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EXHIBITION OF OBJECTS BEARING ON PROF. A. HAMBERG'S INVESTIGATIONS OF THE SAREK MOUNTAINS

BY

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Exhibition of objects bearing on Prof. A. Hamberg's investigations of the Sarek Mountains.

A. The Exhibition in the Session Hall of the Meteorologico-Hydrographical Institute.

The Sarek region forms a comparatively extensive mountain region, which is situated about between 67° 5′ and 67° 30′ N. Lat. and between about 0° 5′ E and 0° 45′ W of Stockholm. It contains seven summits which rise above 2,000 m and at least forty which stand between 1,800 m and 2,000 m. In spite of the not very considerable height great parts of the region, thanks to its northerly situation, show a high-alpine character with some hundred glaciers. Since the year 1895 it has been the subject of a detailed scientific investigation conducted by the present writer.

On the occasion of the meeting of the Hydrographical Union there are being exhibited a number of photographs and apparatuses etc. throwing light upon both the peculiar natural scenery of the district and the methods of hydrographical and meteorological investigation that have been used. As the precipitation conditions seemed to be of specially great interest, the present writer attempted, as long ago as 1899, to obtain some measure of the magnitude of the precipitation. But as the district was, and still is, uninhabited, it was not possible to obtain precipitation observations by means of daily measurements of it. I therefore resolved to attempt to collect the whole precipitation for about a year by making the precipitation gauges very great and providing them with salt to melt the snow that fell into the gauge and to prevent evaporation of the collected precipitation by providing the gauges with a quantity of oil which, owing to its lower specific gravity and its impermeability by water, should form a protective covering. This was, so far as I know, the origin of what are known as totalisators, wichh have since then spread over the whole world. On the bare fell, however, owing to the influence of the wind, this method gives very uncertain results for snow, but in the forest, even the comparatively low and thin birch forest, the results seem to be satisfactory. These first totalisators, however, had a far from suitable form and are not represented at the exhibition. Since then I have combined totalisators with meteorographs: a picture of one of these contrivances is shown in Nos. 11, 13 and 14.

The distribution of the glaciers in the Sarek district is shown in the little provisional sketch-map (No **1**). Their number amounts to about 100. As a rule, they are marked valley-glaciers, but plateau-glaciers of what we may call a

Scandinavian type are also to be found, such as the Jokotjkaska glacier (No **2**). The valley-glaciers have sometimes a considerable breadth in comparison with their length, such as the Pårte glacier (No **3**), which is 2—3 km broad with a length of only 5 km.

One of the most magnificent glaciers is the Mikka glacier, which is illustrated by the panorama (No **4**). This glacier has been the object of a detailed research with regard to velocity, ablation and accumulation. A certain part in the development of the technique of glacier investigations would seem to have been taken by the niveometer which was set up on the Mikka glacier and on the accumulation area of the Pårte glacier in the summer of 1903 (No **5**). On the roof terrace there are exhibited both a niveometer (Exhibit 32) and drills that have been used in ablation measurements (Exhibit 33).

Numerous investigations into the structure of the ice, the morphology of snow etc. have also been made. No **6** shows an inner moraine which emerges discordantly to the veined structure. No **7** illustrates very beautifully the undulations assumed by smooth snow and ice surfaces owing to the turbulence of the wind. This circumstance stands out extremely distinctly on the photograph (7), as fine dust has settled on the crests between the depressions.

Owing to the fact that the district is uninhabited and is seldom visited, little is known about the occurrence of avalanches. After storms with a deposit of hoar-frost on the highest summits it is possible to observe them on their steep slopes as soon as mild weather sets in. Within the higher parts of the glaciers there are sometimes encountered great piles of avalanche snow, and even in narrow valleys with an altitude of about 800 m. I have now and again seen great piles of avalanche snow which had not yet melted by 1 August.

No **8** shows an avalanche of snow that rested over a brook which I and my fellow-workers had the advantage of using as a bridge in our passage there in the beginning of August 1900. At that time all transport of goods was effected by means of pack-reindeer and porters, and we lived in tents; but in 1902 there was built a little wooden hut, »Hotel Säkokjokk» (No **9**). About ten years later I built several rather good huts, some of which are reproduced in Nos 18, 19, 21, 22, 23, 24 and 26.

As the precipitation appeared to be exceptionally great, it seemed to be of interest to obtain an idea of its magnitude not only by precipitation gauges, but also by investigations of the amount of water discharged. The first work of this kind began in 1897, and was performed with a plummet that was sunk from the end of a rod down to the surface of the water (No **10**). As the observer, a Lapp settler, had a long way to go, the observations were made only twice a month during the period when the ice-covering did not exist. These observations ought to give a fairly good idea of the great abundance of precipitation in the district.

However, I long had visions of the idea of effecting continuous observations on this river, the Rapaätno, which drains at least 30 % of the glaciers of the district and plays such a great part in the whole of its physiognomy. Attempts were made as long ago as 1903 with a gauge whose tubes were filled with

paraffin oil, but the result was not good, mainly owing to the enormous amounts of silt which the river carried and which stopped up the openings of the gauge-tube.

Hence it proved necessary to use wider tubes and to place the mouth in the strongest current possible. But the carrying out of this idea was postponed until the years 1914—1915, when a large meteorograph was built below the Litnok rapids, intended to record not only the water-stage, but also the meteorological facts, the temperature of the air, the humidity of the air, the velocity and direction of the wind. Owing to the inaccessibility of the district the meteorograph was furnished with clockwork that would go for a year; and this rendered it possible to obtain continuous observations without winding up the clockwork except on visits every summer (No **12**). Another thing is that in order to obtain fairly reliable values for the atmospheric temperature, comparisons are necessary both in the summer and in the winter.

No **11** shows the Litnok meteorograph in the summer, No **13** in the winter. After it had been in use for some years, it turned out that the float did not follow the water-stage exactly, which was considered to be due to the fact that despite the strong current, the mouth of the tube in the river had become to some extent stopped up by silt. Since then I have cleaned the gauge-tube every summer by pumping; and after such a thorough rinsing the gauge-tube has always remained open until the following summer. No **14** shows the execution of such a pumping process.

The great amount of silt carried by the Rapaätno from the thirty glaciers that it drains is for the most part dropped at the point where it flows into the Lake Laitaure. That lake formerly had a length of about 15 km, but has already been half filled up by a complicated delta, (which is reproduced in the panorama in No **15**), which will probably in the course of time fill up the whole lake, leaving behind such a system of arms of the river, lagoons, channels, sandbanks etc. as is made quite clear by the panorama. Several lakes which formerly existed in the Rapa valley have been filled up by such delta formations. Such a filling, about 10 km long, is illustrated in No **16**.

The numerous watercourses, together with the vegetation of the valley and what is in certain places a fairly abundant fauna, contribute to give the landscape colour and mobility. In the winter almost the whole landscape is covered with ice and snow, with the exception of the writhen alpine birches and a dark moraine hummock or rocky crag here and there which has been freed from its covering of snow by the wind. Lakes and brooks are covered with ice and snow and make no appearance whatever in the landscape. Hardly any springs occur at a height exceeding 900 m. The lakes are covered by a layer of ice about one metre thick and this takes a long time to melt. On land the melting of the snow in the spring takes place more rapidly, and owing to the rise of the water in the lake basin the ice-covering is raised so that channels are formed along the shores, where also, owing to the absorption of heat, melting is to some extent accelerated. No **17** shows persons rowing in such a land ice-hole on Lake Randijaur east of the fell.

The surmised great precipitation, the glaciers and the changes of vegetation with the altitude above sea-level led to the institution of meteorological observations in the district. They were begun with self-registering apparatuses, but in 1914 there was erected on a rocky plateau 1834 m high, belonging to the Pårtetjåkko massif an observatory where meteorological and atmospheric electricity observations were made during the period from 1 July 1914 to 15 September 1918. Nos **18**, **19** show this observatory during the first summer of its activity. We notice the balls set up on rods which are intended to measure the amount of hoar-frost which is very considerable in time of storms, especially during the autumn. No **20** shows clearly how the hoar-frost settles like a kind of horizontal stalactites on the thermometer cage and other erect objects. At the opening of the cage, which is placed on the eastern side, the hoar-frost has been scraped off. The dwelling-house itself (No **21**) was also covered by a hard, adhesive, knobby mass of ice, which on the lee side may be assumed to have attained great dimensions where it had not been scraped off. No **22** shows the observatory on a cloudy winter day.

The observatory on Pårtetjåkko was at the time of its establishment the most northerly meteorological observatory at any considerable altitude north of the Alps. As a comparative station it was possible to use the little Government station at Kvikkjokk (330 m). In 1916, however, I set up another comparative station at Pårek (710 m) at the foot of Mount Pårtetjåkko, almost exactly on the forest limit. This little observatory (Nos **23**, **24**) was at work for two years; but during some summers continued series of observations from there have been obtained, and a meteorograph is still at work there.

For the study of the forest limits there have also been set up at several places thermometer cages with thermographs and hydrographs and apparatuses for the study of the velocity (Nos **25**, **26**) and direction (No **26**) of the wind.

The Litnok meteorograph, which was mainly built to aid the study of the amount of the flow of the water and the variations of the River Rapaätno, has also supplied continuous meteorological observations. The diagram in No **12** shows samples of the nature of the registrations. We may specially notice the excellent daily periodicity in the variation of the water-stage in the summer, which is dependent on the variations in the melting of the glaciers. It is not until about 1 a. m., however, that the maximum reaches Litnok, which lies about 30 km below the centre of the glacier area.

No **27** gives a total view of the mountain region from the west. Here we notice that the only high summit Lanjektjåkko is covered by snow to the very highest peak in spite of the heavy exposure to wind. It is evidently masses of hoar-frost that cover it and prevent the snow from blowing away.

B. Exhibition of apparatus on the roof-terrace of the Meteorologico-Hydrographical Institute.

This section of the exhibition comprises a number of meteorological apparatuses which have been used in the investigation of the Sarek district but have been brought home; there is also a niveometer.

28. The meteorograph, which runs for nearly two months. It registers the temperature of the air, the humidity of the air, the velocity and direction of the wind.

29. An apparatus for registering the duration of the sunshine, running for nearly two months. An image of the sun is reflected from the mirror into a camera, the optical axis of which is made parallel to the axis of the earth. On the surface of the picture there is moved forward every night by means of clockwork, a new piece of sensitive paper.

30. An apparatus registering the velocity of the wind on a Richards registering cylinder with thermograph paper. 1° in the hour corresponds to a mean velocity of about 0.6 m per second.

31. An apparatus for the registration of the direction of the wind on an ordinary registering cylinder, which requires winding up once in twenty-four hours or once a week.

32. A niveometer of the same kind as those which were set up on the Pårte glacier and the Mikka glacier in 1903.

33. Ice-drills that have been used for many years for the measurement of ablation, mainly on the melting area of the Mikka glacier.

List of objects exhibited.

A. *In the Session Room.*

1. Sketch-map of the Sarek district, mainly showing the place-names and the shape and size of the glaciers there.
2. The Jokotjkaska glacier, a plateau-glacier of mainly Scandinavian type.
3. The Pårte glacier, a broad valley-glacier 2—3 km broad and 5 km long.
4. The Mikka glacier, a comparatively narrow valley-glacier, about 5 km long and with an ice-tongue only 1 km broad.
5. Niveometer in the accumulation area of the Mikka glacier.
6. Inner moraine emerging discordantly in relation to the veined structure.
7. Melt-holes that have arisen owing to the turbulence of the wind and that are strongly marked by streaks of mud.
8. Avalanche snow forming a bridge over a brook.
9. »Hotel Säkokjokk», the first hut that was built in the district, 1902.
10. The earliest arrangement for measuring the water-stage in the River Rapa, the chief drainage river in the fell district.
11. The Litnok meteorograph, registering the water-stage of the River Rapaätno, together with the temperature of the air, the humidity of the air, the velocity and direction of the wind, with clockwork needing to be wound up only once a year.
12. Sample of the registration of the Litnok meteorograph. The water-stage curve shows during clear summer-days a fine daily variation, due to the periodicity of the melting of the ice on the glacier.

13. The Litnok meteorograph in the winter.
14. The gauge-tube of the Litnok meteorograph being pumped to clear it of silt.
15. The delta of the Rapaätno, which carries a great quantity of silt at high water, at its outflow into Lake Laitaure.
16. Delta formations which fill up a former lake, 10 km long, between Mount Skårkas on the right and Mount Pelloreppe, on the left, about 20 km above its outflow into Laitaure.
17. Rowing in a land ice-hole, a kind of channel which is formed during the spring between the shore of the lake and the metre-thick ice-covering after that has been lifted by the rise of the water-stage.
18. The meteorological observatory on Pårtetjåkko, 1834 m above sea-level, from July 1914.
19. The observatory on Pårtetjåkko from July 1914.
20. Hoar-frost stalactites on the thermometer cage.
21. The observatory hut covered with knobby hoar-frost.
22. Winter view of the observatory on Pårtetjåkko, 1916.
23. The meteorological observatory at Pårek, 710 m above sea-level.
24. The observatory at Pårek.
25. Anemometer in the Rapa valley, looking towards Snavvavagge and the Skårkas hut.
26. Anemometer and wind-gauge fitted on a joint platform. Pårek.
27. View from Mattåive, looking towards the Sarek mountains in the east with the lofty Lanjektjåkko covered with hoar-frost.

All the photographs have been taken by the present writer except Nos 20 and 21 taken by H. Köhler and No 22, taken by M. Hofling.

B. *On the roof-terrace.*

28. Meteorograph with clockwork running for two months.
29. Sunshine register running for two months.
30. Anemometer registering on an ordinary thermograph cylinder.
31. Apparatus for registering the direction of the wind on an ordinary registering cylinder, running either for a day or for eight days.
32. Niveometer, model 1903.
33. Ice-drills used for ablation measurements.

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