

The Eocambrian stratigraphy of the Bjørånes window and the thrusting of the Kvitvola nappe.

By

KNUT BJØRLYKKE

(Institute of Geology, University of Oslo.)

Introduction.

The present paper presents the preliminary results of recent investigations of the Eocambrian sediments of the Bjørånes window in the Koppang area, southern Norway, undertaken by the writer. This mapping is a part of the investigations of the sparagmite area of Southern Norway carried out by the Geological Survey under the leadership of Professor S. Skjeseth (former state geologist).

The author has compiled a generalized map of the sparagmite area presented on fig. 1. For the preparation of this map the following workers of the sparagmite area have kindly submitted unpublished results: State geologist P. Holmsen, Cand. real. J. O. Englund, and the students D. Huseby, L. Kirkhusmo, B. Løberg, J. P. Nystuen, H. Chr. Seip.

Acknowledgements.

The author is indebted to Professor T. Strand and to Professor S. Skjeseth for critical discussions and for reading the manuscript. The field work has been financed by the Geological Survey of Norway. Cand. mag. O. Ihlen Sopp has kindly instructed the author in the process of making radiographs by use of industrial X-ray equipment. Miss I. Dillan has drawn the maps presented in this paper. Forskningsstipendiat B. Jensen has corrected the English manuscript.

The author wishes to thank them all.

The Eocambrian stratigraphy of the Bjørånes window.

The Bjørånes window is located in the Koppang area, Østerdalen, southern Norway, and is a window in the Caledonian nappes of metamorphic Eocambrian sparagmites (Kvitvola nappe).

The Koppang area has been surveyed by several of the earlier Scandinavian geologists, among whom Törnebohm (1896) and K. O. Bjørlykke (1905) have given the most detailed descriptions. Törnebohm's paper provided basic information on the nappe-tectonics in this part of the Caledonides.

The Koppang area has been mapped on scale 1 : 100 000 by Chr. Oftedahl as a part of the map area Ytre Rendal and Stor-Elvdal. (P. Holmsen and Chr. Oftedahl 1956). This map and the appurtenant description have been a great help to the present author in his work in this area.

The sediments of the Bjørånes area form a relatively flat-lying or gently dipping sequence of sandstones and shales, but are not undisturbed by tectonic movements. The sediments are slightly metamorphosed. Their autochthonous relationship to the rocks of the Kvitvola nappe above was pointed out by Chr. Oftedahl (1956 p. 59). The valley of the river Glomma makes a section through this sequence. The larger part of the sandstone sequence on both sides of the river (see fig. 2) has been correlated by Oftedahl with the Moelv sparagmite. Oftedahl made no special correlation of the underlying dark shale.

A new interpretation and description of the stratigraphy of this area will be given below:

Vemdal sandstone (quartz sandstone): Below the gabbros, augen-gneisses, and the metamorphic light sparagmite of the Kvitvola nappe, a less metamorphosed quartzitic sandstone is found in Rau-fjell east of Glomma.

This sandstone grades downwards into a coarse red arkose. This special lithology is very characteristic of the Vemdal sandstone in type sections in the southern part of the sparagmite basin (Vogt 1924). The upper quartzitic sandstone may be correlated with the Ringsaker quartzite and the lower with the Vardal sandstone. Particularly on the western side of Glomma, scattered pebbles, 5–10 cm in diameter, are found in the Vemdal sandstone. The thickness of the Vemdal formation is roughly 200 m.

Ekre shale: The Vemdal sandstone is underlain by a green shale with

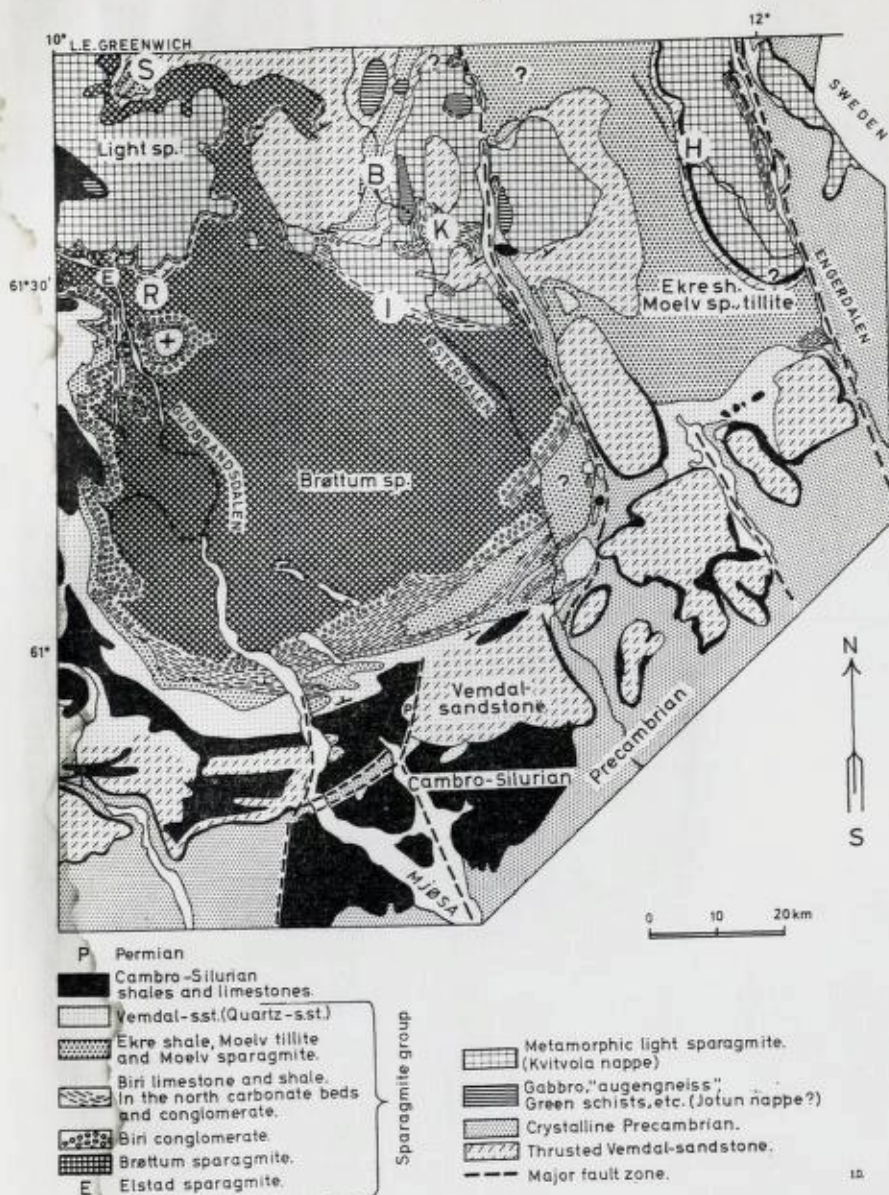


Fig. 1. Generalized map of the Sparagmite region, Southern Norway.

The following localities are indicated on the map:

B - Bjørånes K - Koppang I - Imsdalen
S - Snødøla H - Høgberget R - Ringebu

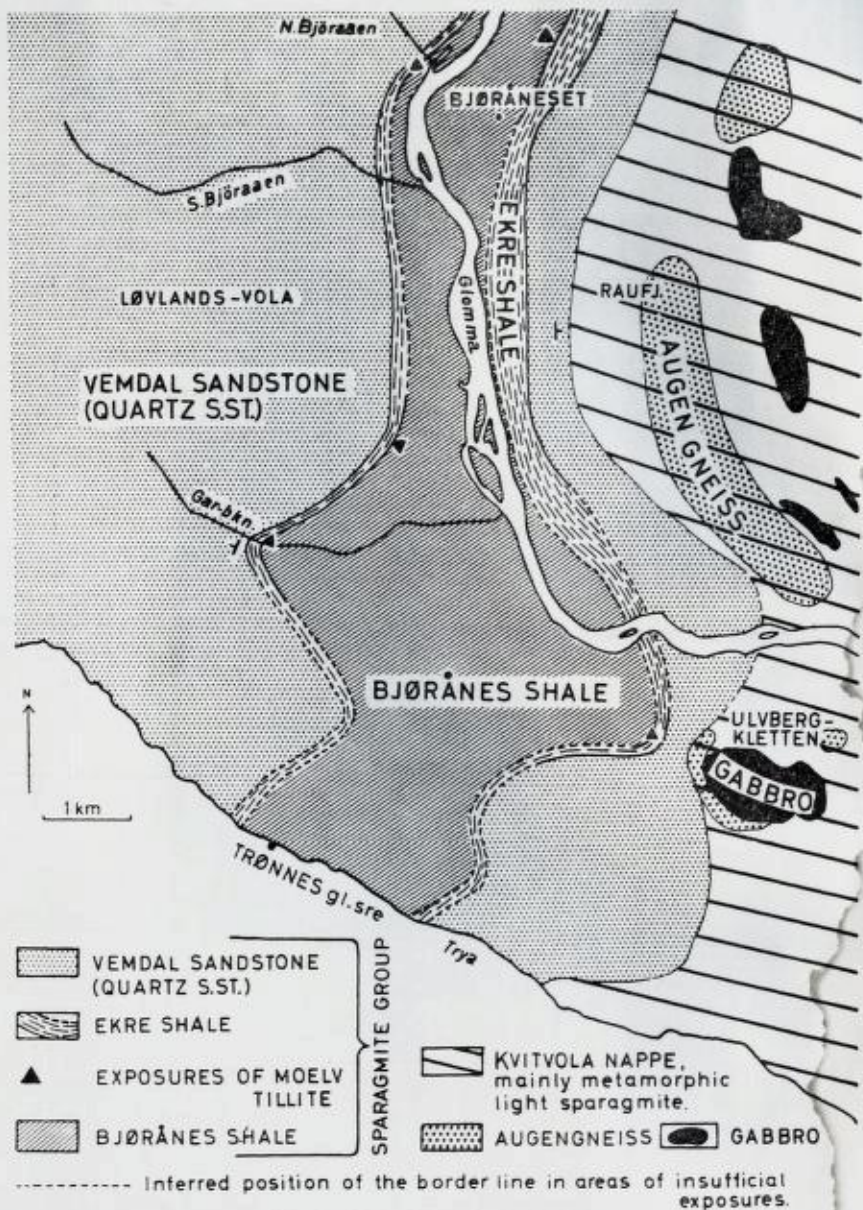


Fig. 2. Map of the Bjørånes window.

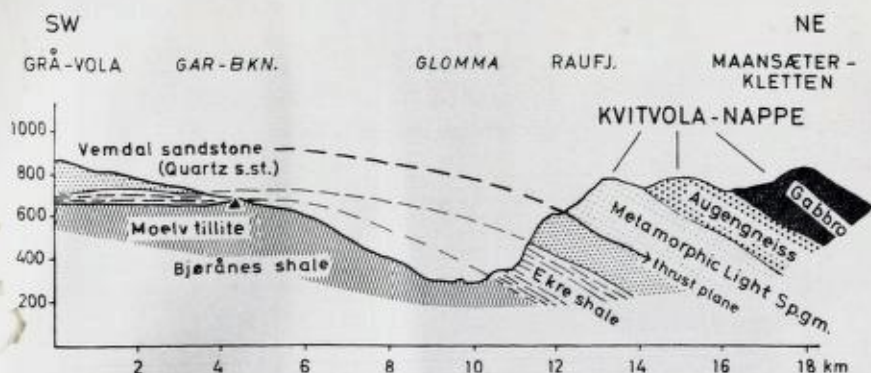


Fig. 3. Profile of the Bjørånes window.

silty or sandy beds. "Varved" layering is commonly found (fig. 4), which is regarded as a usual characteristic of the Ekre shale (Holtedahl 1953). This Ekre shale seems to be rather flat-lying with slaty cleavage dipping westwards. On the eastern side of Glomma the Ekre shale has a thickness of approximately 100–120 m, while the same shale on the western valley-side seems to be tectonically squeezed out to a thickness of 10–20 m. In Gar-bekken (see figs. 2 and 3) the tectonically disturbed contact towards the base of the Vemdal sandstone is exposed, indicating movements of the Vemdal sandstone relatively to its substratum.

Moelv tillite: Erratics of Moelv tillite have been reported by Chr. Oftedahl (1956 p. 60) in a small stream NW of Ulvbergkletten, and the present author found here bedrock exposures of this conglomerate below Vemdal sandstone and Ekre shale, resting upon dark shale. This conglomerate shows little sorting or grading of the clasts which is a characteristic of Moelv tillite. The Moelv tillite has since the paper of O. Holtedahl (1922) been interpreted by Scandinavian geologists as an ice-dropped sediment. New localities showing similar sections of a probably equivalent conglomerate, found by the present author, are indicated on the map (fig. 2). In these localities the clastic fragments are commonly smaller, rarely exceeding 6–8 cm, and many of the smallest have an angular shape.

The thickness of the Moelv tillite of the Bjørånes window is only about 2 m or less, and the clasts are less common and smaller than in the type areas of Moelv tillite in the Moelv and Rena districts where the thickness is about 20 m and the larger clasts exceed 1 m in diameter. If the conglomerates in both areas are ice-dropped sediments, the facies of the Moelv-Rena area characterizes the marginal parts of the basin, while

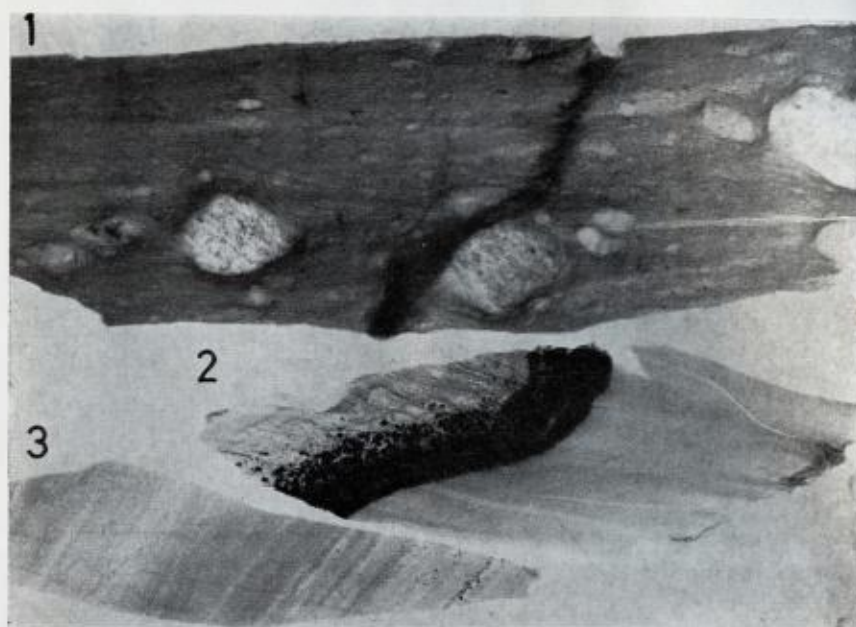


Fig. 4. Radiographs of sediments from the Bjørånes window.

3–4 mm thick rock slices are placed on an X-ray film and exposed by use of industrial X-ray equipment. (10 mA, 60 Kv, 2 min.) Procedure described by Hamblin (1962). Sample 1. Moelv tillite, 1 km north of Bjørånes st.

- * 2. Bjørånes shale with a band of pyrite (dark). Note fold with axial cleavage.
- * 3. Ekre shale. Road cut 4 km south of Bjørånes st. Note grading with layers of sand and silt.

Natural size.

the Bjørånes facies characterizes a more central part of the basin with lower frequency of floating icebergs. A similar pattern could be produced by turbidites, but no grading or other characteristics of turbidites are observed in either areas.

Bjørånes shale: Below the Moelv tillite a dark argillaceous shale is found, covering the larger part of the western valley-side, southwestwards to Trønnes gl. Sre. and to the north side of Skramsvola. Bands of pyrite and thin carbonate layers are interbedded in the shale. Silty or sandy beds are also observed. The shale has obviously suffered from tectonic movements, and has a slaty cleavage dipping westwards, while the bedding is probably nearly horizontal or dipping eastwards. The thickness of this formation must be at least 200 m, probably more than 300 m. The base is not exposed.

The upper part of the shale should be chrono-stratigraphically equivalent to the coarse arkose of the Moelv formation in the Mjøsa area.

As this shale represents a new and different facies of the pre-tillite sediments of the sparagmite group, the name Bjørånes shale will be introduced for this formation with Bjørånes as the type-locality.

Chr. Oftedahl (1956 p. 117) has analysed a sample of this dark Bjørånes shale from erratics (probably in situ) near Bjørånes station, which proved to be very rich in alumina (27 % Al_2O_3). He considers that the larger part of this alumina is present in muscovite.

The sediments described above represent a normal sequence of Eocambrian formations in a tectonic window in the more metamorphic and far-thrusted Kvitvola nappe. The lithology of the two uppermost formations, the Vemdal sandstone and the Ekre shale agrees relatively well with their development in the type-locality, in the Moelv District. The conglomerate is thinner and contains smaller clasts than the typical Moelv sparagmite, but has the characteristic unsorted glacial character of the Moelv tillite. The underlying shale has however a development so different from the established formations of the Mjøsa area that a new name must be introduced for it. Several profiles indicated on the map (see fig. 2) reveal that this shale is older than the Moelv tillite, but a closer correlation to the formations of the Mjøsa area is not possible at this stage. A more detailed mapping of the profiles of the Bjørånes area may however provide criteria for such correlations.

The thrusting of the Kvitvola nappe.

According to the present author's interpretation of the stratigraphy in the Koppang area, mainly based on profiles in the Bjørånes window, the Kvitvola nappe is here resting upon a normal Eocambrian sequence with the Vemdal sandstone at the top. At Andrå near Storsjøen Cambro-Ordovician shales are found with an imbricated structure together with Vemdal sandstone below the "augen-gneiss" of the Kvitvola nappe (P. Holmsen and Oftedahl 1956 p. 53). At Høgberget and further east in Engerdalen, Vemdal sandstone and Cambro-Silurian sediments are found below the thrust-plane of the Kvitvola nappe (Holtedahl 1921). The Vemdal sandstone west of the Bjørånes window continues westwards as Werenskiöld's "Lower light sparagmite", which in the Snødøla window rests upon shale and basal conglomerate above the Precambrian basement (Werenskiöld 1911). It seems then quite natural to interpret

the basal conglomerate of the Snødøla window as an equivalent to the Moelv tillite, overlain by the normal succession of Ekre shale and Vemdal sandstone. The Vemdal sandstone in the Snødøla window is overlain by metamorphic dark schist and light sparagmite of the typical Kvitvola facies, as observed in the Koppang and the Engerdalen areas.

Further southwest in the Ringebru area, however, the Kvitvola nappe rests on carbonate rocks which pass downwards into a probable equivalent of the Brøttum sparagmite. This correlation is in part based on similarity with the sequence south in the Fåvang District where the stratigraphy has been worked out by Englund (unpublished University thesis), but here the Kvitvola nappe is lacking, and a normal sequence of folded and slightly metamorphosed sediments of the Sparagmite group is found. Thus the Kvitvola nappe with its light sparagmite which is usually correlated with the Moelv formation, is here most probably in its normal stratigraphic position. The light sparagmite of the Kvitvola nappe is obviously more metamorphosed and tectonized than the underlying sediment, but no distinct thrust-plane seems to be present. The thrust movements must therefore have taken place as differential movements along several planes in the calcareous shale at the base of the nappe.

A similar section is met with in Imsdalen south of the Koppang area. A slightly metamorphic Brøttum sparagmite is overlain by shales and carbonate beds with the light sparagmite at the top. It is not possible to point out any thrust-plane and the metamorphism seems to be gradually increasing upwards towards the light sparagmite.

The Kvitvola nappe seems to be occurring in two different tectonic positions.

1. Kvitvola nappe resting on Vemdal sandstone (quartz sandstone) and Cambro-Ordovician sediments.
2. Kvitvola nappe with carbonate beds and conglomerate schists in the lower parts overlying the autochthonous Brøttum sparagmite.

In the case 1. the Kvitvola nappe is overthrust as a unit, while in case 2. the nappe seems to have been thrust differentially along several small thrust-planes below the light sparagmite, in the Biri limestone giving a gradually decreasing metamorphism downwards from the light sparagmite.

Fig. 1 illustrates that the areas of overthrust of the Kvitvola nappe are located southwest of the crystalline Precambrian windows. West of Snødøla the axes of the anticlinal ridges with the windows of Precambrian

rocks sink down in a depression in Gudbrandsdalen, where the Kvitvola nappe is not overthrust. Skjeseth (1963 p. 89) points out that the Kvitvola nappe has been thrust over the Precambrian geanticlinal ridge and into the southern Sparagmite area. It is therefore reasonable that the Kvitvola nappe in the lee-side of this ridge is resting upon the top of the sparagmite-group in this area. In Gudbrandsdalen this ridge is lacking, or present at a deeper level, and consequently no overthrusting took place.

P. Holmsen (1953) suggests that the gabbro and augengneiss belong to a separate nappe, the so-called Lower Jotun nappe, but these rocks are always associated with the sparagmites of the Kvitvola nappe, and most probably belong to the same tectonic unit.

Sammendrag.

Den foreliggende artikkel gir en beskrivelse av den eokambriske sedimentlagrekken ved Bjørånes i Koppang-området i Østerdalen. Vi finner her en lagrekke som skiller seg fra utviklingen i Mjøsa-området ved at vi under Moelv-tillitten finner en mørk skifer, slik at Moelv-sparagmitten i sin vanlige utvikling som grovklastisk sandsten ser ut til å mangle. Navnet Bjørånes-skifer blir her foreslått for denne skiferen med typeområde ved Bjørånes. Tidligere analyser (P. Holmsen, Chr. Oftedahl, 1956 p. 117) viser at denne skiferen er svært aluminium-rik (27 % Al_2O_3). Øverst i denne parautoktone, lavmetamorfe serien finner vi Vemdalsandsten (kvarts-sandsten), som dog ser ut til å være skjøvet noe i forhold til det underliggende langs Ekre-skiferen. Over Vemdalsandstenen finner vi *Kvitvola-dekket* med metamorf sparagmitt, øyegneis og gabbro. Av kartet (fig. 1) vil det gå frem at Kvitvola-dekket hviler på Vemdalsandsten eller på kambro-ordoviciske skifer i de nordlige deler av Østerdalen og i Engerdalen. I Gudbrandsdalen derimot hviler Kvitvola-dekket på sitt normale underlag, antagelig Biri-kalk og underliggende Brøttum-sparagmitt, og vi finner her intet markert skyveplan mot de underliggende, mindre metamorfe sedimenter. I områder som ligger S-Ø for rekken av grunnfjellsvinduene som strekker seg fra Snødøla og N-V over, er Kvitvola-dekket blitt presset opp og skjøvet over den parautoktone lagserien i sparagmittbassenget. I Gudbrandsdalen der grunnfjellsantiklinalen ser ut til å ha en depresjon, er det metamorfe Kvitvola-dekket skjøvet langs den underliggende karbonatskifer (Biri-skifer) uten noen skarp grense mot sitt mindre metamorfe underlag.

List of references.

- Bjørlykke, K. O.*, 1905. Det centrale Norges fjeldbygning. N.G.U. 39, 595 p., map.
- Englund, J. O.*, 1964. Sedimentologiske og tektoniske undersøkelser av bergartene i Fåvang-området. Unpublished thesis, University of Oslo. 174 p., map.
- Hamblin, Wm. K.* 1962. X-ray radiography in the study of structures in homogeneous sediments. *J. Sedimentary Petrology*, Vol. 32, No. 2, pp. 201-210.
- Holmsen, P.*, 1953. Et langt fremskjøvet "Jotundekke" i Rendalen. N.G.U. 184, pp. 95-97.
- Holmsen, P. and Oftedahl, Chr.*, 1956. Ytre Rendal og Stor-Elvdal. N.G.U. 194, 173 p., maps.
- Holtedahl, O.* 1921. Engerdalen. N.G.U. 89, 74 p., map.
- Holtedahl, O.*, 1922. A Tillite-like Conglomerate in the "Eo-Cambrian" Sparagmite of Southern Norway. *Am. Jour. Sci. Ser. 5*, vol. 4, pp. 165-173.
- Holtedahl, O.*, 1953. Norges Geologi. N.G.U. 164, Bd. 1. 583 p. maps.
- Skjeseth, S.*, 1963. Contributions to the geology of the Mjøsa districts and the classical sparagmite area in southern Norway. N.G.U. 220. 126 p., maps.
- Törnebohm, A. E.*, 1896. Grunddragen af det centrala Skandinaviens bergbyggnad. *Kgl. Svenska Vet. Akad. Förh.* 28 no. 5, 210 p., map.
- Vogt, T.* 1924. Forholdet mellom sparagmitsystemet og det marine under-kambrium ved Mjøsen. (English summary: The Relation between the Sparagmitian System and Marine Lower Cambrian at Lake Mjøsen.) N.G.U. 7, pp. 281-384.
- Werenskiöld, W.*, 1911. Søndre Fron. N.G.U. 60. 107, p., map.