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Geology. — “*Some new sedimentary boulders collected at Groningen*”.

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(Communicated in the meeting of May 31, 1919.)

Some ten years ago a favourable opportunity offered for collecting sedimentary boulders at Groningen, where in three different spots at the northern extremity of the Hondsrug and in the neighbourhood of the northern cemetery, which has already become known as a findingplace of erratics, important excavations were performed. First when the foundation was laid for the new tram-shed, and shortly after when new streets were being made, viz. the Tuinbouwstraat and the Koolstraat.

When trenches were dug for sewer-pipes, the Diluvium was not reached at the point, where the Tuinbouwstraat joins on to the Nieuwe Ebbingestraat. The presence of sherds of pottery at a depth of more than 1 m., however, made us suspect that the upper soil had been turned over or earthed-up. A little higher up in the Tuinbouwstraat the Diluvium emerged, and gradually rose to the surface, until about halfway it was seen half a meter above the present level of the street and was covered only by a thin layer of mould. Subsequently it first sank again below the street-level, after which it rose once more to the height just mentioned. Afterwards, on the occasion of the excursion made in 1913 by the Geol. Section of the Geol. Mijnbouwkundig Genootschap (28 p. 83), it was encountered again in the first part of the Verlengde Tuinbouwstraat, also covered with a layer of mould.

In the three localities just mentioned boulder-clay was found, which is calcareous but already oxidized. Besides this a number of bands of gravel were to be observed.

Among the large number of boulders, found by me during these excavations, there were several interesting specimens. Of the species rarely found near Groningen I mentioned already (30 p. 231) the Upper-Silurian limestone with *Pristiograptus frequens* Jaek. and the Saltholms-limestone (also the glauconitic variety, the so-called Glauconitic Terebratula-rock) from the Danian.

In the following pages I purpose to discuss three more Silurian

boulders, hitherto unknown in our country, the last two not having been met with in any other country as yet.

Limestone with Strophomena Jentzschii Gag.

Among the erratics found when the new tram-shed was being built, there was i. a. a plate-shaped piece of rock about 2 c.m. in thickness and 1 d.m. in length and in breadth, in which occur a large number of dorsal valves of a typical *Strophomena*. Of other fossils this boulder appeared to contain only a longitudinal section of a *Pleurotomaria* and a small pygidium of *Asaphus raniceps* Dalm. so that from this it is obvious that it belongs to the Lower Silurian.

The rock is a fine-grained, rather hard limestone, with scattered small rounded quartz-granules. I have not been able to detect glauconite. The primitive colour is undistinguishable, as through weathering it has changed into a more or less yellowish grey. Also some brownish spots still occur.

In looking up the literature I soon became aware that the very same *Strophomena* has already been described by GAGEL of East-Prussia, who termed it *Strophomena Jentzschii* (15 p. 17 44 pl. V fig. 26). One of the blocks in which this fossil has been found, consists of brownish grey hard limestone with somewhat weathered, yellowish spots. It comes from Spittelhof and contains besides numerous dorsal valves of the above mentioned fossil, also the rests of a large *Strophomena* and another irrecognizable brachiopod. The other specimen comes from Pr. Holland and is composed of coarse-crystalline limestone in which only one dorsal valve of *Strophomena Jentzschii* Gag. occurs, beyond corals and rests of crinoids. Their petrographical character induced GAGEL to refer both erratic blocks to the Upper-Silurian series. However, it will appear presently that also these boulders, at all events the first-mentioned, have been proved to belong to the Lower-Silurian. On the other hand, according to ANDERSSON, the other may possibly originate from the Upper-Silurian and contain a closely related species.

Now in order to make assurance double sure, I begged Prof. ANDRÉE of Königsbergen to send me one of GAGEL's original samples for comparison. This request was readily complied with. A couple of well-preserved valves of Spittelhof were sent me, for which kindness I still feel greatly indebted.

My suspicion came true in every respect. The short description of this fossil by GAGEL I quote here for the sake of completeness:

Umriss querverbreitert, Schlossrand gleich der grössten Schalen-

breite. Schale anfänglich flach, dann allmählig unter einem rechten Winkel nach der Ventralseite zu gekrümmt, so dass die Dorsalschale convex wird. Oberfläche mit zahlreichen feinen, aber deutlich runden Rippen bedeckt, deren Zwischenräume durch 2—3 sehr feine Radialstreifen angefüllt sind. Ausserdem befinden sich auf dem flachen Teil der Schale noch eine Anzahl unregelmässiger, flacher, concentrisch angeordneter Runzeln, ähnlich wie bei *Strophomena rhomboidalis*. In der Mitte der Dorsalschale befindet sich oft noch eine kleine, aber deutliche Einsenkung".

The concave ventral valve has not been discovered by GAGEL either.

In consideration of my scanty material I was not enabled to make certain about the petrographic resemblance between the boulder from Spittelhof and the one found by myself; still it seemed to be rather great.

The second and latest writer that has described erratics with *Strophomena Jentzschii* Gag. from Germany is STOLLEY (20 p. 136). Without mentioning the finding-place (only the district Schleswig-Hollstein is given), he mentions two more blocks. The one is composed of light-grey limestone, in which here and there vermiform concretions of glauconite grains occur. Beyond a number of specimens of *Strophomena Jentzschii* Gag. this boulder contains only *Orthisina plana* Pand. The other resembles in a most marked degree the preceding one, but contains only a trace of glauconite and the only fossil accompanying *Stroph. Jentzschii* Gag. was *Orthisina concava* v. d. Pahl.

To my knowledge this *Strophomena* has not been detected in erratics from Denmark.

Only a few years after GAGEL had described the species, J. G. ANDERSSON also recorded a number of erratics with the same fossil from Sweden. One of them originates from L. Brunnby in the parish of Stenåsa in Oeland, one from Källunge Myr in Gotland and four from Gotska Sandön.

All these specimens differ largely from the one of Groningen as well as from the German pieces in that they are filled with a number of rolled fragments of brown phosphorite and brown to black phosphoritic sandstone. This makes them true conglomerates, which induced ANDERSSON to style them *Strophomena-Jentzschii-conglomerate*. Similar blocks have not been recorded either by STOLLEY or by GAGEL, who do not make mention either of any phosphorus-content. Neither does my specimen. What typifies ANDERSSON'S erratics, is that some phosphorite blocks contain Upper-Cambrian fossils, viz. *Peltura scarabaeoides* Wahlb., *Sphaerophthal-*

mus sp. and *Agnostus pisiformis* Linn., which proves them to come from a region of Cambrian deposits, which was exposed to erosion during the early part of the Lower-Silurian period. ANDERSSON (l.c. p. 79) himself is wrong in inferring from these erratics, that they come from the very locality whence originated also the boulders they contained, and that at the very least in that place the whole Upper-Cambrian must have been eroded away. I think this need not be so at all, and I even believe that it is most likely not the case, but that the region, from which these Cambrian blocks originate, has to be looked for rather in the vicinity of the original locality of the Silurian erratics. First of all we think of the districts near the coast of the mainland of Sweden to the West and to the North of Gotland.

The cementing material also which consolidates the phosphorite blocks, varies more or less from the first-mentioned erratics, as, according to J. G. ANDERSSON it sometimes consists of grey to white spotted coarse-crystalline limestone and sometimes of grey, compact limestone, in which occur a larger or smaller number of rounded quartz-grains, as well as occasionally some glauconite.

Among the fossils in the last-mentioned erratics are *Orthisina* sp., *Platystrophia biforata* Schloth., *Strepula* sp. *Tetradella* sp., *Asaphus* sp., *Illaenus nuculus* Pomp., *Illaenus* sp., some Bryozoa and other non-descript fossils. Of all these only *Illaenus nuculus* Pomp. was known hitherto from a boulder from East-Prussia, as described by POMPECKJ (16 p. 69). The author referred it to the Lower-Silurian period. This rock consists of brownish, coarse-grained limestone with many quartz-granules.

Finally we refer to one more erratic block with *Strophomena Jentzschii* Gag. from the North-Balticum, recorded by WIMAN (23 p. 103), viz. N° 94 of Ekeby. This boulder consists of red *Asaphus*-limestone and does not contain other fossils.

The age of all these erratic blocks could be established, because *Strophomena Jentzschii* Gag. has been found in solid rock first by ANDERSSON (l. c. p. 77) in the northern part of Oeland, afterwards by LAMANSKY (22 p. 177) on the Wolchow in Russia and finally by HOLTEDAHL (29 p. 46) in South Norway near Vaekkerö and Töien.

LAMANSKY (l.c. p. 177) suspects that also the brachiopod, which is recorded by BRÖGGER (5 p. 50 pl. XI, fig. Va) as a *Strophomena rhomboidalis* Wilck. from the Expansus-shale and the lower part of the *Orthoceras*-limestone of South-Norway, is identical to *Strophomena Jentzschii* Gag. The figure alluded to, is not at all like it, as already observed by HOLTEDAHL.

This fossil is rarely but regularly found in Oeland, in the lowermost, glauconitic Asaphus-limestone, in Russia in the three divisions of the zone B_{III} (B_{III_α} , B_{III_β} and B_{III_γ}) of LAMANSKY. On the basis of his investigations LAMANSKY parallels the lower half of B_{III_α} with the Lower Asaphus limestone of Oeland, but the *Strophomena-Jentzsch*-conglomerate with the Upper Asaphus-limestone and the Gigas-limestone of Oeland, and with the upper part of LAMANSKY's zone B_{III_β} and with his zone B_{III_γ} of Russia, so that from this it follows, that *Strophomena Jentzsch* Gag. is spread over a larger vertical extent than ANDERSSON could have surmised at first. In South-Norway the fossil has been found in the zone 3 c.

If, therefore, we wish to parallel this erratic block with any of the Lower Silurian strata, it is necessary, in view of the varying petrographical character of the divisions, which deserve consideration, and in view of the different character of each of them in different regions, to find out from which region the boulder most probably originates.

According to LINDSTRÖM (11 p. 9—12) *Asaphus raniceps* Dalm. occurs already in the Lower Gray Orthoceras-limestone of Sweden and is still found in the Upper Gray Orthoceras-limestone.

According to SCHMIDT this species is observed in Russia in the zones $B\ 2b$ — $B\ 3b$; according to LAMANSKY (22 p. 169) in the upper strata of the zone B_{III_α} up to the lower strata of B_{III_γ} .

BRÖGGER asserts that it is not quite certain whether they are met with in Norway (5 p. 92).

Most probably this erratic block does not originate from the mainland of Scandinavia, *Strophomena Jentzsch* Gag being known there only in South Norway. Moreover the rocks from those zones differ from our boulder.

Likewise the Russian Silurian need not be considered although the latter fossil also occurs in Russia. It has not been observed yet to the west of Reval. In that region only B_{III_γ} of the zone B_{III} exists and this division consists of calcareous sandstone. Our boulder, therefore cannot come from the East-Balticum.

As has been said, only one erratic block with *Strophomena Jentzsch* Gag. from the North-Balticum is known. The petrographical character of it does not agree with this specimen. Boulders of grey limestone have been found there, indeed, which belong to the Asaphus-limestone of WIMAN and may therefore be of the same age.

In Oeland the Lower Asaphus-limestone consists of limestone partly containing glauconite and partly free from that mineral of which

the first may agree pretty well with STOLLEY's boulders, but neither of them agree with the Groningen specimen, especially as regards the amount of quartzgrains.

The presence of erratic blocks with *Strophomena Jentschi* Gag. in Oeland, Gotland and Gotska Sandön leads us to consider also the localities of the Baltic west and north of the last two islands. It is true, the erratics found there, differ largely from the Groningen boulder; still this district is presumably to be considered as their original site. STOLLEY and ANDERSSON do the same for their blocks, while the assumption also seems warrantable of the presence of similar erratics in East-Prussia, notably the one described by POMPECKJ and the Spittelhof fragment recorded by GAGEL.

Probably this specimen must be considered to originate from a narrow slip of the Baltic, a little north of Gotska Sandön and at a short distance West of Gotland.

From the foregoing it appears therefore, that the place of origin cannot be assigned more accurately, so that we cannot say for sure to which division of the zône *B_{III}* the boulder belongs. It is therefore, like the *Strophomena-Jentschi* conglomerate to be classed provisionally under *B_{III}*.

Calcareous Sandstone with Asaphus raniceps Dalm.

In the Tuinbouwstraat one boulder was found among the many erratics that, judging from the fossils it contains, must be included among the Lower-Silurian. It is however of a peculiar petrographical character, as it consists of rather hard, fine-grained sandstone with a calcareous cement. The like of it appeared to be quite unknown in the literature of erratics.

This erratic block has about the size of a child's head and its primitive colour was gray to bluish-gray, as may still be observed from the inner part; the outside, however, shows a discolouration to brownish-yellow. For the rest it has suffered little from weathering. The quartz-grains are small, all but colourless and rounded. I did not encounter glauconite, but only some grains of calcite. The rock also contains a few pieces of more or less rounded, coarse-grained limestone, black at the periphery, white in the centre. These fragments, which moreover contain a large number of brown, rod-shaped bodies, are presumably little rolled boulders since they differ so much from the surrounding rock. However this is still highly problematical.

Beyond one specimen of an *Orthis*-species this block contains a

small but complete pygidium of *Asaphus raniceps* Dalm. (Length $7\frac{1}{2}$ mm, breadth 11 mm) and numerous other indeterminable fragments of Asaphids; i.a. a fragment of an hypostome.

In the description of the previous boulder I have already communicated something about the occurrence of *Asaphus raniceps* Dalm. in the Lower Silurian deposits in Scandinavia and Russia, so that I now merely refer to it.

From the above it appears, therefore that this block is to be classed under the older strata of the Lower-Silurian, specifically under one of the divisions equivalent to the Swedish Orthoceras-limestone.

However in Scandinavia or in Bornholm no solid rock is known resembling this rock in any way. Starting from Reval, *B_{III}*, of LAMANSKY has developed itself as a calcareous limestone in the Western part of Estland. Fragments of this rock also occur on the beach of Odensholm, so that up to that locality at least this division retains the same petrographical character. There it has sunk already below the sea-level. Having no control-material of this rock I am unable to ascertain its similarity to this boulder.

Moreover some boulders have been discovered, which, being composed of limestone, contain a variable amount of rounded quartz-granules and agree in age with *B_{III}*, as may be gathered from the description of the previous species of erratics.

I therefore believe that this piece is to be considered as a quartz-rich variety of the limestone with *Strophomena Jentzschii* Gag. and of the Strophomena-Jentzsch-conglomerate, especially because in the previous block also occurs a pygidium that belongs to the same *Asaphus*-species.

When examining the fragment more closely with regard to a possible phosphorus-content, both the rock itself and the foreign enclosures distinctly proved to contain at least some phosphorus. The latter, however, did not give off any smell of bitumen when particles were knocked off with the hammer. Furthermore, because they are not fossiliferous, we cannot determine whether these fragments of limestone, as is the case with the erratics of the Strophomena-Jentzsch-conglomerate examined by ANDERSSON, are to be included under the Cambrian.

Most likely the original locality of this erratic block is that slip of the Baltic which covers the prolongation of the calcareous sandstone in Estland and continues along the North side of Gotska Sandön as far as West of Gotland, thus comprising the region, from which the Strophomena-Jentzsch-conglomerate originates.

Limestone with Dinobolus transversus Salt.

A piece of fine grained-crystalline limestone having become brownish-yellow through weathering and of about the size of a fist, contains a dorsal valve of *Dinobolus transversus* Salt. (1 p. 59 pl. V fig. 1—6), which in spite of its extreme thinness has been preserved in admirable perfection. This boulder also, which was also found in the Tuinbouwstraat at Groningen, is a completely unknown species of erratics, as the fossil mentioned just now was not met with in any other country.

The length of the valve is 3 cm., the largest breadth, across the centre, 4.2 cm. The almost straight hinge margin is 3.3 cm. long.

The dorsal valve is almost quite flat and reveals on its surface numerous, very faint, concentric lines of growth and an extremely fine radial striation. Whether there are small spines on the outer surface, as indicated by DAVIDSON (l.c. pl. V, fig. 3 and 3a) cannot be made out.

Of other fossils this boulder contains besides a number of detached portions of crinoid stems also a valve of *Pholidops implicata* Sow. (1 p. 80, pl. 8, fig. 13—17) and a valve of *Beyrichia Jonesi* Boll (13 p. 13, pl. II, fig. 10—12) and a pygidium of *Proetus concinnus* Dalm. (9 p. 78, 18 p. 41, pl. IV, fig. 1—9, 3 p. 22, pl. XVII, fig. 5).

From all this it appears, therefore, that the block belongs to the upper Silurian, the zône being undetermined yet.

Pholidops implicata Sow. contrary to *Pholidops antiqua* Schloth. is probably quite unknown in our upper Silurian erratics as well as in those from Germany and Denmark, which is perhaps due to the fact that various authors have considered the two as synonyms (7 p. 96, 10 p. 173). It appears however, as MOBERG and GRÖNWALL (24 p. 30) have shown, that they were used for fossils which indeed are closely allied to each other but also form a distinct contrast. Only KIESOW (6 p. 245) records that *Pholidops implicata* Sow. (= *Crania implicata* Sow.) is very abundant in West-Prussia in the boulders of the Upper-Silurian Beyrichia Limestone. I think however that he also refers here to *Pholidops antiqua* Schloth.

In solid rock *Pholidops implicata* Sow. is known only from the island of Gotland (from the zônes c—h of LINDSTRÖM (12 p. 13). MUNTZ (27 p. 12—13) mentions the fossil from the layers 2—4 distinguished by him and VAN HOEPFN (25 p. 125) from γ and ϵ_w . LINDSTRÖM, also, records the occurrence in Schonen (l.c. p. 26), but MOBERG and GRÖNWALL state that the species there differs distinctly

from the Gotland species and resembles *Pholidops antiqua* Schloth. It is not known as yet which of these two fossils occur in Oesel and in Estland.

Beyrichia Jonesii Boll. has been reported by KIESOW (13 p. 13 pl. II fig. 10—12) of Gotland from LINDSTRÖM's zônes *c—h*, by VAN HOEPEN (l. c. p. 132) from his zône ε^w_1 . At Schonen this fossil has not been found, and nothing is known of it in Oesel and Estland.

Proetus concinnus Daln. is mentioned only by SCHMIDT (l. c. p. 44) from the Lower Oesel stratum (zône *J*) of the Russian Baltic provinces, of Gotland by LINDSTRÖM (12 p. 3) from the zônes *c—e*, and by VAN HOEPEN from his zône γ (near Mulde) (l. c. p. 142). Moreover this fossil has been found with *Beyrichia Jonesii* Boll in boulders, associated with *Leperditia Baltica* Eichw. and *Beyrichia spinigera* Boll. (2 p. 39, 17 p. 502).

I, therefore, feel justified in assuming, that this boulder probably agrees as to its age, with the Lower Oesel stratum of the Russian Baltic provinces

In Oesel the Lower Oesel stratum consists almost entirely of blue marl and dolomite. Limestone occurs only in the West of the peninsula Taggamois (4 p. 46). The equivalent layers in Gotland, on the other hand, are composed of marl, marly limestone and limestone, and the equivalent layers on the mainland of Sweden of grapholite-shale, so that this region cannot be considered as the place of origin.

Gotland and the part of the Baltic between this island and Oesel and of these probably, first of all, the island of Gotland together with its approximate vicinity is, therefore, in all likelihood to be looked upon as the locality from which our erratic block was derived.

Delft, May 1919.

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