# STUDIES ON THE LATEST PRECAMBRIAN AND EOCAMBRIAN ROCKS IN NORWAY

## No. 3.

# LATEST PRECAMBRIAN AND EOCAMBRIAN STRATIGRAPHY OF NORWAY

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## Introduction.

Research on latest Precambrian and Eocambrian rocks of Norway has been intensified in recent years, and the need for a revised lithostratigraphical division of these sediments has grown. Up to present many lithostratigraphical units have been given only informal names or names conflicting with the rules of lithostratigraphical nomenclature (Henningsmoen 1961, Størmer 1966 a, International Subcommission on Stratigraphy and Terminology 1961, American Commission on Stratigraphic Nomenclature 1961, Stratigraphical Code Subcommittee of the Geological Society of London 1967).

The present paper presents the results of discussions among many geologists concerned with latest Precambrian and Eocambrian stratigraphy in Norway, and members of the Norwegian Geological Society, Section for Stratigraphy.

The authors wish to thank all geologists who have contributed to the result. Particularly detailed comments have been received from Rektor S. Føyn on the stratigraphy of latest Precambrian and Eocambrian of N. Norway, and from Professor G. Henningsmoen and Professor N. Spjeldnæs on stratigraphical nomenclature.

Both in southern and northern Norway moderately deformed sediments of latest Precambrian and Eocambrian age are present in depressions in the crystalline Precambrian basement. These sediments which in both areas contain tillites, are overlain by fossiliferous Lower Cambrian (Holmia series), apparently without any major break. In S. Norway the latest Precambrian and Eocambrian sediments form a well defined lithological unit consisting of sandstones, shales and limestones,

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the overlying Cambro-Silurian rocks being more pelitic. In Finnmark a sandy and shaly facies prevails up to the Lower Ordovician (H. Reading 1965). The present paper is concerned with these moderately deformed sediments only.

## SOUTH NORWAY

Latest Precambrian and Eocambrian sediments in S. Norway have earlier been referred to as "sparagmites", a name introduced by Esmark (1829) to designate coarse feldspathic sandstones and conglomerates. Since "Sparagmite" is not an internationally recognized petrological term, the authors maintain that this term should be avoided in formal lithostratigraphical nomenclature. New names on formations have been introduced to replace names which conflict with the rules of lithostratigraphical nomenclature. According to the code of stratigraphic nomenclature for Norway (Henningsmoen 1961, p. 231), two formations cannot have the same name and it is advised that the name adheres to the earliest established formation. The name Biri Limestone was introduced by Kjerulf (1857) while the name Biri Conglomerate was subsequently introduced by K. O. Bjørlykke, 1905. Since Biri Limestone is the earliest established unit, the name Biri Conglomerate should consequently be avoided, and the name Biskopås Conglomerate is here suggested as the name for this formation. Similarly the Moelv Tillite (Vogt 1924, Moelv Conglomerate) and Moelv Sparagmite (Vogt 1924) are regarded as two formations, and the term Moelv Sparagmite is suggested altered to the Ring Formation. Ring is located north of Moelv and provides good sections through this formation. The uppermost sandstone formation below fossiliferous Lower Cambrian has previously been referred to as the Quartz Sandstone formation. The name Vemdal Formation was first used in Norway by Kulling and Strand (in press) followed by K. Bjørlykke (1965, 1966) and Englund (1966). It seems here natural to follow the rules of priority and retain the name Vangsås Formation which was introduced by Kjerulf (1857). This name refers to a locality in the district around lake Mjøsa close to type localities of other formations of the group, while Vemdal is referring to a locality in Sweden.

The sequence from the Elstad Sparagmite up to the top of the Vangsås Formation is given the name Hedmark Group after the county

(fylke) in which most of the type localities are located. The group is divided into two subgroups, the lower one given the name Lillehammer Subgroup. A good section through parts of the Lillehammer Subgroup is seen along the main road from Lillehammer to Moelv. The base of the Lillehammer Subgroup is not exposed. The upper subgroup, named the Rena Subgroup, is particularly well exposed in road sections between Rena and Åsta (K. Bjørlykke 1966). Spjeldnæs (1959) has claimed the existence of an unconformity between the Rena Subgroup and the Lillehammer Subgroup based on the evidence of crystalline limestone boulders in the Moelv Tillite which should have been metamorphosed prior to the deposition of the Moelv Tillite. This contention has, however, so far not been confirmed by mapping.

| Vogt (1924), Holtedahl (1960) and Skjeseth (1963). | This paper |
|---|---|
| Ringsaker Quartzite } Quartz<br>Vardal Sparagmite } Sandstone | Vangsås Formation { Ringsaker Quartzite<br>Vardal Sandstone |
| Ekre Shale | Ekre Shale |
| Moelv Conglomerate (= Moelv Tillite) | Moelv Tillite |
| Moelv Sparagmite | Ring Formation |
| Biri Shale and Limestone | Biri Shale |
| Biri Conglomerate | Biskopås Conglomerate and Limestone |
| Brøttum Shale and Limestone | |
| Brøttum Sparagmite | Brøttum Formation |
| Elstad Sparagmite | Elstad Formation |

*Fig. 1. Nomenclature on latest Precambrian and Eocambrian formations in S. Norway.*

## The Hedmark Group in the type area.

### *Lillehammer Subgroup.*

*Elstad Formation.* This formation was first described by Kjerulf (1857) as "Elstad Quartzite." Later K. O. Bjørlykke (1905) introduced the name "Elstad Sparagmite."

The formation occurs between Ringebu and Fåvang in Gudbrandsdalen where it is apparently underlying the Brøttum Formation. It is developed as a grey sandstone with a thin calcareous shale at the top, named Elstad Shale by Englund (1966).

Many authors have discussed the stratigraphical position of this formation, and it is still uncertain whether it is younger or older than the Brøttum Formation.

Literature: K. O. Bjørlykke (1905), Werenskiold (1911), Oftedahl (1949, 1954 a, 1954 b), Skjeseth (1963), Englund (1966).

*Brøttum Formation.* In earlier papers this rock unit was referred to as "Older dark sparagmite." The name "Brøttum Sparagmite" was introduced by Vogt (1924).

In Gudbrandsdalen it consist of an alternation between layers of sandstone and shale, while a sandstone with some few conglomerate layers dominates in Østerdalen.

Literature: Holtedahl (1953, 1960), Oftedahl (1954 a), Skjeseth (1963), K. Bjørlykke (1966), Englund (1966).

*Biskopås Conglomerate.* The name "Biri Conglomerate" was proposed by K. O. Bjørlykke (1905) for the coarse conglomerate overlying the "Older dark sparagmite."

Literature: Münster (1900), Goldschmidt (1909), Rothpletz (1910), Oftedahl (1945, 1956), Holtedahl (1953, 1960), Skjeseth (1963), K. Bjørlykke (1966), Englund (1966).

*Biri Shale and Limestone.* The name "Biri Limestone" was introduced by Kjerulf (1857). Because the formation is developed as black shales with limestone it was called "Biri Shale and Limestone" by Vogt (1924) and Skjeseth (1963).

On the eastern side of lake Mjøsa the formation can often be separated in two members (Kirkhusmo, unpubl.). The lower member, be-

low the Biskopås Conglomerate, corresponds to the "Brøttum Limestone and Shale" a name proposed by Vogt (1924). The upper member, the original "Biri Shale and Limestone," has a great areal distribution.

Literature: Münster (1900), Goldschmidt (1909), Rothpletz (1910), Holtedahl (1953, 1960), Skjeseth (1963), K. Bjørlykke (1966), Englund (1966).

*Rena Subgroup.*

*Ring Formation.* The name "Moelv Sparagmite" was proposed by Vogt (1924) for the "Younger red sparagmite."

The Ring Formation can generally be separated in two members. The lower member is fine-grained and corresponds to the "Moelv Shale" of Skjeseth (1963). The upper member consists of a coarse-grained sandstone often conglomeratic.

Literature: Münster (1900), Holtedahl (1921, 1953, 1960), Grender (1962), Skjeseth (1963), K. Bjørlykke (1966), Englund (1966).

*Moelv Tillite.* The name "Moelv Conglomerate" was proposed by Vogt (1924) for this formation. Holtedahl (1922) was the first to assume a glacial origin for this "tillite-like" conglomerate in the type area south of Moelv.

Literature: Holtedahl (1922), Holmsen (1954), Holmsen and Oftedahl (1956), Spjeldnæs (1964), K. Bjørlykke (1966).

*Ekre Shale.* At the base of the "Quartz Sandstone" formation described by Münster (1900), there occurs a green-red shale that was called Ekre Shale by Vogt (1924).

Literature: Vogt (1924), Holmsen and Oftedahl (1956), Skjeseth (1963).

*Vangsås Formation (Vemdal Sandstone).* This unit was first described by Kjerulf (1868) as "Vangsåsen-quartzsandstone." But the "Quartz Sandstone" formation as described by Münster (1900), was divided into the following members by Vogt (1924): Ekre Shale, Vardal Sparagmite, and Ringsaker Quartzite. Later the name "Quartz Sandstone" has been used for the upper two members. Skjeseth (1963) introduced the name "Mjøsa Quartz-sandstone."

The formation has a great areal distribution along the eastern mar-

gin of the Norwegian and Swedish Caledonides. The name Vemdal Sandstone (Törnebohm, 1873) is proposed by Kulling and Strand (1966, in press) for these deposits in Norway and Sweden. The name "Vangsås Sandstone" is here used in a more restricted sense for the formation in the type area in Southern Norway.

Literature: Schiøtz (1902), Vogt (1924), Holtedahl (1953, 1960), Holmsen and Oftedahl (1956), Grender (1962), Skjeseth (1963), K. Bjørlykke (1966), Englund (1966), Kulling and Strand (1966).

**Other lithostratigraphical names in Southern Norway.**

Arnestad Limestone. Schiøtz (1902). Corresponds to Biri Shale and Limestone (Tørnebohm, 1896 and K. O. Bjørlykke, 1905).

Biri Conglomerate. K. O. Bjørlykke (1905). Synonym for Biskopås Conglomerate.

Bjørånes Shale. K. Bjørlykke (1965). Dark shales below the Moelv Tillite in the Bjørånes window.
Literature: Oftedahl (1956), K. Bjørlykke (1965).

Brøttum Limestone and Shale. Vogt (1924). Corresponds to the lower member of the Biri Shale and Limestone.

Elstad Shale. Englund (1966). Upper member of the Elstad Formation.

Elstad Sparagmite. K. O. Bjørlykke (1905). Described as "Elstad Quartzite" by Kjerulf (1857). Lower member of the Elstad Formation.

Elta Limestone. Schiøtz (1902). Corresponds to Biri Shale and Limestone (Tørnebohm, 1896 and K. O. Bjørlykke, 1905).

Gausdal Quartzite Formation. K. O. Bjørlykke (1893). Corresponds to the upper part of the Hedmark Group (Rena Subgroup) and it possibly also includes younger beds.
Literature: K. O. Bjørlykke (1905), Oftedahl (1954 a).

Glomstad Limestone. Schiøtz (1902). Corresponds to Biri Shale and Limestone (Tørnebohm, 1896 and K. O. Bjørlykke, 1905).

Helgeberg Limestone. Vogt (1952). Corresponds to a part of the Biri Shale and Limestone.

Mjøsa Quartz-sandstone. Skjeseth (1963). Synonym for Vangsås Formation.

Moelv Conglomerate. Vogt (1924). Equivalent to Moelv Tillite.

Moelv Shale. Skjeseth (1963). Lower member of the Ring Formation.

Moelv Sparagmite. Vogt (1924). Synonym for Ring Formation.

Quartz Sandstone. Vide: Vangsås Formation.

Reistad Limestone. K. O. Bjørlykke (1893). Corresponds probably to the Biri Shale and Limestone (Skjeseth, 1963).
Literature: K. O. Bjørlykke (1905).

Ringsaker Quartzite. Vogt (1924). Upper member of the Vangsås Formation.

Synnfjell Sandstone. Proposed by Strand (1938), who correlates the formation with the Vangsås Formation.

Vardal Sparagmite. Vogt (1924). Corresponds to the lower member of the Vangsås Formation.

## NORTH NORWAY

The latest Precambrian and Eocambrian sediments in Finnmark have been referred to as "The Finnmark Sandstone Series" by O. Holtedahl (1918) and it seems natural to introduce the name Finnmark Group as a formal name for this unit. The Finnmark Group is naturally divided into a lower subgroup consisting of sediments below the tillites and an upper subgroup containing two tillite horizons. The lower subgroup has by O. Holtedahl (1918) been referred to as Porsanger Sandstone and Porsanger Dolomite. In the Porsanger area, however, the base of the sequence is disturbed by thrusting and the most complete section is found along the Tanafjord. Therefore, the name Tana Subgroup would be most suitable to designate the sequence below the lower tillite (Smalfjord Tillite) in the Tanafjord section. The base is not exposed according to Føyn's (1937) description of the section along the Tanafjord from Grasdalen to Stangenes. The lowermost part of the Tana Subgroup, exposed at the Varanger Peninsula, will have to await more detailed mapping before it can be subdivided into formations.

The Varanger Subgroup rests with angular unconformity on the Tana Subgroup (Føyn 1937). The name Varanger as a lithostratigraphical unit was introduced by Dahll (1868) for brownish shales and conglomerates from the inner part of the Varangerfjord. The Varanger Subgroup is here defined to include the Smalfjord Tillite at the base and the Stappogiedde Formation at the top (Fig. 2). The Vestertana Group as introduced by Reading (1965), comprises the Breivik Formation in addition to the formations included in The Varanger Subgroup. Many members of the Stratigraphic section of the Norwegian Geological Society (= The stratigraphic commission of Norway)

claimed that the Varanger Subgroup had priority to the Vestertana Group and that the Varanger Subgroup and the Finnmark Group should not include the Breivik Formation. Other members held the view that the Varanger Subgroup (or the Vestertana Group) should include the Breivik Formation and possibly also parts of the Digermulen Group (Cambr.–Ord.) since a shaly and a sandy facies prevails also in this part of the sequence.

| | HEDMARK GROUP | FINNMARK GROUP | |
|---|---|---|---|
| Rena Subgroup | Vangsås Formation<br>Ekre Shale<br>Moelv Tillite<br>Ring Formation | Stappogiedde Formation<br>Mortensnes Tillite<br>Nyborg Formation<br>Smalfjord Tillite | Varanger Subgroup |
| Lillehammer Subgroup | Biri Shale and Limestone<br>Biskopås Conglomerate<br>Brøttum Formation<br>Elstad Formation | Grasdal Dolomite<br>Vagge Formation<br>Algasvarre Formation<br>Stangenes Shale | Tana Subgroup |

*Fig. 2. Stratigraphy of the Hedmark Group and Finnmark Group.*

**Remarks on chronostratigraphical units and on the correlation between North and South Norway.**

Both the Finnmark Group of N. Norway and the Hedmark Group of S. Norway have here been divided into two subgroups. In Finnmark the base of the upper subgroup is placed at the base of the lower tillite (Smalfjord Tillite) above the dolomite formation (Porsanger Dolomite –Grasdal Dolomite). The Varanger Subgroup thus corresponds very closely to the chronostratigraphical units: *Varegium* (Asklund 1956), *Varangian* (Harland 1965) and *Eocambrian* as emended by (Holtedahl 1961). According to Holtedahl (1961) the Eocambrian should be regarded as lowermost Cambrian and the base of the tillites should serve as a lower boundary of the Eocambrian. The "Esmarkian" is by Rosendahl (1945) and Spjeldnæs (1965) used as a chronostratigrapic name for the youngest Precambrian below the tillites. The Esmarkian should according to these authors include the Tana Subgroup and the Lillehammer Subgroup but the lower boundary of the Esmarkian has not been sharply defined.

In S. Norway a significant change in lithology is found at the base of the Ring Formation which mainly consists of coarse sandstones and conglomerates resting on the Biri Shale and Limestone. The base of the Ring Formation therefore forms a natural boundary between the Rena Subgroup and the Lillehammer Subgroup. The Moelv Tillite most probably corresponds to the upper tillite (Mortensnes Tillite) of N. Norway, and the Ring Formation may therefore be contemporaneous with the Nyborg Formation of N. Norway. An equivalent of the Smalfjord Tillite (lower tillite) horizon appears to be absent in S. Norway. A close correlation of the base of the Varanger Subgroup with the base of the Rena Subgroup is therefore not possible at this stage.

The top of the Varanger Subgroup may, however, be correlated with that of the Rena Subgroup. To a large extent due to the work by Føyn (1967) a lithological correlation of the upper part of the Stappogiedde Formation with the Vangsås Formation now seems justified (see also K. Bjørlykke, 1967).

**List of formal lithostratigraphic units of the Finnmark Group, N. Norway.**

Algasvarre Formation is here introduced as a formal name for the sediments between the Stangenes Formation and the Vagge Formation as described by Føyn (1937) p. 71, Fig. 5 f—p from the Tananes section.

The formation consists mainly of quartzites and with subordinate shales (590 m).

Borras Group (Føyn 1964) rests unconformably on the Bossekop Group and is overthrust by a metamorphic nappe.

Type locality: Alta area.

Corresponds probably to the upper part of the Varanger Group (Føyn 1964).

Bossekop Group (Føyn 1964)—rests unconformably upon the Raipas Suite and is overlain by the Borras Group.

The Bossekop Group corresponds to the upper part of the Tana Subgroup (Føyn 1964).

Grasdal Dolomite is in this paper introduced as a formal name on the sediments overlying the Vagge Formation in the Tanafjord section at Grasdalen (Føyn 1937, p. 75).

The formation consists of dolomite and shales (50 m) and is overlain by the Smalfjord Tillite.

Karlbotn Quartzite (K. Bjørlykke, 1967) is a conglomeratic quartzite overlying the Kvalnes Conglomerate at Karlbotn.

Klubbfjell "series" (Rosendahl, H. 1931, p. 491) is a part of the Tana Subgroup exposed at Klubbfjell below the unconformity at the base of the Varanger Subgroup.

Kvalnes Conglomerate (K. Bjørlykke, 1967) rests unconformably upon the Tana Group.
Type locality: Kvalnes on the south side of the Varangerfjord.

Mortensnes Tillite (O. Holtedahl 1918) is the upper of the two tillite horizons in Finnmark and is often referred to as "the upper tillite."
Type locality: Mortensnes on the north side of the Varangerfjord (O. Holtedahl 1918, H. Reading 1965).

Nyborg Formation (O. Holtedahl 1960)—is a red and grey shale and sandstone found between the two tillite horizons.
Type locality: Nyborg on the north side of Varangerfjord east of Varangerbotten.
Literature: Rosendahl 1931, 1945, O. Holtedahl 1960, H. Reading 1965, H. Reading and Walker 1966.

Porsanger "avdelingen" (division) (O. Holtedahl, 1918) consists of massive sandstone (Porsanger Sandstone) and an upper dolomite (Porsanger Dolomite). Corresponds to the Tana Subgroup of the Tanafjord section.

Smalfjord Tillite—is in this paper introduced as a formal name for the lower of the two tillite horizons in Finnmark. The type locality at Smalfjord is described by Føyn (1937).
Literature: Holtedahl (1918), Føyn (1937), H. Reading (1965), H. Reading and Walker (1966).

Stangenes Shale (Føyn 1937, p. 70) makes up the lower part of the Tananes section and is underlain by conglomeratic beds and shales which is not yet included in any formally established Formation.

Stappogiedde Formation (H. Reading 1965)—is divided into three members: 1. Quartzitic sandstone (at the base) 2. Blue green and violet slate. 3. Red quartzitic sandstone with greywackes, sandstones and mudstones.
Type locality: Stappogiedde at the Digermulen peninsula.

Vagge Formation (Føyn 1937, p. 73) consists of an upper quartzite member (150 m) and a lower shale member (80 m).

Varanger Subgroup (Størmer 1966 b) consists of the Smalfjord Tillite, Nyborg Formation, Mortensnes Tillite and the Stappogiedde Formation.

The Varanger "System" was introduced by Dahll (1868) to designate brown conglomerates and shales at Mortensnes. Holtedahl (1918) used the name Varanger "Avdelingen" about parts of the Tana Group at Kongsfjord.

Vestertana Group (Reading 1965) includes the Breivik Formation in addition to the formations included in the Varanger Subgroup.

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