8. An Occurrence of Stromatolithic Limestone at Hovenäset, Bohuslän.

By

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In the summer of 1942, on a vacation, I visited Hovenäset, situated about 14 kilometers NW of Lysekil. North of the village, on the eastern shore of the creek Kleve Kilen there is a small depression, bounded on the South by a high and steep cliff (cf. fig. 7) and on the North and the West by less conspicuous granitic hills (figs. 2 and 3). The depression is occupied by a shell-bed. Recently, great masses of this shell-bed have been removed and a system of hillocks composed of the underlying granite, polished by the ice, has been uncovered (see map; only a square, about 20 meters by 20, a former cholera graveyard, has been spared). The exposed hillocks are arranged on the sides of a small valley extending SSW—NNE. Their surfaces, particularly on their lee side, are occupied at intervals by masses of so called stromatolith, very various in form, and also of varying internal structure.

The following short description of the stromatolithic limestone at Hovenäset shows beyond doubt that we have to do with exactly the same structures as those described by WESTERGÅRD from the Sote Kanal (S. G. U. Årsbok 28, Stockholm 1934), in fact no new type has been recognized at the new locality. The occurrence at Sote Kanal is no longer accessible for study, other localities are less well known, some of them only from loose fragments of the limestone, and I have therefore thought that it would be of some interest to give an account of my observations at Hovenäset.

The situation sketch, fig. 1, covers only the central part of the »Slätten» depression. The top of the hillock at *a* (fig. 2) and the hill in the very right lower corner of the map (four »contours») were originally above the surface of shell-bed; for the rest, the hillocks must have been covered by it (see fig. 3: level of the original grass-grown ground at ←). The surface of the shell deposit to the right of *d* on the map lies 6—7 meters above sea-level (the points marked with an X lie, roughly estimated, 5 meters above sea-level). An attempt to determine the age of the shell-beds has not been made.[1]

[1] The shell-beds on the E side of the Kleve Kilen described by ANTEVS (Geol. Fören. Förh. p. 608—609) lie 13—17 meters above sea level.

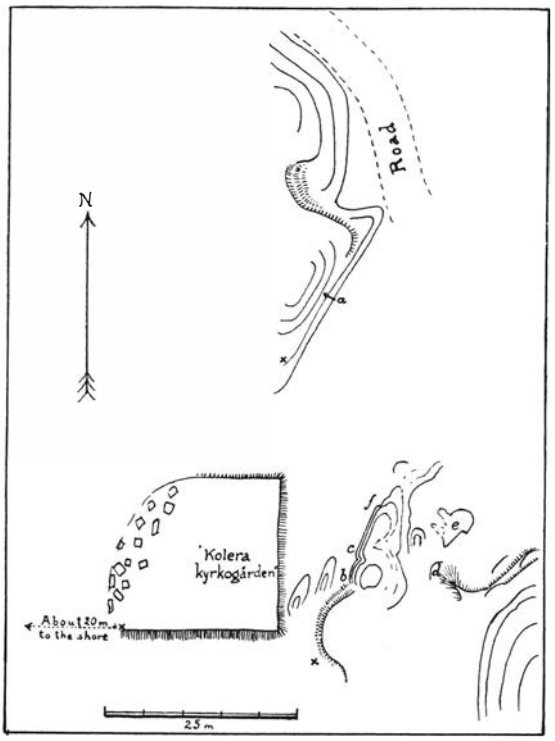

Fig. 1. Situation sketch of the »Slätten» locality, Hovenäset. Distances paced. The contours are rough free hand sketches made to give an approximate idea of the shape of the hillocks. See also the text.

I will confine myself to a brief description of the occurrence at the points *a—f* on the accompanying map.

a. A sheet of poorly consolidated sandstone measuring some 7 square decimeters, and with a thickness of a few centimeters, preserved in a small and shallow hollow in the granite. The surface of this sandstone is much corroded, and in small cavities entire shells of *Saxicava arctica* are found in the position which they evidently kept when in life. This sediment can on no condition be called a limestone, and it probably belongs to the same category of sediment, that in other spots has been densely pressed to rough surfaces of the granite by the ice (see below under *e*).

b. Fig. 4 shows a schematical section (approximatively E—W) at this place. At *I* there is a small portion of residuary sandstone preserved in lee of a striated granite surface east of it. At *II* a fairly heavy covering of crystallized black limestone (bituminous?) occurs, from all evidence formed by water saturated with lime carbonate sickering down over the surface. This sheet of limestone continues without interruption and evidently with the same thickness on the lower face into a small crevice. At *III* the granite surface is covered by small »warts» of sandy material

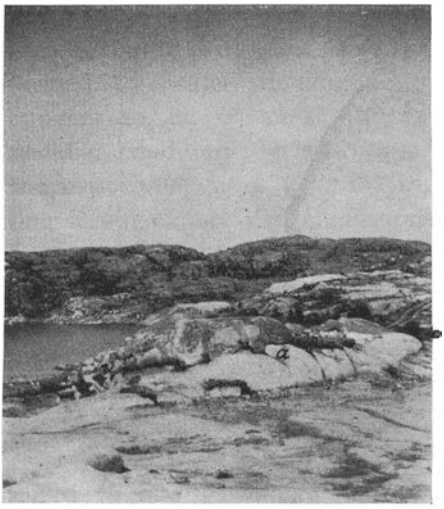

Fig. 2. The northern hillock on the map seen from SSE. The dot to the right marks the northern limit of the map. Photo G. BÖRJESSON, Hovenäset.

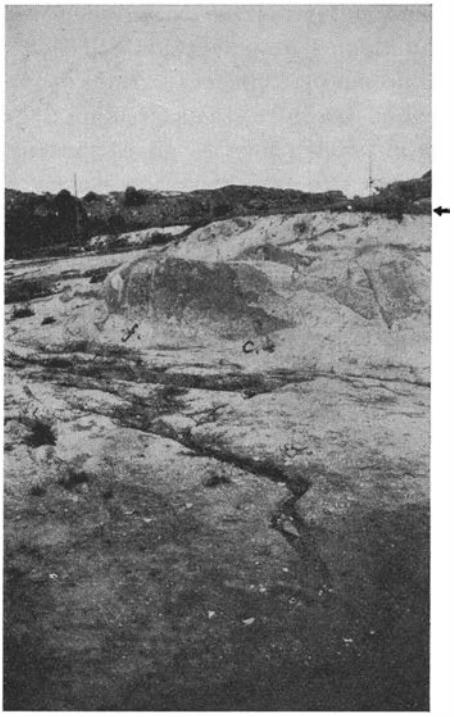

Fig. 3. The southern hillock on the map seen from SW. Photo G. BÖRJESSON.

(diameter 1—2 centimeters; size in relation to the rest of the details in the fig. greatly exaggerated). A sample found loose shows an aggregate of similar rounded warts which have increased in size until they finally have fused to a continuous sheet (cf. WESTERGÅRD Pl. 11).

c. In one spot the stromatolith shows glacial striae, and on the scratched surface a second generation of stromatolith has been formed. The upper edge of the sheet of stromatolith reaches the striated upper surface of the granitic hillock and is there itself polished by the ice. On account of the comparative softness of the limestone it is eroded more deeply than the granite, and thus the adjoining surface of the granite and the stromatolith form an obtuse angle with each other (cf. WESTERGÅRD Pl. 7).

Near the spot showing the above-mentioned structures, stromatolith is deposited on two adjoining granite surfaces, an upper one with a comparatively gentle dip, and a lower one that is almost perpendicular. It is interesting to notice how the deposition of the limestone must have been influenced by the angle of dip. The stromatolith on the upper surface gives the impression of a diminutive delta (the internal structure may not correspond to what is suggested by the outer form), to which has been added lamella after lamella until finally the lower edge of the surface was reached; then the deposition took place in a more drawn-out flow (fig. 5; cf. WESTERGÅRD Pl. 9 fig. 1).

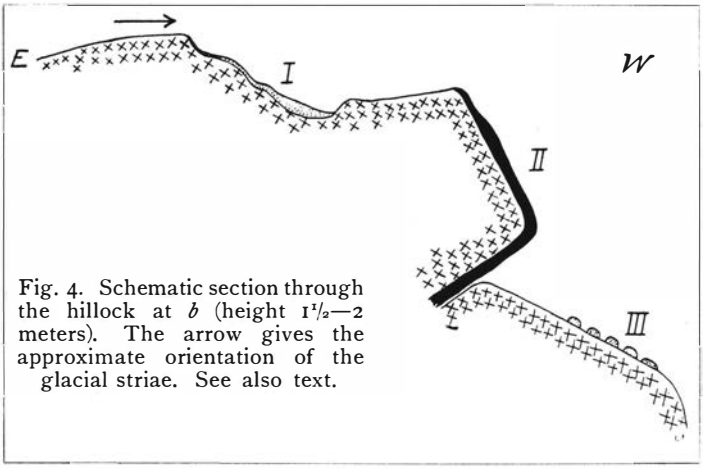

Fig. 4. Schematic section through the hillock at *b* (height 1½—2 meters). The arrow gives the approximate orientation of the glacial striae. See also text.

d. At this place a shelf of granite protrudes out of the shell-deposit. Its upper, almost horizontal surface shows glacial striae. On the lee side there is a heavy covering of stromatolith forming irregular but on the whole vertical ridges separated by deep grooves. The lower part is not exposed (fig. 6).

e. A shelf of granite split by a fissure striking ESE—WNW. There is a distinct thrust side at the eastern end. Part of the upper side is rough and unpolished but levelled by a deposition of hardened fine silt with glacial striation on its surface. Adjoining parts of the upper side lack this deposition and show a (comparatively slight) glacial striation. On the lee side again stromatolith limestone is found.

f. The sheets of stromatolith shown in fig. 7 occur at this place. One of them has its uppermost part abraded by the ice. The ridges show a great number of irregular swellings which, as far as I could recognize without damaging the beautiful structures, contain small rock fragments, the accumulation of which might be responsible for the irregularities. A little farther north the stromatolith is of quite another type, viz. the one shown in fig. 5 (fig. 5 B is in part based on fig. 7).

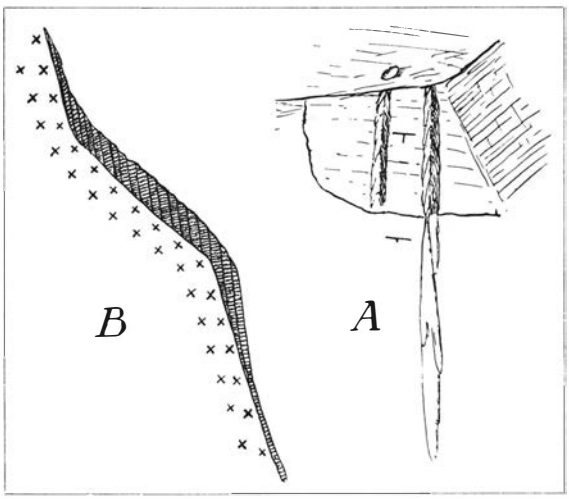

Fig. 5. Sketch of stromatoliths at *c*. See text.

WESTERGÅRD's interpretation of the stromatolith is not altogether convincing. At Hovenäset one decidedly has the impression of something formed by water trickling down the steep surfaces, *i. e.* the stromatolith appears to be of stalactitic formation, though probably formed under peculiar conditions. I attach special importance to fig. 5 which shows how the deposition varies with the dip of the surface in exactly the way which one would expect if running waters were responsible for the formation. It is true that WESTERGÅRD has been able to discover interesting abnormalities: small rounded »concretions» attached to perpendicular surfaces (*l. c.* p. 15), and the types figured in his figs. 3 and 4 (p. 16) and Pl. 6 fig. 2, but it seems more reasonable to assume that these abnormalities are due to special causes, than that they should upset the obvious interpretation of the majority of cases. I may add that at Hovenäset all sediments found on horizontal, or nearly horizontal, surfaces appear to be of a type which I would prefer to call sandstone, whereas those on steep surfaces consist of black, often coarse-grained, limestone.

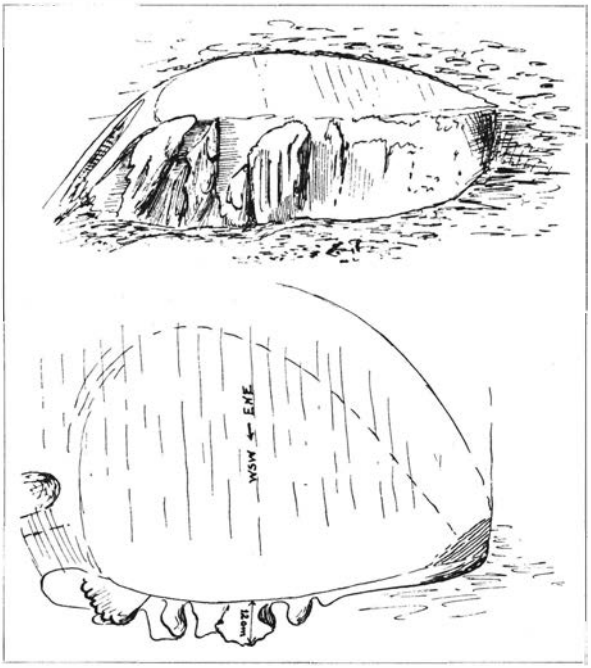

Fig. 6. Shelf of granite imbedded in the small deposit. Lee side and upper striated surface. Field sketch.

As pointed out by WESTERGÅRD, the localities in which the stromatolith has been found have been depressed by the ice to a considerable depth below sea-level, and thus the stromatolith has, in all probability, been formed in water. If my hypothesis of stalactitic origin is correct it appears necessary to assume that the limestone has been formed beneath the ice. The water from the melting ice was undoubtedly under high pressure in the deeper portions of the ice, and was thus able to dissolve great quantities of lime carbonate (I have thought of shell-beds swept away by the advancing ice as the source). The water reached the bottom of the ice through fissures, and was pressed towards the edge of the ice sheet between the ice and the underlying rock. Finally, the supersaturated water attained a point where the pressure suddenly lessened and a pre-

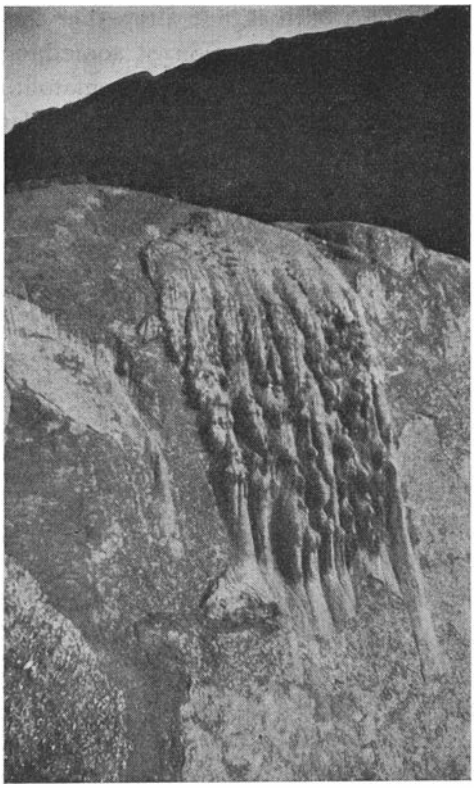

Fig. 7. Stromatoliths at *f*. In the background the steep side of the granite hill bordering the »Slätten» depression in the south. Photo G. BÖRJESSON.

cipitation of the dissolved matter took place. A series of lee sides facing a wide and deep cleft in the substratum would be a locality where such a deposition could be expected, as even there sea-water under normal pressure is likely to have entered.

The occurrence of several generations of stromatolith, separated by surfaces scratched by the ice, has probably nothing to do with interstages. Beneath the ice an increase or a lessening of the pressure, a closing or a reopening of passages for the water might have occurred so irregularly that stromatolith in neighbouring places may have been deposited (or polished by the ice) at very different times.

I do not intend to enter further on the matter of interpretation, as I know that Dr. LJUNGNER has devoted much time to the limestone in question. In fact I owe to a lecture by Dr. LJUNGNER my first knowledge of the Sotenäs limestone, and I would perhaps have paid far less attention to the locality described in the present notice if Dr. LJUNGNER had not given such an interesting orientation concerning the limestone and the problems connected with it.

I am also indebted to lic. I. HESSLAND for information about the shell beds in Bohuslän, and for his willingness to discuss questions connected with the occurrence and formation of stromatolithic limestone.

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