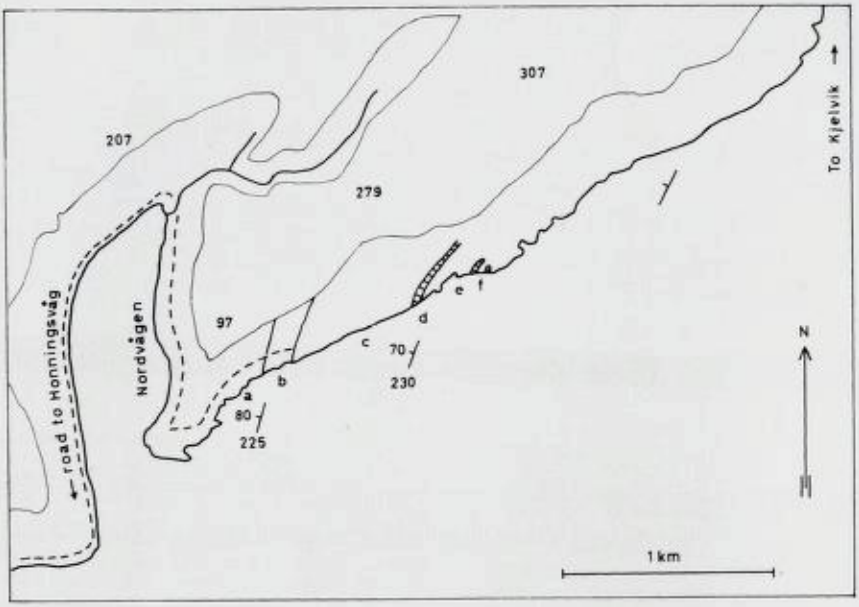

Fig. 2. Sketch map of the coast of Magerøy between Nordvågen and Kjelvik, drawn from air photos. 207, 97, 279, 307 are heights in metres above sea-level. The thin line indicates the edge of the plateau. The figures of strike and dip are based on the 400° scale. a: fine-grained, grey coloured arenaceous beds of 20 - 30 cm thickness and dark banded argillites. b: thin-splitting black rusty phyllite. c: dark grey slates. d: limestone and conglomerate with crinoid stems and sandstone. e: dark grey slates. f: limestone and limy sandstones with fossils. Further to the east: Mainly dark grey slates with intercalations of arenaceous beds.

Kartskisse over kysten av Magerøy mellom Nordvågen og Kjelvik, tegnet etter flyfotografi. 207, 97, 297, 307 angir høyde over havet i meter. Den tynne linjen antyder randen av platået. Strøk og fall er oppgitt i grader basert på kompass med 400° inndeling. a: finkornete, grå, 20 - 30 cm tykke sandsteinslag i veksling med mørke leirsteinsbergarter. b: tynnspaltende mørk fyllitt med rustbelegg. c: mørke grå skifre. d: kalkstein og konglomerat med enkrinitt-stilker (sjøliljestilker) og sandstein. e: mørke grå skifre. f: kalkstein og kalkholdig sandstein med fossiler. Videre østover: hovedsakelig mørke grå skifre med innleiringer av sandige lag.

members, Dr. John Rodgers, found at the eastern locality (se maps Fig. 1 and 2), chain corals, crinoid stems and pentamerids, without doubt of Silurian age (Henningsmoen, 1961). The discovery of this fauna implies that the other sedimentary rocks east of Nordvågen most probably also have to be ascribed to the Silurian period. Moreover, it makes it necessary to reconsider the age problem of the rocks in the central part of Magerøy, among them the Duksfjord tillite. As mentioned above, in Geul's opinion the rocks east of Nordvågen and those of the Duksfjord-Sardnes area are stratigraphically related.

Fig 3. The "first" fossil locality east of Nordvågen (d on the map Fig. 2).
Text see p. 214.

Den vestlige av de to fosillokalitetene øst for Nordvågen (d på fig. 2). Fra venstre mot høyre: Mørk grå leirsteinsbergart med tynne lag av lys sandstein, 2 m kalkstein, 3 m sandstein med konglomeratbånd, 10 - 15 m grovt konglomerat med linser av sandstein. Lagstillingen er invertert (overkippet), oppad i lagrekken er mot høyre.

In order to try to contribute to the solving of this problem, I visited Magerøy for a few days in 1962 and 1966. In addition to investigations at the two fossil localities east of Nordvågen (where more fossils were collected) and a reconnaissance trip along the shore to Kjelvik (about 3 kilometres further to the east), I went (by boat) to Sardnes and also traversed from Sardnes to the "North Cape-road".

The fossil localities east of Nordvågen

The main features of the geology along the shore east of Nordvågen appear in Fig. 2. All the beds have apparently about the same strike, N 25° E (based on 400° compass) near to Nordvågen, somewhat more easterly further to the east. The dip is towards the NW, about 80° (vertical = 100°) near to Nordvågen, decreasing a little eastwards along the coast. It is difficult to decide whether or not there is any repetition of beds in the section, although the presence of nearly isoclinal folding must be considered possible or perhaps very probable.

Fig. 4. Conglomerate at the "first" fossil locality east of Nordvågen (d on the map Fig. 2). The beds are inverted.

Konglomerat i den vestlige av de to fossillokalitetene øst for Nordvågen. Lagene er invertert.

The western (in this paper called the "first") fossil locality is situated about 1300 metres east of the populous area of Nordvågen. Details of this locality (d on the map) are seen on the photograhp Fig. 3. From the left (west) the sequence is:

1. Dark grey argillite with thin beds of light coloured sandstone.
2. 2 m limestone.
3. 3 m sandstone with conglomerate bands.
4. 10 - 15 m coarse conglomerate with lenses of sandstone.
5. (Outside the photo) 10 m sandstone.
6. (" " ") Dark grey argillite.

Apparently there is a slight unconformity between 1 and 2. Judging from the tectonic picture of the locality as a whole, I believe that this apparent unconformity is of tectonic, and not of stratigraphical, origin.

The limestone, sandstones and conglomerates are usually light grey in colour, with a yellowish coating. The conglomerate contains pebbles consisting mostly of limestone, but also of sandstone. Sedimentary structures indicate that the sequence youngs to the right (see Fig. 4). This view is supported by the

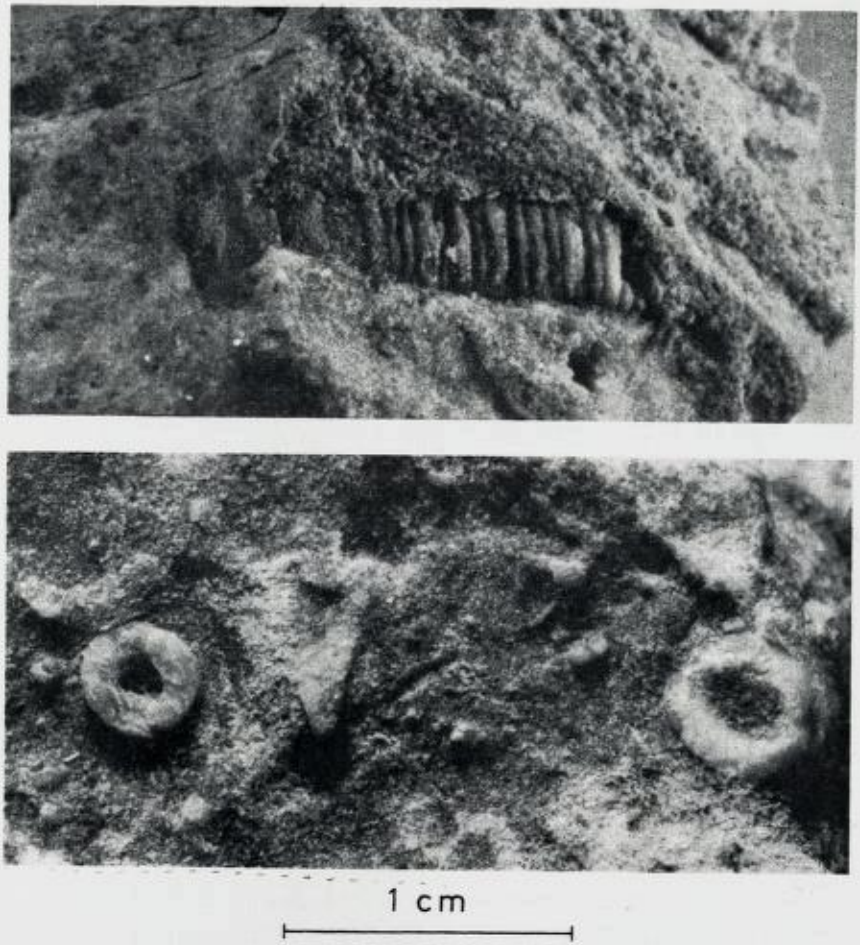

Fig. 5. Crinoid stems from the "second" fossil locality east of Nordvågen (f on the map Fig. 2). Pal. Mus., Oslo 74649 and 74651. Photo: I. Aamo.
Enkrinitt-stilker (sjøliljestilker) fra den østlige fossillokaliteten.

fact that crinoid stems are found not only in the limestone, but also in pebbles of the conglomerate. The beds are thus inverted here. The pebbles have, during the metamorphic processes, generally been somewhat elongated. The bedding planes show a lineation, which plunges 70° to the NNE.

The "second" fossil locality on the map is situated about 350 metres east of the "first". The dark argillites (with sandy beds) grade into a 4 metres thick, bluish-grey, somewhat sheared limestone which contains fragments of

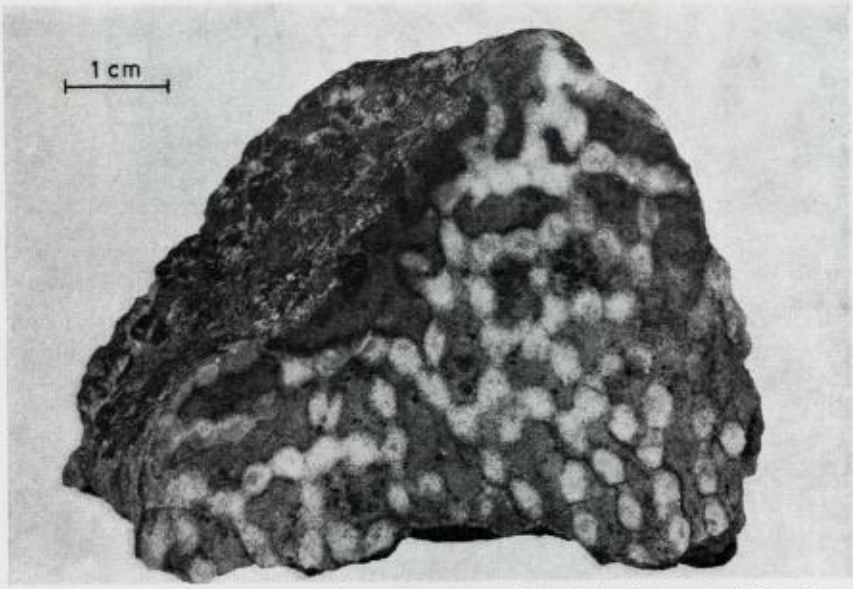

Fig. 6. Chain coral (Catenipora?) from the "second" fossil locality east of Nordvågen (f on the map Fig. 2). Pal. Mus., Oslo 74648. Photos: I. Aamo.

Kjedekorall fra den østlige fossillokaliteten.

crinoid stems and a rugose coral. Then comes (eastwards) a ridge of light yellowish sandstone, 6 metres thick. This rock is partly a limy sandstone or sandy limestone, in which most of the fossil specimens were found (crinoid stems, pentamerids and corals). About 10 metres further to the east, at the shore line, another "body" of fossiliferous limy sandstone or sandy limestone is seen. It is separated from the above-described band by dark argillites.

The fossil-bearing rocks seem to be entirely recrystallized. The fossil fragments consist of calcite grains, while the groundmass contains, in addition to calcite, quartz and a mineral which is probably dolomite.

Figs. 5 - 7 show examples of the collected fossiles.

The existence of a pentamerus species makes an Upper Llandoverian age for the sediment most likely.

The two fossil bearing bodies at the "second" locality are found only near to the shore line, no northward continuation on the mountain slope could be found. Signs of strong tectonic movements are present (joints, quartz lenses and quartz veins). In my opinion, the two bodies are probably parts of one bed. A connection may exist offshore, or the original bed may have been split during the deformation into rods or lenses with a steep orientation, corresponding to a supposed north-eastern plunge of the fold axes.

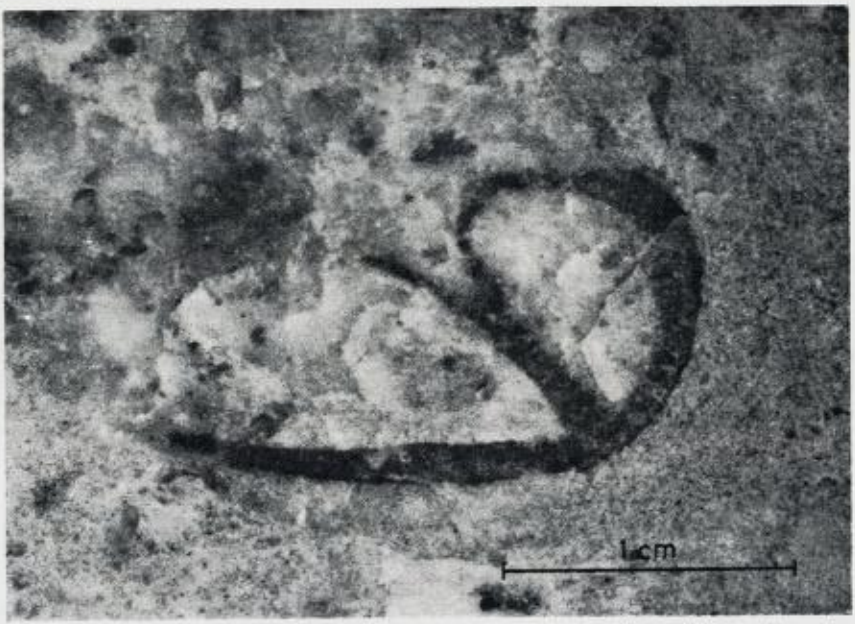

Fig. 7. Pentamerus (?) from the "second" fossil locality east of Nordvågen (f on the map Fig. 2). Pal. Mus., Oslo 74650. Photo: I. Aamo.
Pentamerus (?) fra den østlige fossillokaliteten.

The convergence of the beds of the two fossil localities as drawn by Geul (see map Fig. 1) and indicating an anticline, is not in accordance with my view. The absence of known continuity between the fossil-bearing deposits of the two localities, does not exclude the possibility that they belong to one horizon. Nor does the absence of conglomerate at the second locality, as we know from other parts of the island that beds of conglomerate may vary considerably in thickness, swelling into lenses and then diminishing and even disappearing.

The area between Sardnes and Duksfjord

As already mentioned, Geul in 1958 showed me occurrences of a conglomerate at Sardnes very similar to that at the "first" fossil-bearing locality east of Nordvågen. According to Geul's map, the Sardnes area is the southern part of a large synclinorium which extends towards the NNE to a fault situated south of Duksfjord. The synclinal form west of Duksfjord, of which the tillite-like conglomerate is an integral (upper) part, is apparently a parallel synclinorium. At the inner part of Duksfjord, anticlinal structures seem to dominate.

In the lower parts of the hillsides at Sardnes the rocks are of almost the same metamorphic grade as the rocks east of Nordvågen (e.g. phyllites). On the plateau, west of the line drawn by Geul on the map (Fig. 1), the rocks are of a higher metamorphic grade (garnet- and hornblende-bearing mica schists).

East of the outer part of the bay at Sardnes the beds have a moderate dip towards the NW. Lowermost there are grey sandstones with dark argilliaceous bands, then (westwards) black, rusty, fissile phyllites. These two members have a general appearance very like that of the members a and b of the section east of Nordvågen.

Lying above the phyllite horizon, north of the bay and above the scree, these beds are found: 4 m bluish limestone, 0,5 m light coloured sandstone and (uppermost) 15 to 20 m limestone conglomerate (yellowish on the surface). Because of the soil and vegetation on the conglomerate bed, it was not possible to observe its upper boundary.

The limestone appeared to contain small fragments of thin crinoid stems. The preservation of the fossils is poorer than at the localities east of Nordvågen. Because of the crystallinity and schistosity of the rock, they were seen only on weathered rock surfaces. At the foot of the hill several boulders of limestone yield remnants of crinoid stems - which I also found in a pebble in each of two conglomerate boulders.

Outcrops of the limestone band are seen westwards for a distance of about 3 kilometres to the west side of Sardnespollen (the innermost end of the fjord west of Sardnes, off the map), and at several localities I found fragments of crinoid stems. The limestone horizon continues further up the valley onto the plateau, the strike curving gradually through north-west to north. About 2 kilometres from Sardnespollen it thins out and disappears beneath the cover of moraine. From Sardnespollen, the limestone gradually becomes more coarse and granoblastic, and no traces of fossils were found. Also the adjacent argillaceous rock shows traits of an increased degree of metamorphism.

Over the last kilometre the dip of the limestone band is about 35° towards the east. The band thus forms an integral part of the western flank of the large synclinorium on Geul's map (but west of the westernmost bed drawn on the map Fig. 1).

Following the strike further towards the NNE, I observed outcrops of conglomerate in addition to those drawn on Geul's original map. Near to the "North Cape road" the westernmost conglomerates strike towards the west side of Duksfjord, thus suggesting that the Duksfjord syncline may be an integral part of the large synclinorium. Time did not allow me to continue my field

trip north of the road, and therefore the significance of the fault drawn by Geul with regard to the general geology between the road and Duksfjord is not known. At the present time it is, therefore, safer to regard the Duksfjord syncline as a fold parallel to the large synclinorium.

Garnet-bearing mica schists are the most common type of rock in the central part of Magerøy. Between Duksfjord and Sardnes, however, bluish or white-coloured, bare rock-faces of limestone constitute a conspicuous feature of the landscape. Several bands seem to be present, separated by mica schists; fossil remains are not to be expected, as the limestones mostly have a coarse granoblastic fabric, and in fact, all my searching in that respect was without success.

Bands of conglomerate are subordinate but not rare. They are bedded and contain rounded or subangular pebbles of sandstones, argillaceous rocks and carbonate rocks, and pebbles of quartz dioritic and granitic rocks have also been observed. Thus, their pebble content (and their appearance in general) to some extent differs from that of the conglomerates associated with the fossil-bearing limestones at Sardnes and east of Nordvågen, wherein the pebbles are mostly of carbonate rocks. (The conglomerate of Store Kamøy, where the metamorphism has been of a low grade, is polymict and thus unlike the latter. Fossiliferous rocks seem to be absent.)

Discussion of the age of the tillite-like conglomerate at Duksfjord

The situation is now as follows:

1. The crinoid-bearing limestone and conglomerate at Sardnes is of about the same age as the fossil-bearing limestones east of Nordvågen, i.e. of Silurian (Upper Llandoverian?) age.
2. The fossiliferous beds at Sardnes belong to the lower part of a succession of phyllites and mica schists with conglomerate horizons, limestones and quartzites, a succession which tectonically forms a large synclinorium.
3. At Duksfjord another smaller synclinal fold, parallel to the large synclinorium (perhaps an integral part of one broader synclinorium), is comprised of mica schists, limestones, quartzites and conglomerates. The tillite-like conglomerate is one of the uppermost (perhaps *the* uppermost) bed of this syncline.
4. Although the existence of recumbent folds must be taken into consideration, there is no evidence of an inversion on a grand scale of the upper part of the Duksfjord syncline and/or the large synclinorium.
5. Locally, thrusts certainly exist. The common features of the sequence as a whole, however, tell against the presence of any large-scale thrusting of an older (Eocambrian?) group of rocks upon a younger (Silurian).

Holtedahl and I have discussed the age problem on the basis of the above-mentioned points. We find that an Eocambrian age for the tillite-like conglomerate is now less probable than it was before the discovery of the Silurian fossils. The available evidence favours the view that the tillite-like conglomerate at Duksfjord is a younger member of the sequence than the fossil bearing horizon at Sardnes, and therefore should be ascribed to the Silurian.

Furthermore, as the presence of a tillite of Silurian age in Norway would be very astonishing, the revised view with regard to the age means that the supposed glacial origin of the conglomerate is now questioned. Most likely, the unsorted and unbedded character of the rock must be looked upon as due to other agencies, e.g. landslides. An interpretation of the rock as a tectonic breccia is hardly conceivable, for it appears as a layer with a sedimentary boundary with the underlying member of the sequence.

The suggested mode of formation of the conglomerate is, at present, only guesswork. A final solution to the problems of its origin, age and metamorphic history would be very welcome. Indeed, a detailed investigation of the stratigraphy, sedimentology and tectonics of the rocks of Magerøy would be an important contribution to the geology of Northern Norway.

Some remarks on relations with rock formations outside Magerøy

Magerøy is the only place in Finnmark where Silurian fossils have been found. Elsewhere the youngest fossils (Tremadocian) are present on the Digermul Peninsula west of Tanafjord, in the top formation of the groups of non-metamorphosed rocks of Finnmark (Reading 1965). In the Guide to excursion A 3 (1960) it was suggested that east of Nordvågen there might occur equivalents of the dark coloured Cambrian and Lower Ordovician sediments on the Digermul Peninsula. This is prehaps drawing too detailed conclusions, especially after the Silurian (and not Ordovician) age of the limestones east of Nordvågen was demonstrated, as it requires a break at the base of the Silurian limestone, with a hiatus corresponding to the greater part of the Ordovician period. Nevertheless, the discovery of the Silurian fossils is of importance in a regional respect, especially because Magerøy is situated in the metamorphic belt of the Caledonides. Earlier, the sedimentation of the (later metamorphosed) rocks of the nappes of eastern Finnmark was presumed to have taken place mainly in latest Precambrian and/or Eocambrian times. The existence of Silurian fossils on Magerøy favours the tendency to regard the larger part of the rocks in question as being of a somewhat younger, viz. Cambro-Silurian age (see Strand, 1960, p. 275).

Acknowledgements

The report of Mr. J. J. C. Geul has been of the greatest value to this work on Magerøy. His geological map formed the basis of the planning of the excursions and was my guide in the field. I thank him too for the interesting time we spent together on the island.

I am also highly indebted to Prof. dr. Olaf Holtedahl for the exchange of views during our visits to Magerøy in 1959 and 1960, as well as during the preparation of the present paper.

Finally, thanks to Dr. David Roberts, who has kindly corrected the English.

Sammendrag

Stratigrafiske konsekvenser av oppdagelsen av siluriske fossiler på Magerøy

I 1959 og 1960 ble det funnet fossiler fra silurtiden i to lokaliteter ved stranden øst for Honningsvåg, henholdsvis 1300 og 1650 m øst for bebyggelsen ved Nordvågen (se kartskissen fig. 2). Fossilene består av sjøliljestilker, kjedekoraller, hornkoraller, og brakiopoder av slekten pentamerus (se fig. 5 - 7). Bergarten som inneholder disse fossilene er en grå kalksandstein med gulaktig forvitringshud. Sjøliljestilker ble også funnet i et kalksteinskonglomerat (fig. 4) ved den vestligste (fig. 3) av de to lokalitetene. I skifer ble det funnet graptolitter. I den vestlige fossilforekomsten ble det funnet bare sjøliljestilker (og graptolitt i skifer i nærheten), de øvrige slags fossiler ble funnet i den østlige lokaliteten. Bergartene langs stranden er ellers mørke skifre i veksling med grå sandsteiner. Bergartene har vært utsatt for metamorfose, som bl. a. har ført til at kalksteinen er blitt krystallinsk.

Funnet er oppsiktvekkende da det ikke tidligere er kjent sikre siluriske fossiler nord for Trøndelag. For Magerøys vedkommende har funnet ført til at spørsmålet om alderen av også de andre bergartene på øya måtte tas opp til ny vurdering. Av spesiell interesse er et usortert konglomerat ved Duksfjord i den nordlige del av øya (se kartet fig. 1). Det ble tidligere ansett for å være tillitt (morenekonglomerat), avleiret under samme istid som tillittene i Alta og Øst-Finnmark, d.v.s. i eokambrisk tid (tidlig kambrium). Resultatet av de undersøkelser som nå foreligger, tyder på at det tillitt-liknende konglomeratet er et av de øverste ledd (kanskje det øverste) i en lagrekke av glimmerskifre, krystallinske kalksteiner og konglomerater, en lagrekke som danner et stort synklinorium (foldningstrau) mellom Duksfjord og Sardnes, og hvorav noen av de laveste lagene ses nord for Sardnes (i det sørvestlige hjørne av kartet fig. 1 - navnet står ikke på kartet). Disse lagene ved Sardnes minner om bergartene øst for Nordvågen. Forfatteren av denne artikkel fant i 1962 (dårlig

bevarte) sjøliljestilker i kalkstein og i konglomerat i flere lokaliteter nord for Sardnes. Det er dermed sannsynlig at også det tillitt-liknende konglomerat ved Duksfjord er av silurisk alder. Forekomst av tillitt fra silurisk tid i Norge ville være svært overraskende, det er derfor ikke lenger rimelig å anse konglomeratet for en istidsavleiring, det er mer naturlig å ty til andre forklaringer på dets usorterte karakter, f. eks. at det er dannet ved et slags undersjøisk ras.

Gabbroen i den sørøstlige del av øya kan ikke være eldre enn fra silurisk tid, idet dens fremtrengning førte til at de sedimentære bergartene omkring ble kontaktmetamorfosert (omdannet til hornfels. Merk at "Gabbro complex" på kartet fig. 1 også omfatter hornfelser, som til dels har tydelige sedimentære strukturer).

En upublisert rapport fra den hollandske geolog J. J. C. Geul, som i sommerhalvåret 1958 utførte geologisk kartlegging på Magerøy etter oppdrag fra Norges geologiske undersøkelse, var grunnlag for de undersøkelser som førte til funnet av fossilene og har vært et verdifullt hjelpemiddel ved det videre feltarbeid på Magerøy. Fig. 1 er et forenklet kart tegnet på grunnlag av det kart som hører til J. J. C. Geuls rapport.

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