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GLACIAL STRIATIONS ON CLAST FROM THE MOELV TILLITE OF THE LATE PRECAMBRIAN OF SOUTHERN NORWAY

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ABSTRACT. Well-preserved glacial striations are described from a cobble in the late-Precambrian/Eocambrian Moelv Tillite in southern Norway. The stratigraphy of the late-Precambrian and Eocambrian rocks in southern Norway is discussed, and the evidence of glaciations in this sequence is summarized.

INTRODUCTION

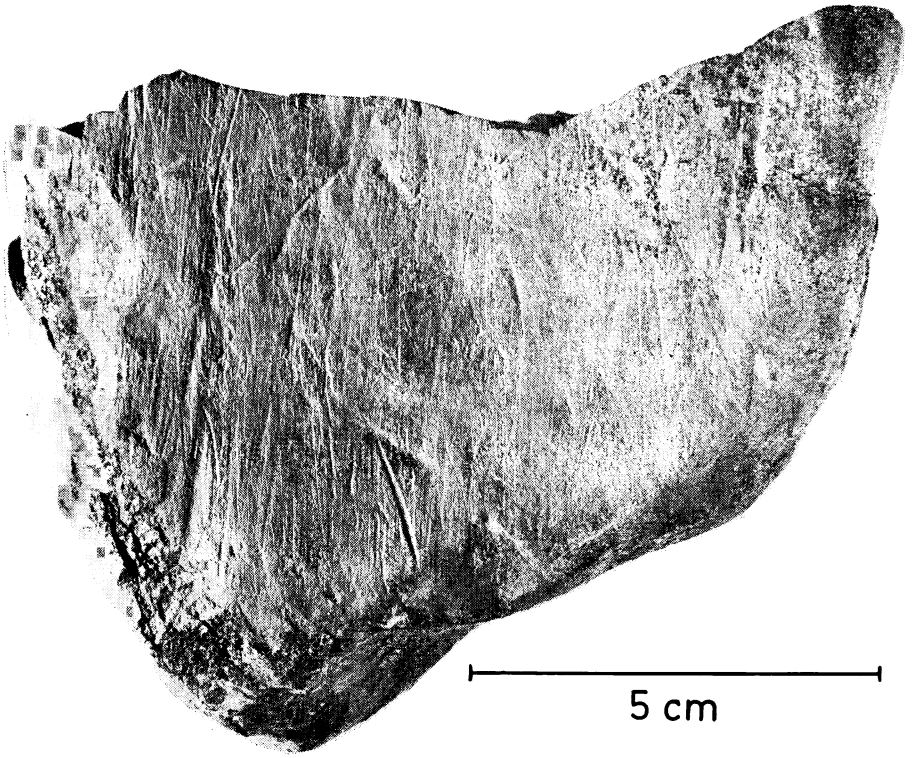
Since Holtedahl (1922) first suggested that the Moelv Tillite was a glacial conglomerate, considerable evidence has accumulated supporting his interpretation. The distribution of the Moelv Tillite and equivalent conglomerates in the Kvitvola nappe was discussed by Oftedahl (1945), and a review of the Eocambrian glaciation in Norway was published by Spjeldnaes (1964). Nelson (1963) challenged the interpretation of the Moelv Tillite as a glacial conglomerate because of its association with sandstones containing turbidite structures. In the author's opinion only the Brøttum Formation several hundred meters below the Moelv Tillite (Englund, 1966, 1972) contains structures characteristic of turbidites. Evidence supporting a glacial origin of the Moelv Tillite was summarized by Bjørlykke (1967). The most important points are:

1. The Moelv Tillite has a wide distribution as a stratigraphically well-defined single horizon in southern Norway and in corresponding beds in Sweden and northern Norway.
2. Neither graded layers nor slump structures have been observed in the Moelv Tillite.
3. The conglomerate is poorly sorted and usually unstratified.
4. Neither the pebbles nor the matrix show signs of weathering, and a large proportion of the clasts are very angular.

EVIDENCE OF GLACIAL STRIATIONS

Up to the present no pebble or boulder with unmistakable glacial striations has been described from the Moelv Tillite. However, in 1972 the author found in the tillite a cobble 10 cm in diameter, showing glacial striations (pl. 1-A). The cobble, of fine-grained sandstone, has one facet with very distinct striations running in slightly different directions (pl. 1-A). The fact that only one surface is striated suggests that the boulder was frozen into the ground and overrun by a glacier. The striations are visible also in the mould in the poorly sorted sandy matrix (pl. 1-B). There is no suggestion of any tectonic deformation or slickensides in the matrix around the cobble.

The fine-grained sandstone of which the cobble is composed is a rare rock type in the Moelv Tillite. It may originate from the Trysil (Dala) Sandstone to the east near the Norwegian-Swedish border. This rock type is ideally suited for the preservation of glacial striations.



A.

The majority of the larger clasts consist of granite, granitic gneisses, quartzites, and limestones. The coarse-grained gneisses and the hard quartzites do not readily take striations, and the carbonate pebbles are generally difficult to extract from the matrix. This explains why good examples of glacial striations are rare in the Moelv Tillite.

On the other hand, faceted pebbles similar to those typical of glacial pebbles are common.

The glacial striations described are very well preserved and of a type that could hardly be produced by other than glacial processes. This find adds an important piece of evidence to what has already been established in support of a glacial origin of this conglomerate. In Finnmark (northern Norway) there is abundant evidence of glacially striated pebbles and well-preserved striations at the base of ancient moraines (Biggenjargga Moraine) (Reusch, 1891; Bjørlykke, 1967).

STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENT OF THE MOELV TILLITE AND ASSOCIATED SEDIMENTS

The Moelv Tillite occurs in southern Norway, in restricted basins with late Precambrian sediments (sparagmites). The base of this sequence (table 1) 2500 m thick is not exposed nor is it reached by drill holes 500

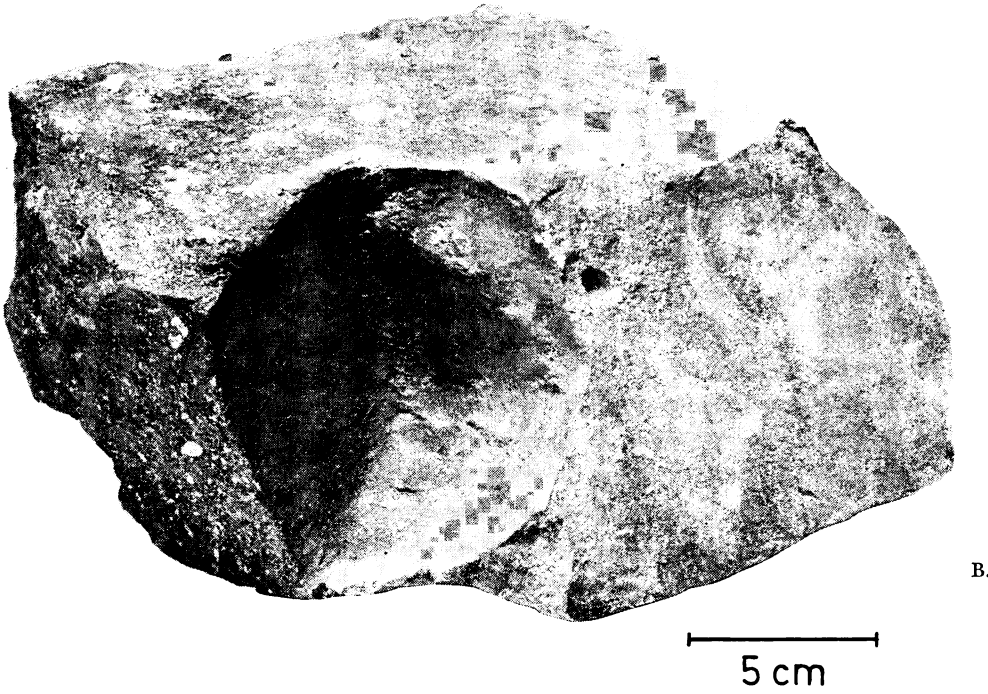


PLATE 1

A. Glacial striations on sandstone cobble in the Moelv Tillite. Only one faceted surface is present on the cobble. Locality: Road section near Neveråsen, about 16 km north of Rena st. and 150 km north of Oslo.

B. Mould of the same cobble (A) in the sandy matrix of the Moelv Tillite.

to 600 m deep in the central part of the basin (Englund, 1966, 1972). The Brøttum Formation, with an estimated thickness of at least 1500 m, makes up the lower part of the sequence. In the upper part of the formation and particularly in the eastern part of the basin, coarse arkoses occur interbedded with conglomerates indicative of shallower water. The overlying Biskopåsen Conglomerate is coarse grained, with pebbles, cobbles, and boulders very similar to Quaternary glaciofluvial conglomerates. This conglomerate forms distinct deltas that thin out into sandstones at the top of the Brøttum Formation. A glaciofluvial origin of this conglomerate seems probable, but the evidence is not conclusive.

The overlying Biri Limestone represents a transgressive marginal facies of limestone around the margins of the basins (fig. 1). The Biri Limestone contains oölites, stromatolites, intraformational breccia, and other indications of shallow, probably tidal environment.

The overlying Ring Formation is an arkose 200 to 300 m thick, deposited as local deltas near the margins of the basin. The coarse conglomeratic arkose passes through finer-grained standstone into a shaly facies in the central parts of the basin (fig. 1). No erosional uncon-

TABLE 1

Late Precambrian and Eocambrian stratigraphy of the "Sparagmite Region", southern Norway (from Bjørlykke, Englund, and Kirkhusmo, 1967)

Holmia Series (Lower Cambrian)	50 m
Vangsås Formation (Quartz sandstone Formation)	200 m
Ekre Shale	40 m
Moelv Tillite	20-1 m
Ring Formation (Moelv Sparagmite)	300-0 m
Biri Shale and Limestone	150 m
Biskopåsen Conglomerate (Biri Conglomerate)	100-0 m
Brøttum Formation	1500 m

formity has been observed between the Ring Formation and the Moelv Tillite, and there is usually a gradual transition from the arkose of the Ring Formation into the tillite. Where investigated (Bjørlykke, 1967) there seems not to be a well developed preferred orientation (till fabric) of the clasts.

The absence of a well-defined till fabric and the usually gradational transition from the Ring Formation to the Moelv Tillite together suggest that these sediments were deposited from floating shelf ice or icebergs. It can not be excluded, however, that the Moelv Tillite locally may have been deposited as true moraines as is the case in northern Norway (Reading and Walker, 1966; Bjørlykke, 1967; Banks and others, 1971).

The Moelv Tillite is overlain by a green or red shale (Ekre Shale), which may show varve-like graded laminae similar to Pleistocene varves (Holtedahl, 1953). Similar relations have been observed, likewise, in the probably equivalent Lånmarkberg Group in Sweden (Kulling, 1955), where pebbles with striations have been found also.

In Finnmark, northern Norway, one finds two distinct tillite horizons (Føyn, 1937; Reading and Walker, 1966). A good correspondence of the overlying formations from Finnmark (Føyn, 1967) through Sweden into southern Norway suggests that the Moelv Tillite should be correlated with the upper (Mortensnes Tillite) of the two. The Biskopåsen conglomerate indicates a general regression in the basin area (Spjeldnaes, 1964). This regression might be due to eustatic sealevel changes accompanying the glacial periods during which the Lower Tillite (Smalfjord Tillite) in northern Norway was deposited.

PALEOCLIMATIC IMPLICATIONS

Because the glacial origin of many late-Precambrian conglomerates has become well established, the aim of our research should be to characterize the nature of the glacial environment. The paleoclimatic implications of ice-rafted tillites may be very different from those deposited by a glacier. This can be demonstrated by looking at the distribution of Pleistocene glacial conglomerates. We know that drifting icebergs reach down to low latitudes even in interglacial periods like the present, while moraines have a more restricted distribution.

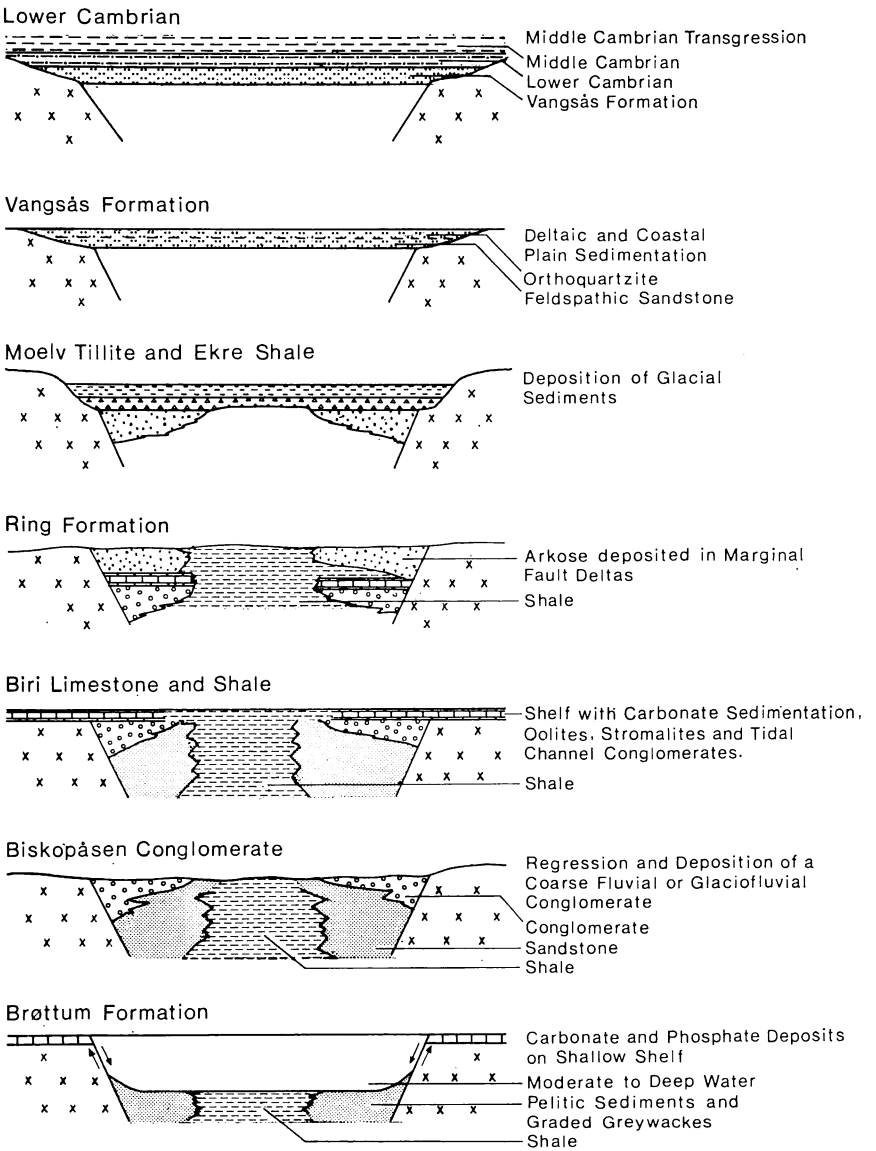


Fig. 1. Simplified diagram which illustrates the history of deposition and distribution of sedimentary facies in the "Sparagmite basin" in southern Norway. The diagram is an idealized cross section at one of the fault controlled basins which is about 50 to 60 km across in east-west direction.

The Moelv Tillite cannot have been deposited by icebergs derived from distant glaciers at ice shelves, because it is composed of rocks that crop out in the basement around the basin. On the higher ground around the sparagmite basins, glaciers or ice sheets must have flowed down into the basins.

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Research grant for field work by the Norwegian Research Council (NAVF) is gratefully acknowledged.

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