Preliminary Report on Boulders of Swedish and Baltic rocks in the Southwest of Norway.

By V. Milthers.

In this summer by the aid of the Carlsberg Fund I made a journey to Lister and Jæderen at the southwest point of Norway. The object of the journey was if possible to find boulders of Dala porphyries in the Quaternary deposits which have for many years been known to contain boulders from the Christiania district and flint boulders carried from the Skagerak. As Dala porphyries are found in no small quantities in the Northwest of Jutland[1]) it was an obvious conclusion that the same land-ice, by the movement of which the Christiania boulders and the flints were brought on to Lister and Jæderen, could also have brought Swedish rocks hither.

This supposition was fully confirmed by the investigation. Boulders of the Dala porphyries were found not only among the strand-stones and in glacial gravel-layers lying above the uppermost limit of the late-glacial sea but also lying in the clay belonging to that moraine, which contains the other boulders which came from a southerly direction. Of Dala boulders there were found Bred-

[1]) V. Milthers: Scandinavian indicator-boulders in the Quaternary deposits. Danmarks geol. Undersøgelse II R. Nr. 23. 1909.

vad porphyry and two other porphyry varieties from the western Dalarne, both belonging to the oldest porphyry group of Dalarne, the red porphyries, as also Grønklitt porphyrite belonging to the porphyrite group above the red porphyries. The highest situated locality, where Dala boulders were found, was Opstad brickfield, which lies ca. 175 m above the sea and where a boulder of Grönklitt porphyrite was taken in the shell-bearing moraine-clay[1]) which also contains relatively many boulders of rhomb-porphyry.

But besides the Dala boulders there also occurred Baltic boulders under quite the same conditions and in nearly the same quantities as the Dala porphyries. Of Baltic boulders the following were found:

from Åland: Rapakivi, granite, quartz porphyry and rapakivi-like quartz porphyry;

from the Baltic south of Åland: red Baltic quartz porphyry and brown Baltic quartz porphyry.

On Lister more specimens of Baltic boulders were found in the late-glacial gravel layers at Kviljo, ca. 8 Km SW. of Farsund, where a great many facetted, wind-worn stones lie on the field.

On Jæderen most of the Baltic boulders were found among the strand-stones, but some specimens on the other hand were taken in glacial gravel as for example in the Husvegg Ås in the south of Jæderen, and in shell-bearing moraine-clay as for instance at Lerbræk near the old church of Varhaug[2]).

In the north of Jæderen the Baltic and the Dala boulders seem to be more seldom than in the south; in the extensive gravel deposits near Time railway-station and at the Frøiland Lake (Frøilands vandet) neither Baltic nor Dala boulders were found; the same was the case

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[1]) K. O. BJØRLYKKE: Jæderens Geologi. Norges geologiske Undersøgelse Nr. 48. pag. 25. 1908.

[2]) K. O. BJØRLYKKE l. c. pag. 22—23.

in the shell-bearing moraine clay at Sandnæs. At all these localities however more specimens of rhomb-porphyry were found.

The observations confirm the supposition[1]) that the transport to Jæderen of the Christiania boulders and the flints is not due to the Norwegian Channel but that the conveyance hither, similar to and connected with the transport of Scandinavian boulders to the east coast of England together with the striæ on the Orkney Isles, indicate a Baltic ice-flow right across Denmark and a long way out into the North Sea.

With regard to the time for this ice-flow there is every reason to suppose it anterior to the interglacial era in Denmark represented by a boreal, marine clay[2]) lying below the Older Yoldia-clay in Vendsyssel, by the interglacial peat bogs in South Jutland and the Cyprina-clay in the South of Denmark[3]). Further the »Baltic« or »Danish« moraine on Jæderen is then in all probability of the same age as the oldest known moraine-layers in Vendsyssel (under the above-named boreal, marine clay), as the »Basement clay« of Yorkshire and the »Cromer Till« of Norfolk and as the moraine layers in Holland, older than the Eem zones[4])[5]).

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[1]) V. Milthers: l. c. pag. 127—29 and pag. 140.

[2]) A report on this clay will be published by »Danmarks geologiske Undersøgelse«.

[3]) Cfr. N. V. Ussing: Dänemark. Handbuch der Regionalen Geologie. 1. Bd. 2. Abth. Heft. 1. 1910. pag. 18—21.

[4]) V. Nordmann: Molluskfaunaen i Cyprinaleret og Mellem-Europas andre Eemaflejringer. Kjøbenhavn. 1908. J. Lorié: Het interglacialisme in Nederland. Tijdschrift van het Kgl. Nederl. Aardrijkskundig Genotschaap. 2. Ser. dl. XXIV, 1907. Afl. 3.

[5]) See also K. O. Bjørlykke l. c. pag. 45—46. At the brickworks of Sandnæs on Jæderen there occurs a shell-bearing boulder-clay containing rhomb-porphyry similar to the Opstad and the Lerbræk moraines, but according to Bjørlykke the fauna is different.

While Bjørlykke rightly refers the »Cyprina-fauna« from Opstad and Lerbræk anterior to the »Danish« moraine in which its shell-fragments lie, he supposes that the Yoldia fauna from the

The discoveries thus increase our knowledge of the extension furthest to the west of the East-Scandinavian or Baltic land-ice during the older part of the ice-age. They also therewith make it more probable than before that not only Norwegian boulders but also boulders of Swedish and Baltic rocks have been carried even as far west as the east-coast of England, where their occurrence has not yet been determined with certainty.

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clay at Sandnæs is younger than the corresponding moraine here. This can certainly not be correct. Both faunas must have lived at a time anterior to the forming of the boulder-clay which contains the foreign boulders and the shell-fragments; both of them must be older than the »Danish« moraine.

From Dr. V. NORDMANNS investigation of the shells which I collected at the three localities, we find moreover a great difference between the fragments of *Cyprina islandica* and all the other shells and shell-fragments which occur there. All the fragments of *Cyprina* are worn and rounded; the other shells are generally not rounded but are only broken and have still parts of the »epidermis« preserved.

This indicates that the *Cyprina*-fragments, like the flints and other foreign boulders, are carried a long way by the ice, while most of the other shells are on the contrary taken from clay-deposits in the neighbourhood of the finding-places. The boulder-clay at Sandnæs lies directly upon a stratified clay, from which its unworn shells possibly originate, and at Lerbræk we seem to have a quite similar case (BJØRLYKKE, l. c. pag. 22—23).

The native faunas at Opstad and Lerbræk are fully arctic and under these circumstances only differ from the fauna at Sandnæs (where I have also found a fragment of *Cyprina*) by the absence of *Yoldia arctica.* As this absence is probably due to a mere accident, we see that there is no faunistic reason either for referring the faunas named to different horizons or periods, as BJØRLYKKE has done (pag. 40 and 47—48).

The supposed proof for the presence of a real interglacial period, before the deposition of the »Danish« moraine, which — according to BJØRLYKKE — is given by the »Cyprina-clay« at Opstad and Lerbræk, falls therewith to the ground.