Geologiska Föreningen i Stockholm Förhandlingar

Publication details, including instructions for
authors and subscription information:

<http://www.tandfonline.com/loi/sgff19>

The Quaternary History of the Ragunda Region, Jämtland

H. W:son Ahlmann , C. Carlzon & R. Sandegren

Published online: 06 Jan 2010.

To cite this article: H. W:son Ahlmann , C. Carlzon & R. Sandegren (1912) The Quaternary History of the Ragunda Region, Jämtland, Geologiska Föreningen i Stockholm Förhandlingar, 34:3, 343-364, DOI: [10.1080/11035891209448696](https://doi.org/10.1080/11035891209448696)

To link to this article: <http://dx.doi.org/10.1080/11035891209448696>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is

expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

The Quaternary History of the Ragunda Region, Jämtland. Preliminary Report.

By

H. WILSON AHLMANN, C. CARLZON, AND R. SANDEGREN.

(With Pls. 5—6.)

As early as the latter half of the 18:th century, the people living by the Lake of Ragunda, in the valley of the Indalsälf, had been at work with the purpose of draining a part of that lake. During the year 1796 their work had progressed so far that the glaci-fluvial ose, damming the lake, had been partly dug through. One spring night that same year the water, however, broke through the obstructing masses of sediments, and the lake was emptied in a few hours. Storforsen (The Giant Fall), formerly the outlet of the lake, was dried up, and the Indalsälf eroded at an extraordinary rate a new channel in the layers of gravel, sand, and clay which filled the lake-basin. Accordingly there were formed series of magnificent natural sections, where the structure as well as the formation of the masses of sediments, gradually deposited in the valley ever since the recession of the inland ice, could be studied in detail.

In 1899 HÖGBOM published a treatise on the geology of the Ragunda valley in which he gave a survey of the tectonic and petrographic structure of the rock as well as of the Quaternary geology of the district, especially dealing with the rise and disappearance of the lake.

After the recession of the ice, the land was submerged so far below sea-level that the highest marine limit is now found at about 237 *m* above sea-level (taken at Döviken). See Pl. 5. At that time the valley was a fjord in which were gradually deposited, as the ice-margin receded, glaci-fluvial oses, glacial clay, and postglacial sediments consisting of sand, clay, and silt (Swedish »mjåla«).

The first appearance of the lake dates from the moment when the threshold of the Storforsen rose above the surface of the water. Thus, in this case, differing from several previously examined valleys, we find a closed basin where sediments could be deposited and where the quaternary development could take place *independant of the different quaternary epeirogenetic movements of the land below*.

During the *fjord-period*, however, so much loose material had been deposited that *the lake-basin from the very first had been filled up to a great extent*.

Thus the great ose wound through the valley, with its centres lying sometimes on the right side and sometimes on the left side of the present Indalsälf. The bottoms of the side-valleys were filled up almost to their whole breadth by the well rinsed masses of gravel. When the land rose and the mouths of the rivers gradually moved down the valleys, delta-plains were formed on successively lower and lower levels and, thus, little by little were cut through by the rivers. To the rivers which discharged their waters into the Ragunda basin, the rock threshold of the Storforsen (131 *m* above sea-level) was the base of erosion; the highest shore-line of the Ragunda Lake now lies about 138.8 *m* above sea-level.

The masses of sediments, deposited at an early time, filled up the whole extent of the Ragunda basin lying between the Krångede-Falls and the Hammar-Fall. Consequently, the Indalsälf had already been localized in a channel when the rock treshold of the Storforsen rose above the water. Thus, this part of the basin ought to be looked upon as a river

rather than a lake, though we here can trace the lake-shore.

The Indalsälf itself probably carried very little silt by the Krängede-Falls owing to the fact that it had deposited most of its material, brought from the West, in the Lake of Gesunden which lies just to the left of the map, Pl. 5.

Thus, the material of which the lake-sediments themselves were made up was chiefly formed of the sediments in part deposited already at an early time between the Krängede-Falls and Hammarstrand and partly coming from the valleys ending in the Ragunda basin.

Thus, we get a circular movement of erosion and accumulation within a very limited drainage district. When the deltas were cut through, systems of flood-plains arose on account of the meandering and serpentine courses of the rivers.

Fig. 1. The terraces at Ammerån. Scale: Length = 1 : 50 000; Height 1 : 25 000.

Fig. 1 represents a transverse section of the finely developed system of terraces at Ammer river (125,6). As is shown there are four terraces on each side of the river, of which only two have correspondences on the other side: the upper ones, situated 166 m above sea-level (taken at their edge), and the other two at the height of 138.8 m. The latter are the plains of erosion of the lake, the others have been cut out before (the terraces at 148, 145) as well as after (the terraces 131.2; 130.3; 128) the draining of the lake. Formed through meandering they lack correspondence on either of the banks of the river.

Through the draining the base of erosion was very quickly lowered by about 30 or 40 metres, and the masses of sediment, deposited in the lake, were brought above water, subjected to the transforming effects of the erosion.

It was a curious sight that presented itself to the eye when the water had flown off and the river had eroded down to its new furrow. Large, even and muddy plains extended along the old shores, and the deep ravines which were quickly formed laid bare their inner structure.

Prof. DE GEER was the first fully to understand what an unparalleled opportunity here offered itself to study the development of a lake, its first formation as well as the progress of its filling up and final draining. The layers found here are *annual layers*, just as those of the glacial laminated clay,¹ and by measuring and counting them a very good idea could be obtained both of the qualitative and quantitative formations of many of the morphological processes connected with erosion and accumulation.

In the summer of 1909 several standard sections of those layers were measured and connected by Prof. DE GEER at Vikbäcken² as well as several other localities near Hammarforsen, and in the spring of 1911 he controlled and completed those measurements at the same time introducing us in his previous observations and giving us full access to his diagrams, leaving to us the continuation of this interesting work, the chronology and stratigraphy of which were overtaken by C. CARLZON, the morphology by H. AHLMANN, and the subfossil biology by R. SANDEGREN. The authors of this preliminary report wish to take the opportunity of thanking Prof. DE GEER for having given up to them the investigations at Ragunda.

However, already at the revision 1911 it was found that the work would be somewhat more difficult and complex than at first anticipated. Prof. DE GEER found that the uppermost layers were more thick and thus less numerous than indicated

¹ G. DE GEER: On Late Quaternary Time and Climate. G. F. F. **30**. 1908.

² G. DE GEER: A Thermographical Record of the Late Quaternary Climate. Die Veränderungen des Klimas seit dem Maximum der letzten Eiszeit. 11. internationalen Geologenkongress 1910.

— — Om den senkvartära tidens indelning. G. F. F. **33** (1911).

by the extrapolation and by his and CARLZONS continued investigations it became probable that the sedimentation at this place was ended before the draining of the lake in 1796.

Through our measurements with Testorpli's tube on the above mentioned plains, extending all round Hammarstrand and round the mouths of the Halå and the Singså, it became evident that their surface was so near the shore-line that it came to be above or at least quite near the surface of the water at low tide. The Lake of Gesunden, which lies somewhat W. of the map, Pl. 5, shows a difference of 5.3 *m* between high and low tides. As the lake, with regard to its position and formation, is greatly analogous to the old Lake of Ragunda, this measure can be considered to hold good even in the district of our investigation.

Fig. 2, which represents a part of the plain round Hammarstrand, shows that the surface here lies 2.5—4.5 *m* below the high-water level (here 138.7 *m* ab. sea-level). At Vikbäcken the measure rises to 5 *m*, at the mouth of the Halå to 2—5.5 *m*.

By comparing this with several transverse sections which we had measured we arrived at the following result: *the lake was saturated by sediments before its draining*, and the abovementioned plains were *filled up plains*¹ whose formation had already been brought to an end long ago.

As to their morphological formation these are quite like the delta-plains, but as to their genesis they are somewhat different.

The cause of their formation also depends upon the fact that perhaps no sedimentation could have taken place even if the plain had lain 0.25—0.50 *m* below the surface of the water. In shallow water there can be no free formation of the waves in a vertical direction. The movement of the water-particles which, in the upper layers of deep water, should theoretically be circular, becomes more elliptical. Long, low waves thus glide in over the space of shallow water. At the shore they

¹ In Swedish »mättad» och »utfyllnadsplan».

are reflected, and there arises an undulation which most aptly can be characterized as *standing transversals*. By these waves the fine material on the bottom is stirred up, but not removed very far. It falls to the bottom as soon as the water becomes settled again. If any current should carry material from neighbouring parts, that too is prevented from being deposited on the shallow places by the undulation. Such little side-currents were probably rather rare in the Lake of Ragunda during the latter period of its existence. Gradually, as the lake was filled up, the main current became localized in one special channel, in which it ran without deviating.

The position of this channel in the lake can be traced at a few places, especially at the mouth of the Singså, where the current seems to have passed in a shallow hollow between a rocky island and the shore. This gully is bounded on both sides by the above mentioned filled up planes. This hypothesis is supported by an old statement of a current really having passed here once. The shallow and narrow hollow noticeable on fig. 2 probably marks out the course of a small side-current. It is difficult to tell when it was formed, and it is also very improbable that this current has ever accumulated material; it is far more probable that it has only re-deposited or only eroded sediments.

As mentioned above, the Indalsälva cut a new channel through the sediments at a very quick rate. Still the process could not proceed continually, as the river at some places met with material, difficult to erode, consisting of old material. The first obstacle was the one which traversed the valley S. of the farm Träfoten and S. of Prästberget. At both these places falls were situated for a short time, during the existence of which erosion-terraces were formed.

At Hammarstrand where a rock threshold was found, the river, however, was stopped in its course and the fall Hammarforsen was formed. When the fine-grained sediments were laid bare, they naturally were at first drenched with water, and large

slides and ravines were formed. The latter chiefly assume two shapes. We have first the long ravines of a depth of nearly 30 m, whose walls often stand vertically owing to the petrographic composition of the sediments and, secondly, oval hollows with more or less sloping sides. The latter often have a narrow mouth hanging to the main valley:

Fig. 2. The environs of Hammarstrand. Scale 1:10 000. The numbers give the depth below the shore-line (138.7 ab. sea-level).

Fig. 2, which represents a part of the ground at Hammarstrand, shows the old bottom of the lake (1.0—4.8 below the shore-line). On this plane lies the erosion-gully of the side current (mentioned p. 348). That gully cuts the road just to the North of the point 3.8. On the lower part of the figure are two ravines. In its middle as well as at the point 16.2 we find two pairs of hollows of the above-mentioned oval type with hanging mouths. The terraces at 18.4—19.8 m arose when the Indalsälf in its recession formed a fall at Prästberget.

On the Plate 6 appears, to the very left, the end of the

northern large ravine. The terrace on the 19.8 *m* level is represented in the plane occurring at the mouth of the ravine. The sand-plain in the foreground, overgrown with *Myrica germanica*, is flooded only at high-tide.

The greater part of these ravines has surely been formed just after the draining catastrophe. However, the erosion and the work of transformation are still going on. Each year the river cuts away large masses of sediment, the quantitative size of which we have partly been able to estimate by comparing with old maps from the time previous to the catastrophe and also maps of a more recent date.

As mentioned above, we did not succeed in determining the length of the post-glacial period. Through LIDÉN's investigations in Ångermanland¹ we know, however, that this period must extend over a space of at least 6 650 years counting from the time when, according to Professor DE GEER², the first bipartition of the formerly coherent inland-ice near the ice-shed in Eastern Jämtland took place. In the seasonally laminated clay at Döriken this bipartition is registered by a stratum about one *m* thick. *All the following chronological data have been counted from this stratum.* The greatest number of annual strata measured by us in one coherent section of sediments in the Lake of Ragunda, amounts to about 3 600 counting from the same time³. Probably a somewhat higher number will be the result of the measurement of a transverse section at Nr. 51, which is to be undertaken.

In comparing the figures — those found by us and those of LIDÉN — it of course became at once obvious that the figure we had found could only represent part of the postglacial period. This appeared also quite plainly from the transverse sections measured chronologically during last summer.

¹ R. LIDÉN: G. F. F. 33 (1911).

² G. DE GEER: G. F. F. 33 (1911).

³ Part of the chronological dates given in this paper have only an approximate value, but in no case the error might surpass ± 100 years.

Through R. LIDÉN's investigations, referred to above, it has become evident that the order of strata in a Norrland valley is as follows:

Postglacial, sandy, proximal delta sediments;

» *clayey, distal* » » :

» *fjord clay;*

Late-glacial clay.

Beneath the late-glacial clay we often find coarse gravel, synchronizing in each section with the lowest stratum of the normally covering glacial clay.

Within the old Ragunda Lake district, this series of strata is not complete and somewhat deviating from its normal appearance owing to the causes indicated below.

The difference in height above sea between the highest marine limit and the bottom of the valley — that is to say, the depth of the valley below the highest marine limit — the rate at which the land rises, and the quantity of the annual masses of sediment, are the factors determining the appearance of a transverse section. If from one cause or other the depth has been too small, the section does not present appearance agreeing with the general scheme given above. The filling up through distal sediments has gone on at such a quick pace that the river has not had any time of moving its delta¹⁾ owing to the land-rise. In this case, no deposition of proximal delta material can take place and all further sedimentation without a previous erosion is impossible. Where the valley has been particularly narrow and the bottom of the valley has lain very high in relation to the water-surface the valley has often been filled with fluvio-glacial material, coarse gravel and glacial clay. If during the land-rise, the upper part of the valley is isolated from the lower part, owing to the rise of a rock threshold, matters will be very much complicated. This will specially be the case if at that time this part is already

¹ See p. 344.

partly filled up by sediments. The water surface of the lake then becomes constant, regulated by the high and low water level. The water masses of the river allow of the basin being filled to a certain maximum after which no deposition of material can take place. When this maximum has been reached, erosion begins. Owing to the channel having grown narrow, the drift of the current becomes greater. Heavier material can be carried along and discharged as the erosion of the distal and early deposited fine-grained masses of sediment progresses and has made a depression. By this process discordances are formed. So we hope to have given a partial explanation of the following irregular appearance of the sections that we have measured.

In this preliminary report, no attention has been paid to the number of the layers in the uppermost part of each section, which are destroyed through weathering. On a whole, this fact does not influence upon the figures given here. The thickness of this weathered part is namely, in most cases, insignificant compared with that of the whole section, and further the uppermost layers are usually thicker than the underlying ones. As to the position of the transverse sections, see the map, Pl. 5.

Section 17. The surface lying 3 m below the highest shore-line of the Lake of Ragunda:

25,0 cm mould;

47,0 cm weathered silt;

106,7 cm silt, 73 annual strata;

Discordance;

127,5 cm silt, 70 annual strata;

Discordance;

566,2 cm silt, 204 annual strata;

20,0 cm + fjord-clay.

The part of the section lying beneath the fjord-clay, was covered by debris and for that reason it has not yet been possible to examine it. The above section is a good instance of repeated accumulation and erosion. The degree of accumu-

lation in each case is of course impossible to state. The chronology of the annual strata lying above the first discordance as well as that of those lying between the discordances has not yet been fully fixed.

Section 16. The surface lying 4,5 m below the highest shore-line of the Lake of Ragunda:

2 045,8 cm sand, finer (often silt) and coarser alternately peat-lenses in profusion, annual strata as yet not quite fixed.

Discordance;

394,1 cm silt with fossils of plants, 460 annual strata;

544,9 cm + silt (without plant remains), 617 annual strata.

The rest of the section lies below the surface of the river. The proximal delta-sediment arises from the ose, cutting the valley further to the west. This ose could be eroded by the current at a certain period, after the lake had been isolated, owing to the contraction of the furrow. The silt lying beneath the discordance, has evidently been deposited in a calm water at a time when a real lake still existed.

Section 27. Surface 4,5 m below the highest shore-line of the lake of Ragunda.

14 cm mould;

420 cm weathered silt;

232,7 cm silt, 198 annual strata;

Discordance;

753,7 cm silt, 2,734 annual strata;

Fjord-clay.

In this section the thickness of the strata is not generally very great (1 mm—2 cm.) Their limiting surfaces are strictly parallel. This fact as well as their general appearance indicates their deposition in a calm water. However, as is easily understood, the strata are thicker near the discordance.

The section measured by DE GEER at Vikbäcken shows the strata in a wholly undisturbed order, from the late-glacial clay up to the lake-sediments deposited in the year about 3 600. Thus, owing to causes we cannot enter upon, the

section was left untouched by the river, after it had been formed.

In a report of such a nature as that of the present treatise, we cannot enter into further details concerning the general appearance of these sections.

From the above we may draw the conclusion that the bottom of the old Lake of Ragunda forms an eroded surface, not a filled up one. This is the case with the sedimentary surfaces in several valley-lakes of Norrland or will be, sooner or later, if the development is allowed to proceed undisturbed.

Through soundings and by fetching up samples from the bottom of *Lake Gesunden*, lying to the west of the Lake of Ragunda, it has been proved that the bottom of this lake is an eroded surface partly formed in fini-glacial times.

A similar examination of the of *Lake of Helgum*, in the valley of the Faxeälf, has been planned but not yet carried out.

By using the chronological method of measuring, the annual course of sedimentation can be traced. In this we have partly succeeded even at the present stage of our investigation, but much remains still to be done.

As mentioned above, the greater part of the west district of the lake and the parts round the Singså and the Halå were filled up by sediments already in fini-glacial times.

At the points where these have later been left untouched by the current, they form superficial strata, while at other places where this has not been the case, they are discordantly covered by new masses of sediment. In some sections several discordances have been observed, as above mentioned owing to the repeated changes of the drift of the current and the movements of the furrow. By comparing diagrams of sections where discordances do not occur, it is possible to determine chronologically the discordantly covering strata.

Round the Halå at the sections 18 and 31 we have been able to ascertain the synchronism of these discordantly covering strata.

According to DE GEER's measurements the superficial strata at sections 12 and 52 are contemporaneous. That the superficial strata at section 17 may also be paralleled to them is very probable though not yet fully proved. By measuring a sufficient number of sections, however, it will, no doubt, be possible to reconstruct, year by year, the topography of the lake-bottom. The number of sections that have been measured so far (about 50) is, however, too small to supply sufficient material for this purpose.

The appearance of the annual strata differs according to the prevailing hydrographic conditions at the place of deposition. As pointed out by LIDÉN, each stratum is composed of a lower and thicker part, often sandy, and an upper and thinner, clayey one. The former he looks upon as deposited during the spring- and mountain-floods, and the latter he regards as a deposition immediately connected with the former. We are, however, inclined to the supposition that the clayey part wants a somewhat longer time for its deposition and does not only consist of the silt from the spring flood but also of an additional increase of silt from the low-water period. Very often the clay-line is locally divided in two lines, separated by heavier material that, according to our opinion, was deposited during the increase of the drift of the current, caused by the autumn rains. In order to settle this question, if possible, we have begun to take series of silt samples, as yet, however, only in Lake Gesunden. The strata, deposited in comparatively still water, have parallel limiting-surfaces, and a thickness varying in different strata between 1 *mm* and 2 *cm*. If, during the high-water period, there was a particularly strong current, we notice discordant stratification in the part of the stratum deposited during that time. The limiting surfaces become undulated. As may easily be understood, the thickness of such strata varies considerably at different points, but still, by determining the average thickness of the stratum, it has been possible to ob-

tain connections of diagrams from places lying at some distance from each other. In these strata the clay-line has often been partly destroyed (eroded) at the high tide of the following year. In that case, remains are often found in the covering stratum in the shape of balls or bent and twisted pieces. In the purely proximal sediments, we cannot yet for certain distinguish the annual strata at Ragunda. They are made up of sand and gravel, locally separated by stripes of silt and clay with thick lenses of plant remains. Coarse gravel and peat-lenses are often stratified in alternate layers.

So far as the strata have been traced up till now, their thickness has been found to vary considerably. The strata lie in the form of lenses (sand-banks) on each other, and probably the current has succeeded in bringing about a considerable amount of erosion and redeposition.

The *plant remains* in the Ragunda lake-deposits are mentioned by HÖGBOM¹ and have earlier been described by GUNNAR ANDERSSON.² ANDERSSON examined a section about 500 *m* SE. of the old bridge of Ragunda, where he collected fossils from four different levels.

We have been able to confirm that the mode of occurrence of the plant remains at the locality, described by ANDERSSON in his above-mentioned paper, is on the whole in agreement with that of the whole region. In the lower, finer, distal sediments are found masses of leaves from foliferous trees and mosses on the surfaces of the layers, often in strata of a thickness of up to one or two *cm*, so firmly packed together that, when dug out of the sand they are almost as tenacious as pasteboard. After having been washed and sifted, these layers are found to contain all sorts of seeds in great abun-

¹ A. G. HÖGBOM. Om Ragundadalens geologi. S. G. U., Ser. Ca, No 182.

² G. F. F. Bd. 16. 1894.

dance. In the upper, coarser, more proximal sediments the main mass of the plant remains consists of branches, twigs, pieces of bark and coal. Pine-cones are of frequent occurrence, even leaves, mosses, and seeds are found here in a considerable number.

Especially characteristic with regard to the distribution of the plant remains and illustrating the formation of the layers is their *lenticular* appearance. On walking along the steep river-banks trying to follow a single dark streak of plant remains between two sand-layers one will perhaps see this streak gradually swell out to a bank, sometimes one or two dm thick, of veritable alluvial peat, which a little further on again gets thinner and thinner and at last vanishes in ordi-

Fig. 3.

nary not fossiliferous sand. At certain points such banks are accumulated upon each other in hundreds of layers, though a displacement of the layers may be observed in most cases, so that the greatest thickness of the uppermost banks does not lie perpendicular above that of the lower ones. This circumstance seems to indicate that these plant remains are deposited in a back- or still-water caused by some irregularity in the lake-bottom of that time. As the sedimentation went on, the currents changed and the still-water in question was displaced.

In many places, especially in the upper, coarser sediments the layers show a beautiful current-bedding, and then the plant remains lie on these layer-surfaces of the second degree (see fig. 3). In these cases we evidently have to deal with

plant remains deposited on the sedimentation-slopes of such miniature-deltas situated in or in the neighbourhood of some current.

When bringing together chronologically the fossiliferous localities hitherto examined, which are those richest in plant remains, that fact presents itself that these localities show such an inconsiderable difference of age that all of them fall within a period of somewhat more than a thousand years: 1 275—2 400. Of younger fossiliferous layers we note, however, the proximal delta-sediment at section 16, which we have not yet been able to insert in the chronology, further on layers of badly preserved fossils from about 3 000 at section 12. As to more ancient layers we note the discovery of *birch* and *Pinus silvestris* made by Professor HÖGBOM in the fjord clay at a stone's-throw N. of the new bridge of Ragunda, which plant remains are found to date from about 600. By further investigation new fossiliferous localities may, however, be discovered; on the other hand this restriction as to time is only applicable to the macroscopic plant remains. If an opportunity presents itself to extend the investigations to the *diatoms*, it is likely that a great many interesting and valuable results may be obtained.

From the stratigraphic investigations it appears that, on certain points, accumulation and erosion sometimes succeeded each other alternately, until at last the latter predominated so that no more sedimentation could take place there. Thus, it is evident that, when we assign a fossil to a certain annual layer in which it has been found, the number of this layer only gives the *minimum-age* of the fossil in question. It may derive its origin from more ancient layers destroyed by erosion, from where it has drifted with the current a longer or shorter way. Then it has been redeposited and is now found on a *secondary bed*. This redeposition may have been repeated several times.

In the above-mentioned paper GUNNAR ANDERSSON publishes

a detailed list of the plant remains found by him. As it has not yet been possible to analyze more than slight parts of the extensive material which the authors brought from Ragunda last summer in order to analyze the plant remains, we will only in a few words touch upon this part of the investigation and mention the discovery of some species of plants not met with by GUNNAR ANDERSSON.

In some layers at section 9 from about the years 1 275—1 350 after the deposition of that layer which has been taken as the starting point of the chronology, consequently a short time after the lake of Ragunda had been isolated from the fjord by means of the threshold at Storforsen, the following new species were found:

<i>Arctostaphylos uva ursi</i>	<i>Hippuris vulgaris</i>
<i>Zannichellia polycarpa</i>	

together with the following, which have also been met with by GUNNAR ANDERSSON:

<i>Alnus incana</i>	<i>Carex</i> spp.
<i>Betula odorata</i>	<i>Menyanthes trifoliata</i>
<i>Betula verrucosa</i>	<i>Pinus silvestris</i>
<i>Populus tremula</i>	<i>Scirpus lacustris</i>
<i>Potamogeton</i> spp.	<i>Thalictrum flavum</i>
<i>Prunus padus</i>	<i>Viola</i> spp.
<i>Rubus idaeus</i>	etc.

Of special interest is the occurrence of *Zannichellia*. This plant prefers salt or brackish water, and, therefore, if its position in these layers is a primary one, it must have lived in the lake of Ragunda at the time of their deposition as a relict from the fjord-period.

In some layers at section 13 from about 2 300—2 400 the following new species were found:

<i>Batrachium</i> sp.	<i>Hippuris vulgaris</i>
<i>Corylus avellana</i>	<i>Nuphar luteum</i>
<i>Eleocharis palustris</i>	<i>Polygonum</i> sp.

together with the following, which have also been met with by GUNNAR ANDERSSON:

<i>Alnus incana</i>	<i>Prunus padus</i>
<i>Betula odorata</i>	<i>Ranunculus</i> spp.
<i>Betula verrucosa</i>	<i>Rubus idaeus</i>
<i>Carex</i> spp.	<i>Scirpus lacustris</i>
<i>Comarum palustre</i>	<i>Stachys silvatica</i>
<i>Menyanthes trifoliata</i>	<i>Thalictrum flavum</i>
<i>Pinus silvestris</i>	<i>Ulmus montana</i>
<i>Populus tremula</i>	<i>Viola</i> spp.
<i>Potamogeton</i> spp.	etc.

The occurrence of the *hazel* is here of special climatological interest. This find consists of the half of a nut-shell and pollen-grains. We have, as formerly GUNNAR ANDERSSON, in vain searched for remains of *Picea excelsa* in the Ragunda lake deposits. Thus, the lake was saturated by sediments already before the immigration of this tree to the Ragunda region.

As regards the *animal remains* here met with, we have to note several remains of *Insecta* and epiderm of *Anodonta* sp. *Unio* sp. and *Margaritana margaritifera* which mollusks are found in a considerable number through the whole sequence of layers except in the fjord-clay and in the most recent layers at Vikbäcken and Halån.

From the above facts we cannot evidently at present draw any phyto-geographical and climatologic conclusions. However, some facts indicate that the amelioration of the climate has proceeded exceedingly rapidly from the melting away of the land-ice to the time when the climate was more genial than at present. This warm climate is characterised by *Ulmus* and *Corylus*. Evidence of this rapid amelioration of the climate is given by the discovery of *Pinus silvestris* in the fjord-clay from about 600 and of *Ulmus montana* which begins to appear in layers from 1800—1900 and seems to

increase in number upwards until 2 300—2 400 where it occurs abundantly together with *Corylus avellana*, as above mentioned. When the material of our investigation has been gone through in detail, we shall have an opportunity to give an *exact date of the progress of the amelioration of the climate towards the optimum and also of the different points of time when a great many plants immigrated to the Ragunda district*, all this given in minimum numbers. By immediately examining the Ragunda lake deposits themselves, it is impossible to determine the point of time when the postglacial deterioration of the climate began, as the lake was at that time already saturated by sediments.

Besides the examination of the fossiliferous lake deposits, the palæontological part of the investigation has been extended to comprise detailed monographic examinations of two peat-bogs in the neighbourhood. A great number of profiles have thus been analyzed in either of them. In this way we will try to complete the defective material of the lake deposits. The level of *Ulmus* and *Corylus* will serve as a means of connecting the layers of these peat-bogs with the exact chronology.

One of these peat-bogs is situated at Räfvanäset and was separated from the ancient lake of Ragunda only by a thin sand barrier a few *m* high. The second is called Hannmyren and is situated E. of the church of Ragunda, close by the highest marine limit. This peat-bog may be dealt with here in a few words as a new locality of fossil hazel.¹

At the southern border of the bog, on the northern slope of a rather high, rocky hill, the following sequence of strata is found:

- a) 20 *cm* ploughed and mouldered *Carex*-peat.
- b) 20 *cm* dark *Carex*-peat, mixed with *Sphagna*, birch-bark, twigs, and wood.

¹ GUNNAR ANDERSSON: Hasseln i Sverige fordom och nu. S. G. U.; Ser. Ca, No 3.

- c) 10 cm = the preceeding layer, but also containing seeds of *Menyanthes trifoliata* and leaves of *Amblystegia*.
- d) 15 cm brown *Carex*-peat with *Sphagna*, *Amblystegia*, wood, birch-bark, *Menyanthes*, and *Equisetum*.
- e) 20 cm *Carex*-peat with *Sphagnum*, birch-bark, twigs, *Menyanthes*, *Equisetum*, cones of *Pinus silvestris*, and nut-shells of *Corylus avellana*.
- f) 20 cm muddy peat with twigs and bark of *Betula* and seeds of *Menyanthes*.
- g) 20 cm = the preceeding layer, moreover containing wood and *Equisetum*.
- h) 15 cm peat, towards the bottom of an earthy nature, in the uppermost part with fruits of *Carex* sp., the remainder with fragments of birch and *Equisetum*.
- i) Sand.

The strata a), b), and c) contained remains of *Picea excelsa*. In the uppermost part of the stratum d) remains of the plant ceased, however, to occur so that even pollen-grains were not found deeper than the middle of this stratum, where they occurred, though very rarely.

Sammanfattning.

Som bekant tappades 1796 plötsligt den uti Indalsälvens dalgång liggande *Ragundasjön*. Genom denna katastrof, hvilken berodde på, att den glacifluviala ås, som öfvertvårar dalgången, genombröts, torrlades den gamla sjöbotten och serier af naturliga profiler blottades, i hvilka de utfyllande sedimentens bildningssätt och struktur kunna studeras. På grund af att dessa sediment äro afsatta i form af årshvarf, erbjöd sig här, som prof. DE GEER först framhållit, ett unikt tillfälle att i detalj följa en sjös hela utveckling ifrån dess uppkomst, under dess utfyllning till dess slutliga torrläggning.

En dylik undersökning sattes vi i tillfälle att påbörja under sommaren 1911 tack vare erhållandet af ett LILJEWALCHS stipendium från Stockholms Högskola. Denna uppsats utgör ett preliminärt meddelande öfver de hitintills vunna resultaten.

Allteftersom isranden drog sig tillbaka från området, bildades de rullstensåsar, som nu slingra sig fram på botten af dalgångarna, samt den glaciala leran. Då landet steg från sitt läge vid M. G. (vid Dövikens c:a 237 m ö. h.) och flodmynningarna successivt flyttade sig nedåt dalgångarna, uppbyggdes deltan, hvilka i sin tur genomskuros af älvarna. Härvid uppstodo vackra terrasssystem, af hvilka fig. 1 visar en tvärprofil.

Från den stund — enligt R. LIDÉN omkring 1050 år efter den första bipartitionen i Indalsälvens dalgång af isresten kring isdelaren i östra Jämtland — som klipptröskeln vid Ragunda-bäckenets forna utlopp, Storforsen, kom ofvan vattenytan, daterar sig sjöns uppkomst och därmed också undersökningsområdets särställning i förhållande till andra förut studerade norrländska älfdalar. Vi ha nämligen här ett slutet bäcken, i hvilket sedimenten kunde afsättas och hvilket varit oberoende af det nedanför liggande landets epeirogenetiska rörelser. Detta förhållande, som vid första påseendet kan tyckas förenkla sedimentationens gång och utveckling, har i stället invecklat dessa problem högst betydligt. Det visade sig nämligen, att Ragunda-bäckenet redan ifrån sin första uppkomst till stor del var utfyllt af sediment. Då Indalsälven medför ytterst litet slam öfver Krängedeforsarna, har det verkliga sjösedimentet, som hittills endast anträffats på ett fåtal ställen mellan järnvägsbron och Hammarstrand, sålunda till största delen bildats af förut afsatta sediment dels inom sjöbäckenet själf och dels i sidodalarna. Vi få sålunda här inom ett starkt begränsadt område en ständig växelgång mellan sedimentation och erosion. Vid uppmätandet af sedimentprofilerna påträffas sålunda oupphörligt diskordanser och

andra erosionsfenomen. Detta försvårar i hög grad undersökningarna, men lägger dock ej så stora hinder i vägen, att man ej genom ett detaljeradt uppmätande af hvarfven noggrant kan följa utfyllnadsmekaniken.

De profiler, som visa en orubbad lagerföljd, och hvilka innehålla omkring 3 600 hvarf, kunna emellertid ej användas till ett bestämmande af hela den postglaciala tidens längd. Det visade sig nämligen vid nivellering af de stora plan, som utbreda sig vid Hammarstrand (fig. 1 och Pl. 5), Halån och Singsån, att dessas öfveryta ligger så nära den forna sjöstrandlinjen (138,8 *m* ö. h.), att de vid sjöns lågvatten varit torra eller endast täckta af särdeles grundt vatten. Genom att därtill jämföra flera profiler öfver lagerserien från skilda ställen med LIDÉNS resultat kommo vi till den uppfattningen, att *dessa plan voro färdigbildade och att sjön såhunda var mättad med sediment redan flera tusen år innan tappningen 1796 ägde rum.*

Vid de paleontologiska undersökningarna har anträffats *Zannichellia polycarpa* från lager, afsatta kort efter Ragunda-sjöns isolerande från fjorden, 1 050 år efter den första bipartitionen. De fynd af *hassel* och *alm* i lager från omkring 2 300—2 400 hafva vidare gifvit vid handen, att den postglaciala klimatförbättringen försiggått särdeles snabbt från isens afsmältning fram mot det klimatiska optimet. Vidare må omnämnas en ny lokal för fossil *hassel* i Hannmyren, Ragunda socken. Fyndorten är belägen i kanten af myren, hvilken ligger strax invid högsta marina gränsen på nordslutningen af en bergkulle.

Stockholms Högskolas Geologiska Institut, mars 1912.

Section through the sediments near Hammarstrand. (See the map, fig. 2). The dotted line marks a discordance.