

OBSERVATIONS AND PHOTOGRAPHIC MEASUREMENTS OF MOTHER OF PEARL CLOUDS OVER SCANDINAVIA 1930—1938

FIRST PART

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Summary. Given in the present paper are observations and results of photographic measurements of some Mother of Pearl Clouds in the years 1930—32. Height measurements of the clouds on February 12, 1930, gave, from 28 measured points, the mean height of 24.0 km. Under the clouds was a layer of cirrus stratus clouds at a height from 11 to 14 km.

On January 29, 1932, the mother of pearl clouds were exceptionally beautiful and much material was collected. The mean height of 238 measured points was 27.4 km. Measurements of the velocity gave from 10 to 12 meters per second towards SE. The clouds showed

rapid changes probably due to successive evaporations and condensation taking place in the layer 26 to 28 km over the earth. The meteorological conditions were the same as already pointed out by Mohn for the Mother of Pearl Clouds in 1871—1892.

Of some fine clouds in the morning of February 1, 1932, photographs and sketches from amateurs combined with single photographs from Oslo gave a probable height of 23 km.

The next paper is to give the measurements of the Mother of Pearl Clouds on February 19—20, 1932, and on February 6, 1934.

Introduction.

In 1926 and 1932¹ I gave the first reliable height-measurements of the remarkable stratospheric clouds called *Mother of Pearl Clouds* or *Nacreous Clouds*. They were situated in the height interval from 22 to 30 km, were characterized by their brilliant prismatic colours just after sunset or before sunrise and appeared in the winter months over Scandinavia under certain meteorological conditions.

Besides the material from 1926 and 1929 published in these two papers, I have a long series of photographs and visual observations from 1930, 1932, and 1934, which will be published in full in the present series of papers. Only some extracts of this most interesting material² have so far been published.

In the list given below, the occurrences of mother of pearl clouds in the years since 1930 are given; the dates where photographs for height measuring were taken are printed in heavy type.

¹ *Photographische Bestimmung der Höhe von irisierenden Wolken* (Perlmutterwolken) am 30. Dezember 1926. *Geof. Publ.* Vol. 5, No. 2 and *Höhe und Farbenverteilung der Perlmutterwolken*, *ibid.* Vol. 9, No. 4.

1930.

February 11: Nacreous clouds observed from Offersøy in Salten, northern Norway at 16^h.

February 12: Fine nacreous clouds observed and photographed from my stations Oslo and Oscarsborg, from 17^h 49^m to 18.45 M. E. T. Among the simultaneous pictures, 10 could be used to determine height and situation of the nacreous clouds and of certain lower clouds. Some pictures in natural colours were also taken from Oslo.

1931.

December 15: Before sunrise, the sky in Oslo had the same bluish white colour which often forms the back-ground of nacreous clouds. Diffuse shining

² *Mother of Pearl Clouds over Scandinavia in January and February 1932*, *Nature*, June 25, 1932 and *Quarterly Journal of the Royal Meteorological Society*, Vol. 58, No. 245, July 1932; *Nuages dans la Stratosphère*, *Comptes Rendus, Acad. d. Sciences, Paris*, Tome 196, p. 1824, *Höhenmessungen von Stratosphärenwolken*, *Beiträge zur Physik der freien Atmosphäre*, Vol. 21, 1, 1933.

bluish white clouds were seen but without prismatic colours.

At Darbu (latitude $59^{\circ} 40'$, longitude $10^{\circ} 48' E$) Mr. Olaf Hassel observed $15^h 55^m$ M. E. T. in due west, a small nacreous cloud, 9 degrees over the horizon. At 15^h it was red and disappeared soon afterwards.

1932.

January 14: About sunset I saw in Oslo very fine nacreous clouds in breaks of lower clouds, but only for some minutes; in fact a short time afterwards the sky became completely overcast.

January 18: Nacreous clouds reported from northern Norway.

January 19: A series of reports received from northern Norway, Sweden and Finland.¹

January 20: A series of reports from northern Norway and Sweden.

January 22: Nacreous clouds seen at $8^h 15^m$ — $8^h 50^m$ from Øffersøy, Salten, northern Norway.

January 23: Observations from Finland.

January 25: One observation from Finmark, one from Sodankylä, Finland, and one from Oslo.

January 26: Some observations from Abisko, Sweden, from Finland and from southern Norway (one with a coloured sketch).

January 27: Very fine nacreous clouds in Oslo in the morning before sunrise. About 40 observations from different parts of southern Norway.

January 28: About a dozen observations from Trondheim, Dombås and adjacent districts.

January 29: Mother of pearl clouds of exceptional beauty, in the morning, and especially after sunset, all over central Norway from Oslo to Trondheim. More than 100 observations and a series of drawings and photographs from amateurs.

From my auroral stations Oslo and Oscarsborg I obtained 42 successful sets of photographs for determining the height. The late Captain Ween of the Geodetic Survey (Norges Geografiske Opmåling) took some photograms with base-line Oslo—Nordstrand, 5.7 km. Some photographs in natural colours were also taken. Also observations from Sweden and Finland.

January 30: Seven interesting reports from southern Norway of fine nacreous clouds before sunrise.

February 1. More than thirty reports from southern Norway of very beautiful nacreous clouds before

sunrise. A series of single pictures were obtained from Oslo and these together with some pictures and sketches from amateurs may be used for determining height and situation. Also some reports from southern Norway on clouds after sunset.

February 2: One observation from Skjærberget, Trysil, NE of Oslo at $7^h 30^m$ morning.

February 3: Two reports from central Norway (Otta and Trysil).

February 10: One report from northern Norway, Skibotn in Lyngen.

February 14: After sunset nacreous clouds seen from Augedal, Vestre Gausdal, at $16^h 30^m$.

February 17: Report from Finland.

February 18: A further report from Finland.

February 19—20: Nacreous clouds of exceptional beauty about sunset in southern Norway. About 70 reports with sketches and a series of interesting photographs were received. In Oslo, I observed and photographed the clouds after sunset and later from midnight till next morning in moonlight. The aurora stations Oslo, Oscarsborg, Kongsberg and Tømte were in action and 66 good sets were secured for determining height and situation.

A series of photograms was also taken by Captain Ween with base Oslo—Nordstrand.

Four very interesting photographs in natural colours by Mr. Simonsen and moving picture films both common and in natural colours were obtained by Mr. Gihbsson and Mr. Schjerven of the firm, Nerlien, Oslo.

February 20: Small nacreous clouds before sunrise and after sunset were seen in Oslo and at some other places. The photographs and sketches probably sufficient to determine their height.

February 24: Report from the west coast of Norway (Surnadal, Jølster).

February 28: Report from Årdal, Sogn.

March 8: Report from Gåsøy, Finmark.

1933.

No reports received.

1934.

January 20: Very fine nacreous clouds seen from Lødingen, northern Norway, at 10^h to $10^h 15^m$ and from northern Sweden, at about 2^h .

January 23: Interesting report from Balsfjord, northern Norway with photograph of beautiful nacreous clouds at noon. Similar clouds reported to be seen from 11^h to 13^h at Ingøy Finmark.

¹ The reports from Finland are taken from a letter I received from Dr. Keränen, dated 24 February 1932.

January 24: After noon very fine clouds seen both from Ingøy and from Vardø in Finmark, northern Norway.

February 1: Nacreous clouds observed from 8^h to 11^h at Ingøy, Finmark.

February 2: Extremely beautiful nacreous clouds at Ingøy, in SSE, with all the colours of the spectrum and shining very intensely. Appeared from 8^h—15^h but often obscured by lower clouds.

February 3: Very fine nacreous clouds observed at about 9^h from Øffersøy, Salten, northern Norway (sketch followed). Similar reports from two other places, Myken and Meløy.

February 5: Nacreous clouds in SSW reported from Ingøy, Finmark.

February 6: About 30 reports with sketches and some photographs from southern Norway, of very fine nacreous clouds in the morning and about sunset. At sunset, I had my aurora stations Oslo, Oscarsborg, Tømte, Kongsberg and Darbu in action, the last station working independently. A series of 24 sets of good pictures were secured for determining height and situation.

Mr. Hassel took also a series of single pictures from his station Darbu.

Pictures in natural colours were secured from Oslo by Mr. Simonsen and a moving picture film in natural colours by Mr. Gihbsson.

February 7: Most interesting nacreous clouds were seen in SE before sunrise. I took a series of single photographs. Some photographs were also taken independently by Mr. Hassel, Darbu.

About 30 reports from different parts of southern Norway, with sketches and photographs.

February 14: Some photographs and observations from Darbu and from Dombås.

February 16: Beautiful nacreous clouds seen from Dombås in S by Mr. Einbu. Also some observations from other places in southern Norway.

February 17: Nacreous clouds in SSE seen by Mr. Einbu, Dombås.

1935.

January 6: Fine nacreous clouds after sunset observed from Åfjord, Sør Trøndelag.

January 7: Nacreous clouds observed in Kuopio in Finland (according to Dr. Keränen).

January 8: Nacreous clouds observed by Dr. Justesen in Vuotso, northern Finland and from Kajaani by Dr. Keränen.

January 10: Nacreous clouds observed and photographed by Mr. Chalonge from Abisko, Sweden, at 10^h 15^m.

January 15: Nacreous clouds at 15^h—16^h seen from Abisko by Mr. Chalonge. Similar clouds also observed by Mr. Einbu, Dombås, and from Lillehammer.

January 18: Observation from Mr. Einbu, Dombås, in the morning.

January 19: Same observation.

January 20: Observations of very fine clouds from Dombås, Trondheim and from Darbu (with sketches).

January 21: Reports from Porsgrunn and Norderhov, southern Norway.

January 22: Clouds of exceptional beauty observed by Mr. Einbu, Dombås, from Kvam, Gudbrandsdalen and Hjerkin, Dovre.

January 23: Cloud observed in the morning from Nes, Romerike.

March 11: Fine nacreous clouds observed from Billefjord, Porsanger, Finmark from 16^h—18^h.

1936.

No reports received.

1937.

No reports received.

1938.

January 5: Nacreous clouds seen in Kristiansand after sunset.

February 20: Report and sketches of fine nacreous clouds at 16^h 30^m from Gudbrandsdalen, central Norway.

February 21: Nacreous clouds in E seen in the morning, from Ytterstad, Lødingen, northern Norway.

November 14: For some minutes, a nacreous cloud was seen at 15^h 40^m from Lillehammer, by Mr. Haakon Lie.

At my request Professor H. SOLBERG has done me the great service of examining the daily weather maps for the period when mother of pearl clouds appeared. His conclusion is as follows: "By far the greatest number of cases shows that a great cyclone has passed to the north of the place of observation and that the clouds generally appeared as soon as the lower clouds has dissolved after the passage of the cold front.

The three fine cases observed in Oslo, January 29, 1932, February 19—20, 1932, and February 6—7, 1934, were especially typical in these respects, all

three being connected with the passage of a severe cold front over southern Norway.

These results agree with those of the late Professor Mohn, who studied the mother of pearl clouds in Oslo for more than twenty years (1871—92) and arrived at the following conclusion¹: These clouds appear by dry and warm westerly winds, when a low and sometimes very low depression is situated to the north or north-east of Oslo, that is, in the situation of a "Föhn" wind.

Expressed in modern meteorological language this signifies that the clouds were seen after the passage of the cold front of the cyclone".

CHAPTER 1.

Mother of Pearl Clouds 11th and 12th February 1930.

1. Mother of Pearl Clouds in Northern Norway on February 11th, 1930.

From Mr. MAGNUS OS, a school-teacher, *Offersey in Salten*, northern Norway, (Latitude $68^{\circ}.3$, Longitude $15^{\circ}.6$) I received the following report: "In the afternoon of February 11th 1930, about 16^h, I observed a remarkable cloud. As I had never seen anything like it, I followed it with great attention. The sky was filled with shower clouds and the cloud in question was seen in breaks from 16^h to 16^h 30^m.

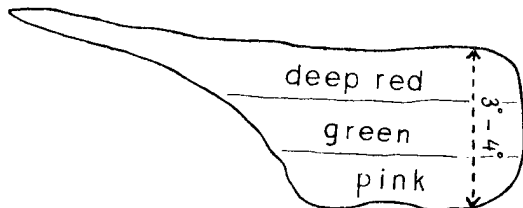


Fig. 1.

The cloud had a form like the sketch (fig. 1) and appeared on an almost clear sky between the heavy shower clouds. Some stripes of cirrus clouds were also seen; these were pale without any colours. The remarkable cloud, however, had the colours of a rainbow, as indicated in the sketch.

The cloud had no perceptible motion. The colours were fine and very conspicuous. It was situated about 30° over the horizon in SW and diametrically opposite to the moon, only some degrees more to the

¹ H. MOHN, *Perlemorskyer*, Chra. Vid.-Selsk. Forh. 1893, No. 10 and *Irisierende Wolken*, Meteor. Zeitschr., March 1893.

west. The cloud was seen for about 15 minutes and then it was obscured by the lower clouds".

From the description, it is clear that the cloud was a mother of pearl cloud.

2. The Measurements of the Nacreous Clouds in Southern Norway on February 12th, 1930.

The next day Dr. Refsdal, a meteorologist of the Norwegian Meteorological Service, telephoned to me after noon and said the meteorological situation over Scandinavia was favourable for nacreous clouds.

I understood from the appearance of the sky that nacreous clouds would probably appear, and made my preparations accordingly. At sunset, I had telephonic connection between my auroral station on the roof of Oslo Observatory and my station on Oscarsborg, south of Oslo, base-line 27.4 km. In Oslo, I myself worked, with my assistant Mr. H. J. Tveter, and, on Oscarsborg, Mr. Harry Larsen. I had also secured the assistance of Mr. Simonsen from the firm Nerlien in Oslo, photographer, who took some pictures in natural colours from a roof in the centre of Oslo.

I am sorry that the sky was not quite clear. Thin lower clouds prevented stars from being seen: the nacreous clouds, however, shone intensely through the lower clouds, and 24 sets of pictures were taken simultaneously from Oslo and Oscarsborg, half of them through filters on pancromatic plates and the other half on Sonja plates.

The horizon on each station gave enough reference points for the measurements. The reference points had been determined by photographing the landscape with stars and measuring out the coordinates of the reference points from calculated coordinates of the stars, by means of nets.

Among the pictures, the following could be used for measuring height and situation:

No.	Time M. E. T.	Plate	Filter	Remarks
1	17 ^h 49 ^m 09 ^s	Pan.	Red	Very good
2	" 49 36	"	"	Good
3	" 50 07	"	"	"
4	" 50 39	"	"	"
5	" 51 14	"	"	Lower clouds interfering
6	" 52 06	"	"	"
7	" 54 33	"	"	"
13	18 22 31	Sonja	non	Only cirrus measured
14	" 22 52	"	"	"
15	" 23 20	"	"	"

Table 1.

No.	P	p	h	a	H	D	Remarks	No.	P	p	h	a	H	D	Remarks																																																																																					
1	1	10.7	13.7	64.1	24.1	96	Points 2, 3 and 4 are the best. Next comes point 1. The rest are not so good on account of diffuse outlines and unfavourable situations to the direction of displacement (see Plate 1 and 3). Mean H = 23.3 km.	<p>Under the nacreous clouds was a layer of high clouds probably cirro-stratus. A series of points of these clouds was chosen and the height determined, which gave the following results, the refraction being taken in account.</p> <table border="1"> <tr> <td>2</td> <td>6</td> <td>9.2</td> <td>4.5</td> <td>83.3</td> <td>13.5</td> <td>149</td> </tr> <tr> <td rowspan="3">3</td> <td>3</td> <td>13.0</td> <td>6.5</td> <td>90.4</td> <td>13.4</td> <td>109</td> </tr> <tr> <td>4</td> <td>13.4</td> <td>7.3</td> <td>86.7</td> <td>13.9</td> <td>102</td> </tr> <tr> <td>5</td> <td>12.0</td> <td>5.6</td> <td>94.8</td> <td>13.3</td> <td>123</td> </tr> <tr> <td>4</td> <td>6</td> <td>9.4</td> <td>4.3</td> <td>83.7</td> <td>12.8</td> <td>146</td> </tr> <tr> <td>6</td> <td>3</td> <td>9.6</td> <td>4.4</td> <td>83.1</td> <td>12.6</td> <td>142</td> </tr> <tr> <td>7</td> <td>4</td> <td>12.9</td> <td>5.4</td> <td>93.3</td> <td>11.5</td> <td>103</td> </tr> <tr> <td rowspan="2">13</td> <td>1</td> <td>8.1</td> <td>3.5</td> <td>78.5</td> <td>12.1</td> <td>163</td> </tr> <tr> <td>2</td> <td>6.4</td> <td>2.8</td> <td>76.3</td> <td>13.4</td> <td>204</td> </tr> <tr> <td rowspan="2">14</td> <td>1</td> <td>8.1</td> <td>3.5</td> <td>78.7</td> <td>12.2</td> <td>163</td> </tr> <tr> <td>2</td> <td>7.2</td> <td>2.6</td> <td>77.3</td> <td>11.0</td> <td>183</td> </tr> <tr> <td rowspan="3">15</td> <td>1</td> <td>9.2</td> <td>4.0</td> <td>84.6</td> <td>12.4</td> <td>151</td> </tr> <tr> <td>2</td> <td>8.1</td> <td>3.4</td> <td>78.8</td> <td>11.9</td> <td>164</td> </tr> <tr> <td>3</td> <td>6.8</td> <td>2.7</td> <td>76.9</td> <td>12.1</td> <td>193</td> </tr> </table>	2	6	9.2	4.5	83.3	13.5	149	3	3	13.0	6.5	90.4	13.4	109	4	13.4	7.3	86.7	13.9	102	5	12.0	5.6	94.8	13.3	123	4	6	9.4	4.3	83.7	12.8	146	6	3	9.6	4.4	83.1	12.6	142	7	4	12.9	5.4	93.3	11.5	103	13	1	8.1	3.5	78.5	12.1	163	2	6.4	2.8	76.3	13.4	204	14	1	8.1	3.5	78.7	12.2	163	2	7.2	2.6	77.3	11.0	183	15	1	9.2	4.0	84.6	12.4	151	2	8.1	3.4	78.8	11.9	164	3	6.8	2.7	76.9	12.1	193
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2	1	9.6	10.8	71.5	24.6	122	Not so good. Mean H = 24.4 km.																																																																																													
	2	9.7	11.0	70.0	24.2	118																																																																																														
3	1	9.8	8.7	92.4	24.6	148	Point 2 gives the best determination. Mean H = 24.7.																																																																																													
	2	9.2	8.5	86.3	24.6	152																																																																																														
	6	7.2	8.0	65.4	23.7	154																																																																																														
	7	10.9	13.3	68.4	24.6	100																																																																																														
	8	10.6	13.7	65.1	24.8	98																																																																																														
4	1	10.2	8.9	93.2	24.1	143	Points 1 and 2 the best. Mean H = 24.5.																																																																																													
	2	8.9	8.4	85.8	25.2	157																																																																																														
	3	9.8	10.8	70.9	23.8	102																																																																																														
	4	6.4	6.7	69.4	24.7	182																																																																																														
	5	7.1	7.5	70.9	24.8	170																																																																																														
5	1	9.1	8.5	86.3	24.9	153	Not so good. Mean H = 25.0.																																																																																													
	2	9.4	11.3	68.5	25.1	120																																																																																														
6	1	10.3	9.0	92.6	24.0	141	Point 1 good. Mean H = 23.2.																																																																																													
	2	10.0	8.5	86.3	22.4	139																																																																																														

As to the methods of measuring and calculating the plates, the well-known methods from aurora work were used, with the great improvements newly published.¹

The work has been done by my assistant, Olav Egeberg. The results are seen in the tables; here the meaning of the letters is: (See Table 1).

No. gives the number of the picture.

P is the measured point of the cloud.

p is the parallax, in degrees.

h is the height over the horizon at the main station, in degrees.

a is the azimuth at the main station, in degrees, reckoned from south westwards.

H is the height in kilometers.

D is the distance from the main station to the projection of the point on the earth's surface.

As main station Oscarsborg was always chosen.

The mean of all 28 heights of nacreous clouds was 24.0 km and the mean of the 14 heights of the lower cirrus clouds 12.6 km.

¹ Carl Størmer: Some Results regarding Heights and Spectra of Aurorae over Southern Norway during 1936, Geof. Publ. Vol. XII, No. 7, p. 6.

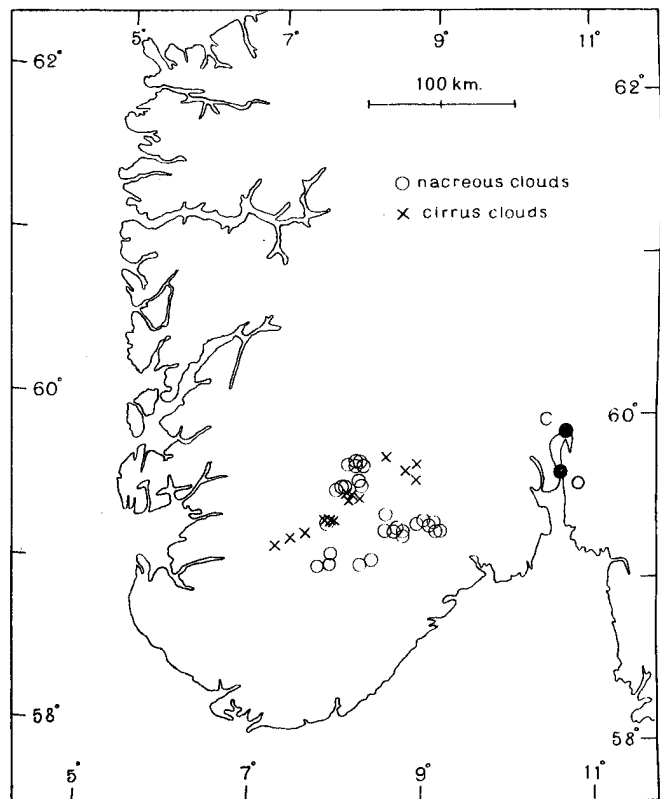


Fig. 2.

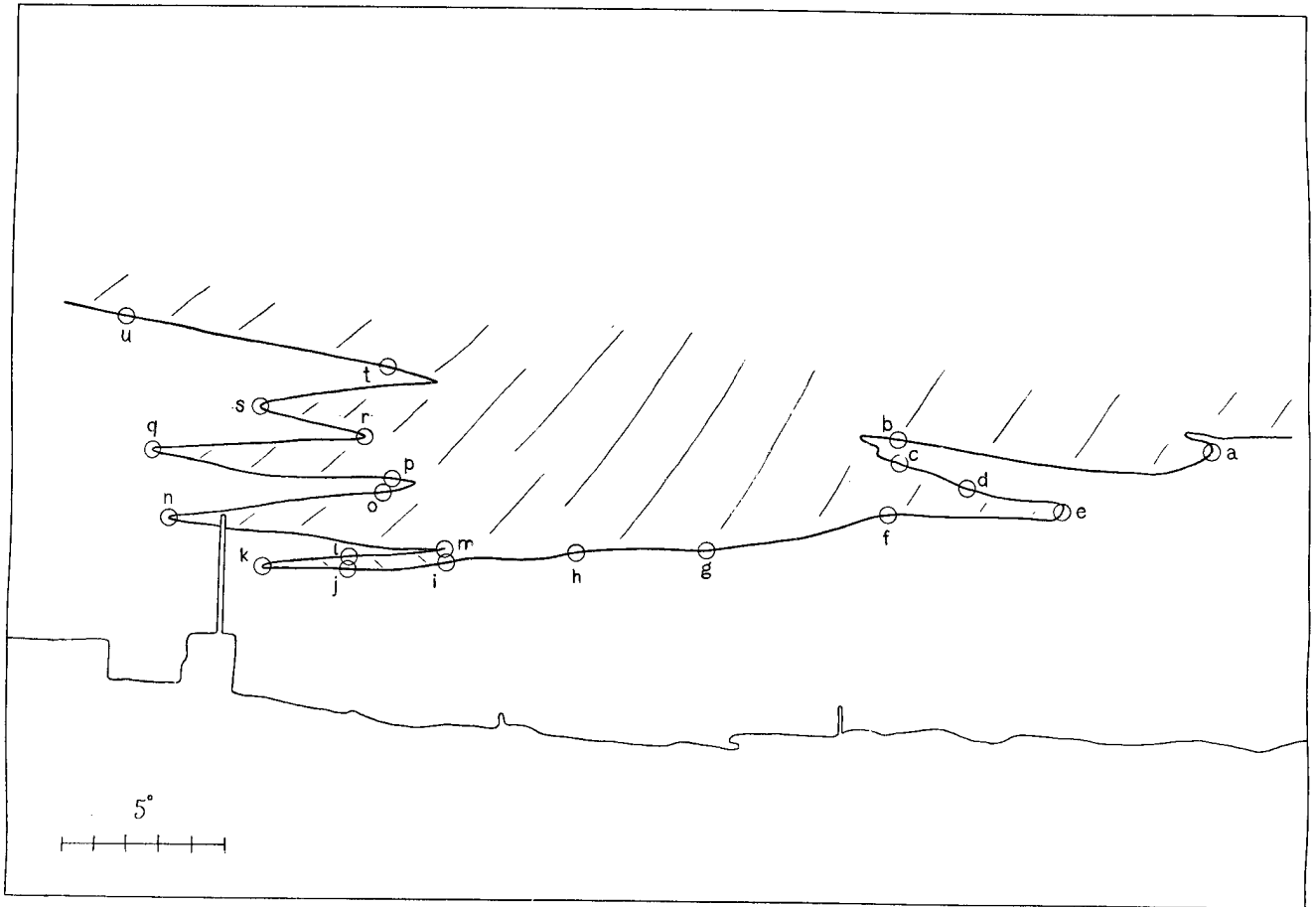


Fig. 3. The chosen points on the Oscarsborg picture.

The geographical situations of all the measured points are seen in fig. 2, the nacreous clouds as circles, the cirrus as crosses.

For the picture 1, which is the best, we have found the situation of the nacreous clouds over central Norway under the supposition that the height of each point measured (see fig. 3) was 24 km. The result is seen in fig. 4.

The corresponding sketches and pictures from Oslo and Oscarsborg are reproduced on plates 1 and 3.

3. The Pictures in Natural Colours.

Two pictures in natural colours were taken from the centre of the town Oslo by Simonsen, photographer, from the firm Nerlien. On these pictures, the characteristic mother of pearl clouds can distinctly be recognized through the cirrus-stratus-like lower clouds (height about 12 to 13 km). The latter had already assumed a red to red-brown colour, but the nacreous clouds still shine through them with the very pure mother of pearl colours so characteristic of these high clouds.

CHAPTER 2.

Some Visual Observations of Nacreous Clouds from January 18th—28th, 1932.

4. Reports of 19th January 1932.

By radio broadcast and by articles in newspapers, I had asked people to send me observations of mother of pearl clouds, and I received several letters among which were many very useful for my purpose.

I give below an extract of some of the most interesting ones.

Mr. *Carl Bertheussen* writes from Tromsø:

"When I left my house at 7^h 40^m the 19th January I immediately recognized a remarkable cloud with spectral colours similar to the clouds I saw in the winter 1882—83. It was, however, much larger than the clouds I saw at that time. It was horizontal and had the form of an almond. The length was about 16° and the breadth about 3°—4°. The western end was somewhat south of west. At 8^h 15^m a new cloud

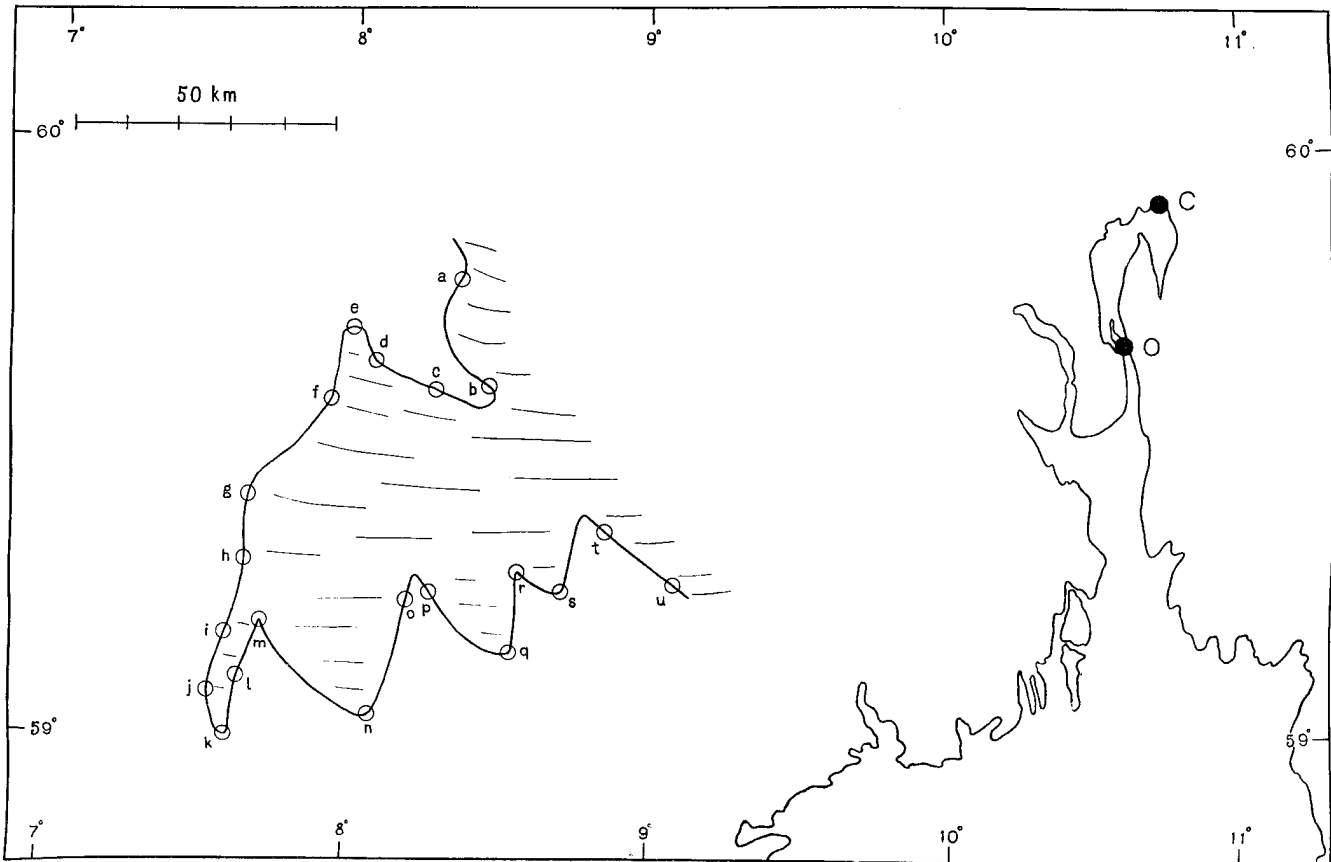


Fig. 4. Corresponding geographical situation.

appeared to the right of the first one. At about 10^h three small clouds appeared to the right of the last one The lower borders of the clouds were about 20° over the horizon and they were shining much more intensely than the bright sky behind". In the letter was enclosed a sketch of these clouds.

Elisabeth Schulz writes from *Hammerfest*:

"Some time ago I saw from the newspapers that you wanted people to send in reports on mother of pearl clouds. As I suppose that we saw such clouds here the 19th and the following day (but fainter), I send you herewith a description of this phenomenon which made a sensation and was a topic of conversation among the people here.

. From 12^h 30^m to 15^h the 19th, I saw two big clouds high up in the southern sky in south west. The clouds were bright and showed colours like two superimposed rainbows. The upper cloud had very marked colours. In the lower one, the distribution of the colours was more irregular and more diffuse. These clouds could be seen even to 15^h 30^m

when the sky was rather dark. It was a most beautiful sight.

Nobody here can remember having seen anything like it, but some days later I saw in the newspaper that an old man from *Sørøya* remembered having seen the same clouds in the winter 1882—83. At that time, they were called *hurricane clouds* because the worst storms and the most terrible disasters occurred at the time of appearance of these clouds".

Another correspondent, *Mr. Petter Rodahl* says about the same clouds in *Hammerfest*:

"The clouds were quite different from common clouds and were of exceptional beauty. I saw two of them and they had all the colours of the rainbow but much more bright and pure; the colours in the centre of the larger cloud were quite dazzling. Towards the borders I saw the most wonderful colours, like mother of pearl".

Director Andr. Quale writes from *Sulitjelma* (latitude 67°.1, longitude 16°.1):

"When I went down to my office on Friday January 19th, at 9^h with *Mr. Fortang*, we observed

the most beautiful mother of pearl clouds towards SE. . . . They had all the colours like mother of pearl. I have never seen the like. The sun reappears here the 29th January".

Mother of pearl clouds were also reported from the meteorological station in Tana (latitude $70^{\circ}.3$, longitude $28^{\circ}.2$) on the 19th and not so bright the following day.

From Statens Meteorologisk-Hydrografiska Anstalt (the State Meteorological Hydrographical Institute), Stockholm, I received a copy of the report from licentiate Erik Hannerz, at Luleå, with detailed observations of nacreous clouds 19th January with coloured sketches. He says that such clouds were seen several times in the period 19th to 29th January 1932.

5. Reports of 20th January 1932.

Mr. *Magnus Os*, Offersøy in Salten (latitude $68^{\circ}.3$, longitude $15^{\circ}.6$), writes.

"Herewith I have the honour to report on a very beautiful occurrence of mother of pearl clouds. When I looked out of the window this morning at $7^h 30^m$ I saw, towards E, a whole bank of these fine clouds. At that time it was quite dark but the nacreous clouds were fully illuminated. They had the form of flat and long almond-shaped clouds from ENE over E to SE. The upper border was 6° over the horizon and under the nacreous clouds the sky was clear. The colours were finest in E, from light red, and violet, yellow and yellow-white to almost white. The clouds were most crowded in E with both large and small almond-shaped clouds towards N and S at the same altitude.

At 8^h the clouds were almost hidden behind lower ones, but at $8^h 30^m$ they were again visible. The part towards E had spread towards S and now reached from E to SE. The upper border was now at 10° and the lower at 5° . There were, as before, almond-shaped clouds on both sides. Now the light was very strong; the landscape was quite illuminated by the clouds with a strange golden-red tinge. The sight was like a fairy tale".

The constable of the parish of Evenes, Lofoten, Mr. *Einar Winnem*, writes:

"At $10^h 10^m$ the 20th January the following observation was made:

I was working in my office and had the light on because it was so dark. On going out for a little walk I noticed that the sky became lighter and brighter,

and after a lapse of two minutes I saw that the illumination came from a cloud in SE about 30° to 35° over the horizon. This cloud was oval, not very large, and a little irregular. The light from the cloud increased rapidly and changed from golden to light green, deep green, light red, deep red, light blue and deep blue and the upper border shone in a sharp golden colour. The colours were arranged in horizontal bands in the order given above. Some minutes later the colours faded and by 7—8 minutes later they had disappeared. The cloud was, for a time, so brilliant that one could not look at it without being dazzled".

Reports were also received from *Melbo* ($68^{\circ}.5$, $14^{\circ}.8$), *Korsnes* ($70^{\circ}.2$, $23^{\circ}.2$), *Altafjord* ($70^{\circ}.8$, $23^{\circ}.5$), *Storsteinnnes* ($69^{\circ}.2$, $19^{\circ}.2$) and *Abisko* in Sweden. From Mr. *Albert Höckenström*, an engineer, Stockholm, I received a report saying that on a journey on 20th January at $8^h 30^m$ he saw very fine nacreous clouds from the train towards E, just south of Boden ($65^{\circ}.8$, $21^{\circ}.7$). He took some good pictures of them which he sent to me. The sky was exceptionally clear without any other form of clouds.

6. Reports from 22nd and 25th January.

Mr. *Magnus Os* from Offersøy, Salten, writes again:

"At 8^h in the morning the 22nd January mother of pearl clouds were again observed at the same place as those of 20th, but not at all so extended". Then comes a description of details which are omitted here.

A letter from Mr. *H. Korneliusen*, an observer of the meteorological service, Sværholt, Lebesby, Finmark, mentions small almond-shaped nacreous clouds in S between 11^h and 12^h the 25th January. Dr. *Keränen* writes that at *Sodankylä*, Finland, nacreous clouds were also seen the same day between 9^h and 10^h at different places in the sky.

From *Bekkelagshøgda*, E of Oslo, Mr. *Enevold Thømt* reports that he saw a small nacreous cloud at 16^h after sunset in W. It seemed like silk with strong red, green and white colours. He saw it for an hour; the colours faded and came again "like fading in radio."

7. Reports from 27th January.

I failed to see the clouds myself, but about 30 reports were sent me. Here are some of the most interesting ones:

Mr. *Erik Lindrup*, Oslo, sent the following report with the sketch fig. 5.

"Having heard your broadcast, I send you the enclosed sketch of the mother of pearl clouds yesterday morning (27th January). In particular, I observed the big cloud to the right. I first saw it at 8^h 45^m, being on the corner of Heggeliveien and Sørkedalsveien going towards Majorstuen. The cloud had the same size throughout the 15 minutes I observed it, but the form changed a good deal, and this was still more the case with the large cloud to the left. . . . As to the small clouds between the large ones, I do not remember details. The colours were those of the rainbow: white, pink, lilac or violet and green were the principal colours. In particular, I noticed the *green* colour which was also the reason why I discovered the clouds".

Mr. C. Lampe, chief clerk in a government office Oslo, reports:

"Going through the Palace grounds, I saw the clouds about 9^h 10^m to 9^h 15^m. On the sketch, fig. 6, I have made a cross where I first saw them and the approximate position of the cloud compared with the Royal Palace". From this the height and azimuth of the cloud can easily be found.

Miss Hanny Lynge, a school-teacher, Oslo, says:

"When I walked to school yesterday 27th January, I saw the mother of pearl clouds mentioned in "Tidens Tegn" to-day. At first they were quite pale, but suddenly they became coloured: innermost green, then a border of red, some orange and yellow, and at the outer border, blue. The time was then 9^h 10^m. I walked along the railway near the new "Vinmonopol-

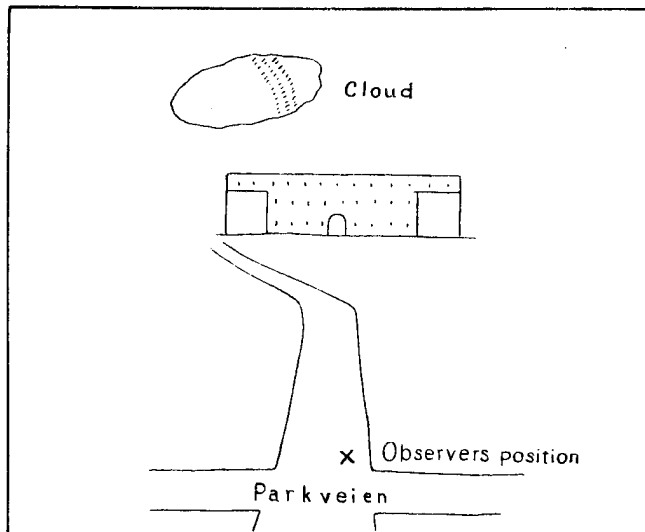


Fig. 6.

building" at Hasle (near Oslo). The clouds were lying in E, the largest to the left of the steeple of Østre Aker church, then a smaller one to the left of this cloud, and the smallest, near the horizon to the right of the church steeple. The height was about 2½ to 3 times the church steeple reckoned from its point. About 9^h 25^m the colours faded and shortly afterwards they disappeared".

From other reports, the clouds were seen from Lier (59°.9, 10°.3) to Ness (60°.8, 10°.9).

In the afternoon about sunset nacreous clouds were seen as far north as at Tolga (62°.4, 11°.2).

8. Reports of 28th January.

From the environs of Oslo, nacreous clouds were seen this day but not at all so beautiful. Farther north, however, they were much more brilliant as the following reports show.

Mr. Peder Bergan from Orkdal (63°.3, 9°.6) writes:

"Concerning mother of pearl clouds I think I saw such clouds today at Gangåsvann, in Orkdal, Sør-Trøndelag. The first time I saw them was at 10^h. Other people saw them between 9^h and 10^h. They were lying in SSE, above the sun, and about 17° above the horizon. They had the colours of the spectrum and some colours were stronger than others. At first the colours were faint, then suddenly quite strong, then faint and then strong again, and so on every five seconds. To the left, there was a small diffuse quadrangular patch of red-violet colour and

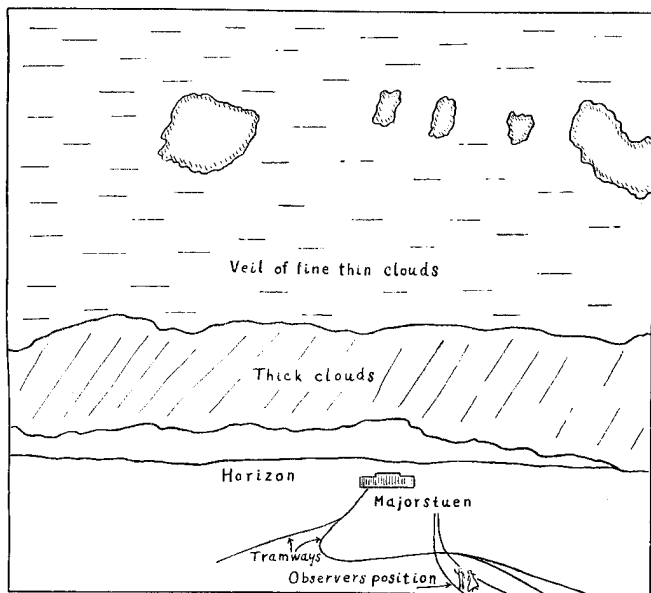


Fig 5.

to the right, a strong white-green with blue, dark violet and brown curved wings on both sides. In the middle it was yellow and brown. There were also other similar clouds. I watched these beautiful clouds for about one hour till they were obscured by dark lower clouds. I also saw them at 16^h towards SW".

From Mr. *Karl Rye, Tolga* (62°.4. 11°.2) I received the following report:

"From 15^h to 16^h 30^m I saw extremely beautiful nacreous clouds in all the colours of the rainbow in the south-western sky. There were a great number of them, some small, others large. I am now 75 years old and have sometimes seen such clouds before, but never so exceptionally gorgeous as this time".

E. Kulvik, a student, writes from *Trondheim*:

"I saw the clouds about 15^h 30^m and observed them until it became dark. Nearest the horizon, in S, there was a layer of grey clouds, but above this the sky was blue. In this sky, the nacreous clouds were seen in different colours, red-lilac, yellow and green. These clouds were uniformly distributed over an area from SW to WSW at a height of about 20° to 35° above the horizon. The colours were most brilliant at a height of 25°. The clouds were sharply defined on both sides".

Reports were also received from Mr. *Einbu, Dombås* (62°.1, 9°.1), who saw the clouds between 10^h and 11^h from SE to SSE at the height from 20° to 50° above the horizon.

Still more to the south, at *Gaupen, Ringsaker* (60°.9, 10°.8), nacreous clouds were seen by Mr. *Alf Mørch Reiersen*, who writes:

"The mother of pearl clouds were seen here from 16^h 50^m and later towards WSW. First as a big shell like a bird in flight seen from the side, later as more extended clouds. The outer border of this



Fig. 7.

shell was deep violet and then lighter. The colours formed concentric belts round the cloud. The next belt was yellow-green and, nearer the middle, the colour was pink At 17^h 5^m the whole cloud became red. At sunset, the sky was intensely yellow.

In the forenoon of the same day, nacreous clouds were also seen in Northern Norway. In fact, from Repparfjord, Kvalsund, Finmark, I received a telegram about nacreous clouds between 8^h and 9^h in SE about 20° over the horizon.

CHAPTER 3.

Mother of Pearl Clouds over Southern Norway on the 29th January 1932.

9. The Work Done at My Auroral Stations.

On the 29th January 1932, mother of pearl clouds of exceptional beauty were seen all over southern Norway, where the sky was clear. I received about 100 interesting reports on clouds seen both in the morning and in the afternoon about sunset. A large material of photographs, both single ones and simultaneous pairs for determining the height, was secured. Before entering into details I shall give a report on our work in Oslo during the afternoon.

Already during the day I had expected something extraordinary; in fact, we had in Oslo a meteorological situation favourable for nacreous clouds: A strong westerly Föhn wind with high temperature and clear sky.¹ Some time before sunset I saw from my house in Oslo some strange clouds in NW which I suspected to be mother of pearl clouds, and I immediately warned my auroral stations in Oslo and Oscarsborg to get everything ready for taking photographs. I also telephoned to Captain Ween of the Norwegian Geodetic Survey to get his stations ready; in fact, I had already arranged with him that he should try to get photogrammetric measurements of the clouds with the cameras of the Geodetic Survey, and with base Oslo—Nordstrand, 5.7 km.

As soon as this was done I hurried to my station on the roof of the old Observatory in Oslo where the photographic station was ready. At 15^h 35^m, (sunset about 16^h 18^m), telephonic connection with Oscarsborg was established. As assistants, I had in Oslo, Mr. Tveter, Mr. Sandøy, and Mr. Simonsen from the firm Nerlien; in Oscarsborg, Mr. Bakøy worked. The station at Tømte, with assistants, Albert and Egil Tømte, was also warned, but telephonic connection was too bad to secure simultaneous pictures.

In Table 2 is seen a list of all the observations and pictures. The meaning of the headings are as follows:

No. gives as before the number of the picture. If the picture has no number, it is written *Pict.* *Obs.* means an observation.

¹ See section 17.

Table 2.

No.	St.	M. E. T.	Ex.	Plate	Ref.	Remarks	No.	St.	M. E. T.	Ex.	Plate	Ref.	Remarks
Obs.	C	16.25.45				Clouds in N and NW, colour white.	T 5	T	17.49.00		Sonja	Lyr. Her.	Clouds in NW.
Obs.	C	.32.45				Colour white blue against darker background.	25	C-O	49.51	11			
Pict.	C	.42.45	60	In natural colours	Landscape	Successful picture.	T 6	C-O	50.47	11		Lyr. Landsc.	
1	C-O	.46.57	1	Pancromatic (red filter)			27	C-O	51.47	14		Lyr.	
2	C-O	.47.59	1				28	C-O	52.35	4		Landsc.	Small clouds in SW.
Obs.	C	.49.45				Greenish colours in stripes; the rest blue white.	T 7	C	54.00	7		Lyr.	Small cloud in W.
3	C-O	57.48	3				29	C-O	54.30	7			O picture bad. Clouds in NW.
Obs.	C	.58.45				Colour blue white, the right end red.	30	C	55.17	10		Landscape	Small cloud in W.
4	C-O	.59.35	9				T 8	T	56.00	8			O picture bad. In W.
5	C-O	17.01.34	6				31	C-O	56.16	8		Lyr. Her.	Clouds in NW.
6	C-O	.02.43	14				32	C-O	56.47	10		Landscape	
7	C-O	.03.43	12				T 9	T	58.00			Landscape	
Obs.	C	.04.45				The whole cloud red.	33	C-O	58.42	8		Lyr. Her.	Clouds in NW.
Pict.	C	.04.45				Successful picture.	34	C-O	59.25	8		Landsc.	Small cloud in W.
8	C-O	.06.44	9	In natural colours			T 10	T	18.00.00			Venus; landsc.	The same in SW.
Obs.	C	.09.45					35	C-O	00.40	13		Lyr.	Clouds in NW.
Obs.	C	.14.45					36	C-O	.01.35	11		Venus; landsc.	Small cloud in SW.
Obs.	C	.17.45					T 11	T	.02.00			Lyr.	Clouds in NW.
9	C	.21.46				The cloud in NW fine red.	37	C-O	.02.18	12		Lyr. Her.	Small cloud in SW.
10	C	.22.15					38	C-O	.03.00	12		Venus; landsc.	Clouds in NW.
11	C-O	.26.06	1	Sonja (no filter)			T 12	T	.04.00			Lyr.	Clouds in NW.
12	C-O	.26.45	2				39	C-O	.04.14	21			Small cloud in W.
13	C-O	.27.10	1				40	C-O	.04.57	16			Clouds in NW.
14	C-O	.33.00	7				41	C-O	.07.10	19		Equ. Del	The small cloud in W.
15	C	.33.37	3				42	C-O	.07.53	19		Lyr. Her.	The cloud in NW.
16	C-O	.34.21	5				43	C-O	.08.33	24		Lyr. Her.	
17	C	.36.18	4				T 14	T	.09.00			Lyr. Her.	
T 1	T	.40.00					44	C-O	.09.16	24		Lyr. Her.	The small cloud in W.
18	C	.40.57	8				45	C-O	.10.08	23		Equ. Del.	The cloud in NW.
T 2	T	.43.00					46	C-O	.10.58	28		Lyr. Her.	
19	C-O	.43.23	6				T 15	T	.11.00			Lyr.	
20	C-O	.44.09	10				47	C-O	.12.14	23		Lyr. Her.	Clouds in W.
21	C-O	.44.46	8				T 16	T	.13.00			Del.	The cloud in NW.
22	C-O	.45.26	6				48	C-O	.13.08	31		Lyr. Her.	Small clouds in SW.
T 3	T	.46.00					49	C-O	.14.11	22		Agr. Peg.	
T 4	T	.47.00					50	C-O	.14.58	31		Lyr. Her.	The cloud in NW.
23	C-O	.47.46	9				T 17	T	.15.00			Del.	Clouds in W.
24	C-O	.48.54	7				51	C-O	.16.30	39		Lyr.	The cloud in NW.
							52	C	.17.37	37			
							53	C-O	.19.27	32		Lyr. Her.	
							Obs.						The following photos, exposed from 30 to 40, were too feeble to be measured.
							63	C-O	.30.27	70		Del. Peg.	Clouds in W.
							65	C-O	.35.10	57			
							67	C-O	.37.40	60			
							68	C-O	.38.55	62			
							70	C	.43.13	60		Peg.	

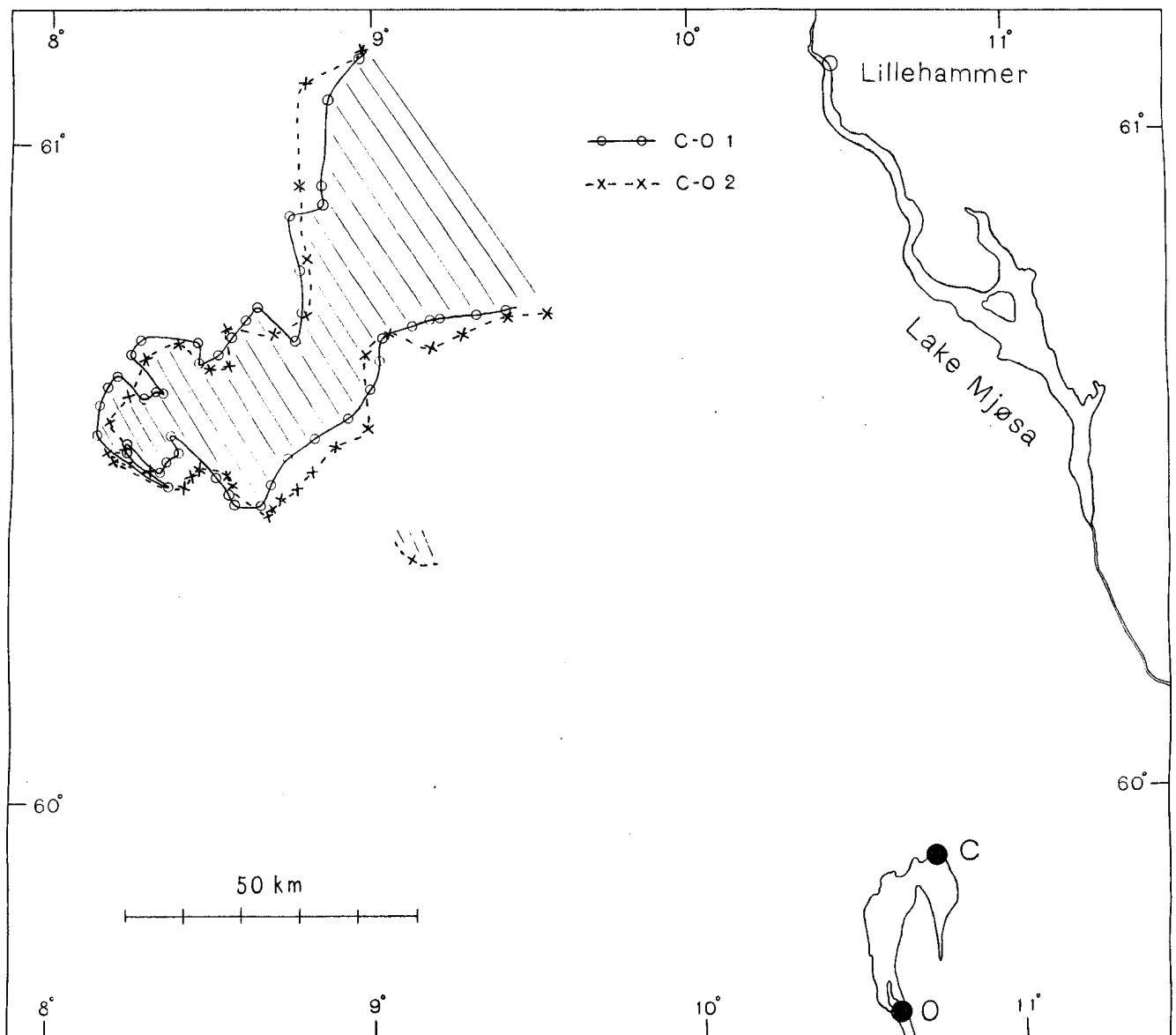


Fig. 8.

St. is the station, and if pictures are taken simultaneously from two and more stations, the main station is written first, e. g., C—O. As before, C means Oslo, O Oscarsborg and T Tømte.

M. E. T. is the time of the observation (for pictures, the middle of the exposure); Central European mean time is used.

Ex. is the exposure in seconds.

Ref. means the constellations towards which the cameras were pointed with abbreviations adopted at the International Astronomical Congress in Rome 1922. If points along the horizon are used, this is indicated by "Landscape".

10. The Height Measurements of the Pictures Nos. 1—8 on Pancromatic Plates.

Among the simultaneous sets of photographs given in Table 2, a great many were excellent for measuring height and situation. For the pictures taken so early that no stars were visible, we have used prominent points of the visible horizon as reference stars, and the angles for these points have been determined as on February 12, 1930, by photographing stars in the neighbourhood.

The plates were first measured and calculated by my assistant Anda and myself in 1933 and con-

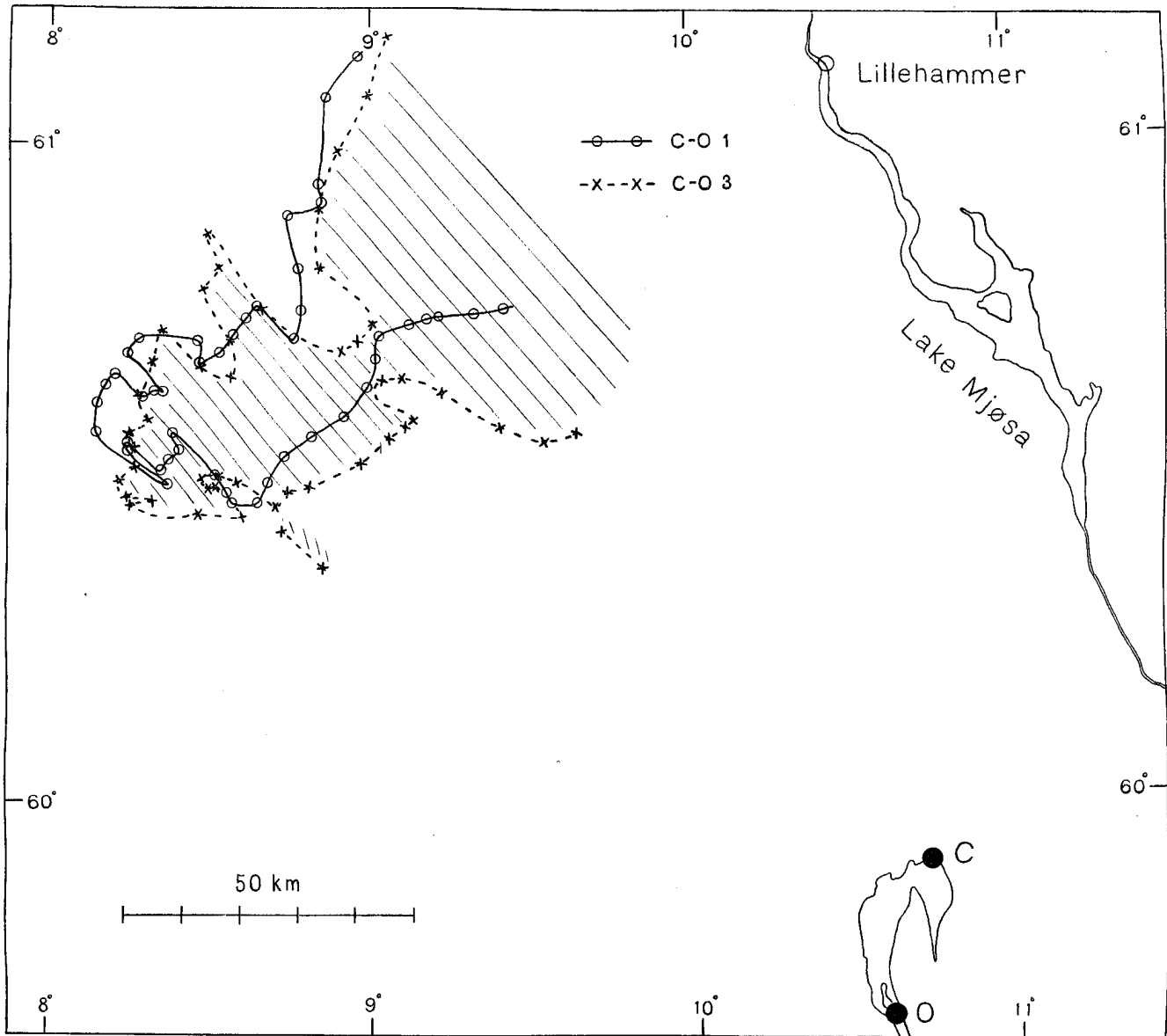


Fig. 9.

trolled by my assistant Olav Egeberg in 1938, who has also made the necessary sketches and maps published here.

In Table 3 are seen the results. The headings have the same meaning as in Table 1.

To the measurements, we add the following remarks: (See Plates 1 and 2):

Pictures C—O, 1, 16^h 46^m 57^s M. E. T.

Along the clouds, the 9 best points which could be recognized on both pictures were chosen for determination of height and situation. The visible horizon gave sufficient reference points. In order to get the outline of the clouds as projected on the

earth's surface, 37 points were chosen and their geographical situation found under the supposition that their height was the mean 27.6 km of the 9 measured heights. The result is seen on the map fig. 8.

Pictures C—O, 2, 16^h 47^m 59^s M. E. T.

As in the preceding pictures C—O, 1, the best recognizable points have been used for determining heights and situation. The point e is chosen on another more diffuse cloud. The mean height for these points was 27.9 km, very near the preceding one.

As seen in fig. 8, the outline in the cloud as projected on the earth's surface, almost covers that of the preceding picture.

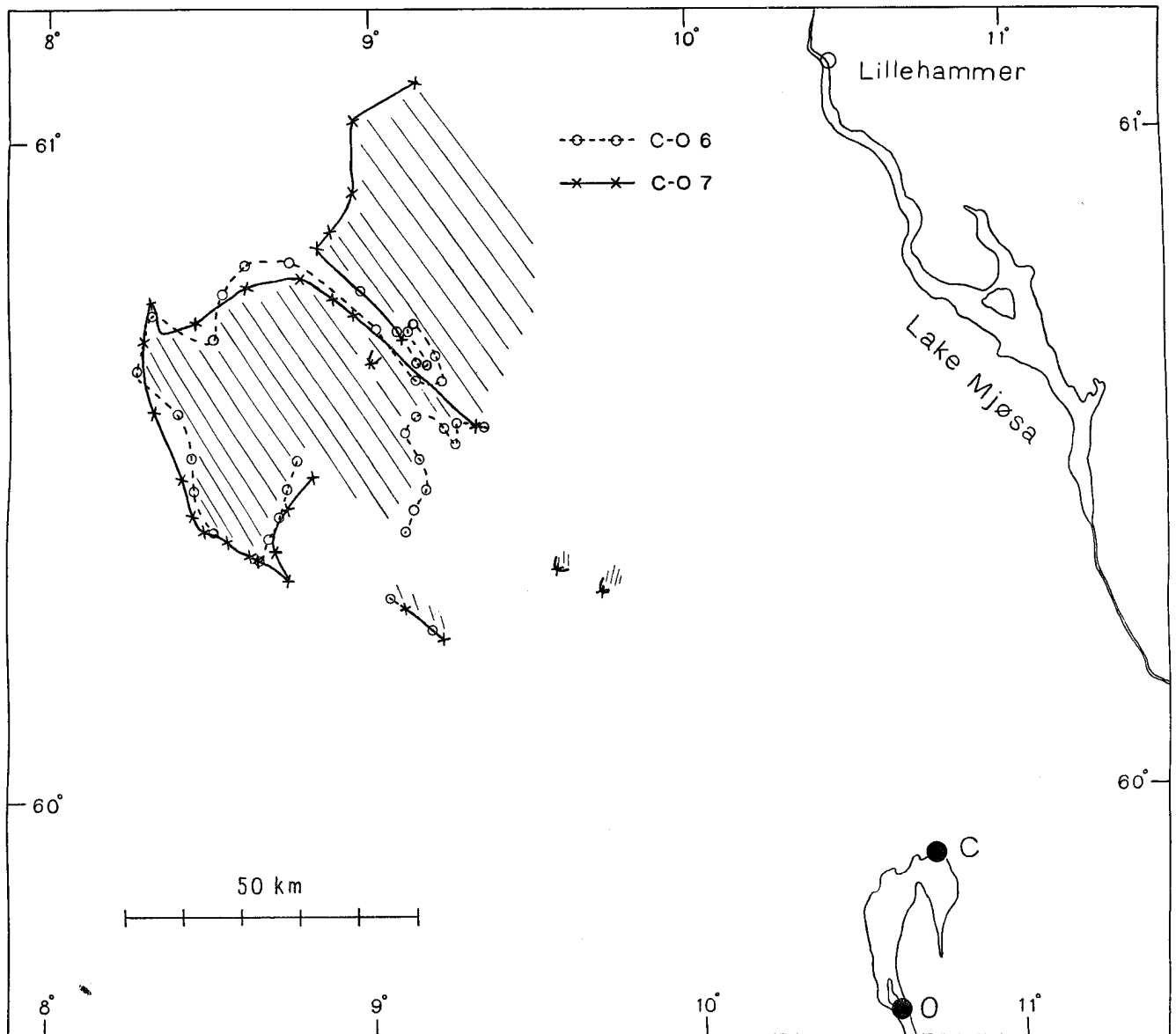


Fig. 10.

Pictures C—O, 3, 16^h 57^m 48^s M. E. T.

These pictures are very fine indeed and are reproduced on plate 4. Above the main cloud, are seen some thinner ones.

The mean height of Anda's measurements was 27.8 km.

In 1938, my assistant Olav Egeberg measured the pictures anew and quite independently. He found for the mean height 28.2 km, not very different from the first measurements.

From the geographical situation, fig. 9, it seems as if the cloud has drifted a little southwards.

Pictures C—O, 6, 17^h 02^m 43^s.

From 10 points, the mean height was found to be 28.0 km. Under this supposition, the geographical situation is found. See fig. 10.

Pictures C—O, 7, 17^h 03^m 43^s.

The mean height was first found to be 27.8 km. A new independent measurement by Mr. Egeberg gave a mean height 28.2 km. The geographical situation about the same as No. C—O, 6. See fig. 10.

Pictures C—O, 8, 17^h 06^m 44^s.

This is a very fine set reproduced on plate 5. The height has been calculated for 19 points (see Table 3) and as mean height was found 27.3 km. The

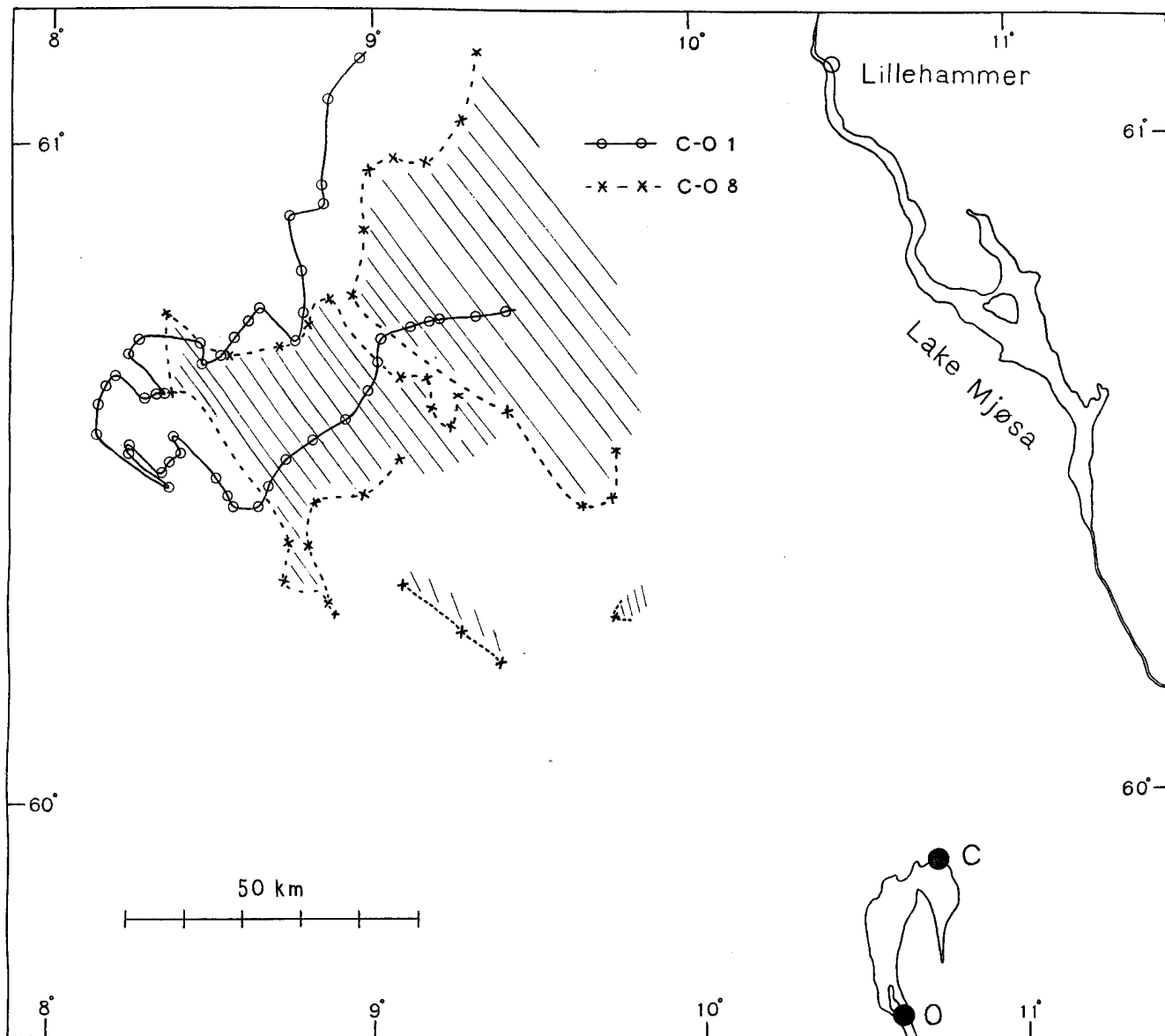


Fig. 11.

rest of the outline of the cloud was determined by assuming this height which gave the geographical situation shown on fig. 11.

Pictures C, No. 9, 17^h 21^m 46^s, and No. 10, 17^h 22^m 15^s.

These were taken of another small cloud in W, quite isolated from the large one photographed before. The Oscarsborg pictures failed, so no height measurements could be made. But, under the supposition that the height was 28 km, the geographical situation was found for comparison with later pictures of the same cloud.

All the following pictures were taken on Sonja plates without filter, and the contrasts are weak until it became so dark that the stars were visible.

As to the reliability of the height measurements, the later pictures with stars are better, because reference points along the horizon are not so near the optical centre as the stars.

Nevertheless, the control measurements show that the height measurements must be fairly good.

A comparison between the geographical projections of the cloud in pictures 1 and 8 which can

be seen on fig. 11, can give an idea of the cloud velocity at the height of 27 to 28 km. *We find that this velocity was about 10 meters per second, and directed towards SE.*

11. Independent Control of the Height Measurements of Pictures Nos. 1—8.

As well-known, the late Professor Mohn¹ tried to find the height of nacreous clouds by observing the moment when the last sun-rays left them. He found by far too great heights because he thought that the cloud in question was *directly* illuminated by the sun, instead of illuminated by twilight.

From the observations given in Table 2, it is seen that at 17^h 04^m 45^s the whole cloud was red and at 17^h 14^m 45^s the right part of the cloud was gray, and the left red, and at 17^h 17^m 45^s the whole cloud gray. It was, however, probable that the cloud was coloured red by the last rays of the sinking sun and that the gray colour came when the sun had set below the visible horizon seen from the cloud.

My assistant Egeberg has made some preliminary calculations of the situation of the earth's shadow at that time, which agree with our supposition. He took account of the refraction in the atmosphere. His results were as follows:

At 17^h 04^m 45^s M. E. T.

In this case the height of the earth's shadow was from 15 km to 18 km, that is, the whole cloud lay in the sunshine.

At 17^h 14^m 45^s M. E. T.

For the left part of the cloud which was red, the height of the earth's shadow was from 20 to 26 km. This part was also lying in sunshine.

For the right part, the height of the shadow was from 27 to 28 km. This part was gray and the sun's rays could hardly illuminate it.

At 17^h 17^m 45^s M. E. T.

Now the height of the earth's shadow for the left part of the cloud was from 26—29 km, for the right part, from 30—33 km. The height of the cloud was from 27—28 km. This agrees with the fact that the sun's rays went over the right part and were too weakened to be able to illuminate the left part.

These results are of course only preliminary. Knowing the conditions of the atmosphere along the

sun-rays it might be possible to come to more definite results by using for instance the formulae developed by Dr. Link¹ for the refraction in the atmosphere.

12. The Rest of the Pictures.

The first pictures taken on Sonja plates showed very faint contrasts because the plates were fogged by the strong twilight. Later, when the stars were visible, much better pictures were taken and the height measurements were excellent as stars near the optical centre were available as reference stars.

As before, the clouds showed great variability, changing their form continually, looking like an effect of evaporations and new condensations in the region where the clouds were situated.

Pictures C—O, 11, 17^h 26^m 06^s M. E. T.

It is the same cloud as before, but the pictures are difficult to measure, and the result is not so reliable.

Picture C, 13, 17^h 27^m 10^s M. E. T.

This picture is taken towards the right part of the former cloud and is used only to find the geographical situation of the clouds in that direction, assuming a height of 28 km. On fig. 12 the situation can be seen. The clouds to the left seem to be the remnants of the two clouds on pictures C—O, 8.

Pictures C—O, 14, 17^h 33^m 00^s M. E. T.

The southern end of the main cloud. The star Vega can now be used as reference star. Feeble pictures.

Pictures C—O, 16, 17^h 34^m 21^s M. E. T.

The same. Good measurements

Picture C, 18, 17^h 40^m 57^s M. E. T.

The cloud rapidly changes its form with a new condensation to the left. Of special interest is the cloud 5, 6, 7, 8, (Plate 2) which can be seen also on a series of the following pictures (See Plates 7 and 8).

On fig. 13, is seen the geographical situation, supposing the height to be 27.5 km. In the following pictures from 17^h 44^m 09^s to 17^h 52^m 35^s, it is remarkable how fast the clouds change their forms and extension. New clouds appear and others fade out. See plates 7 and 8.

¹ H. Mohn: *Irisierende Wolken*. Meteor. Zeit. März 1893, and *Perlemorskyer*, Vid. Selsk. Forh. 1893, No. 10.

¹ *Nouvelles tables de masses d'air*, Journal des Observateurs, Vol. XVII, No. 3, p. 41, and *Tables d'éclaircissements crépusculaires de la haute atmosphère*, Memorial de l'Institut Météorologique de Pologne, 1935.

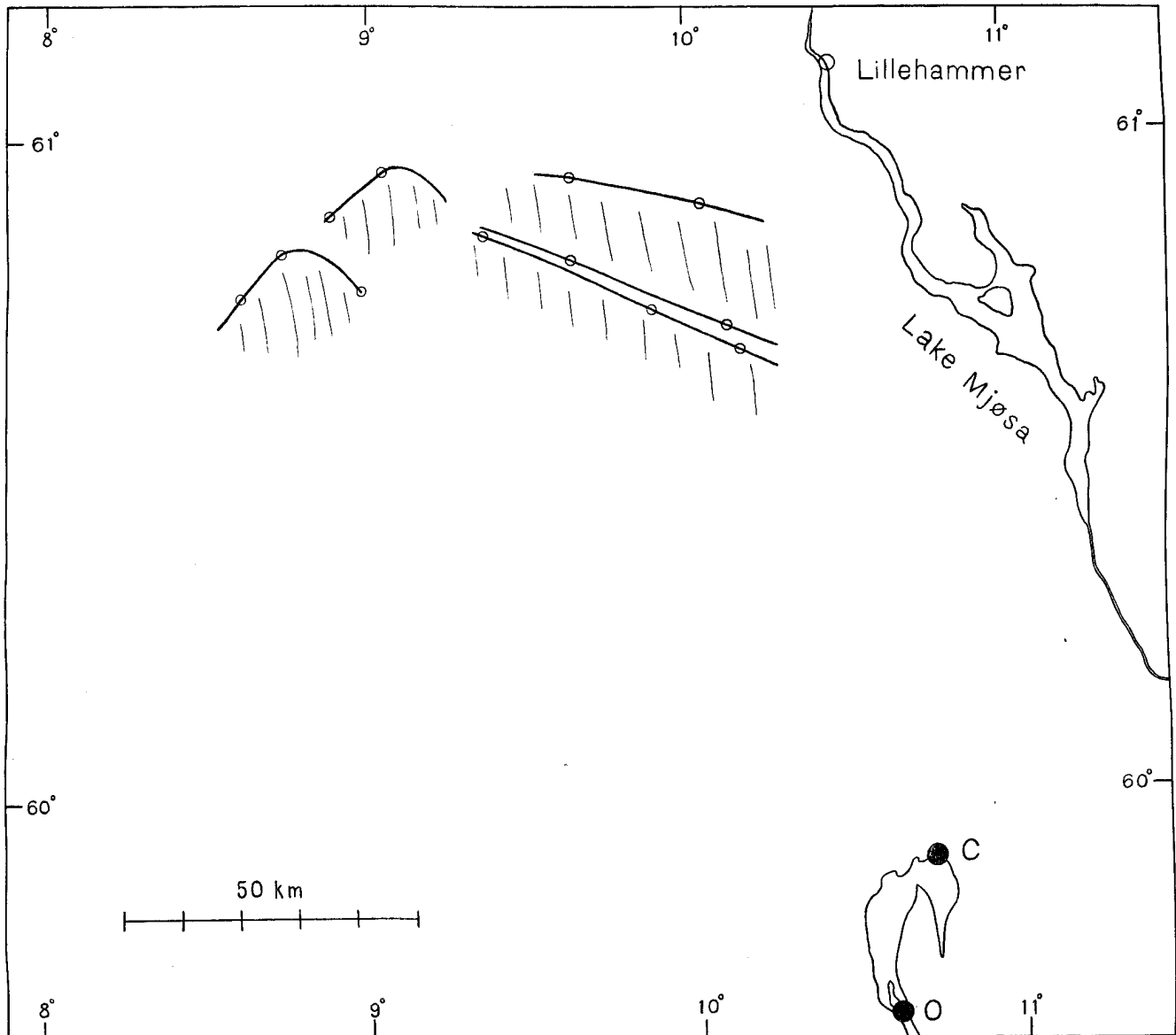


Fig. 12.

Picture C—O, 29, 17^h 54^m 30^s M. E. T.

This was taken of the same small isolated cloud also photographed on Nos. C 9 and C 10. The form of the cloud had changed a little in the northern end, but the southern part was so similar in these pictures that it could be used for determination of velocity. We return to this later.

Picture C—O, 32, 17^h 56^m 47^s M. E. T.

Now the clouds in NW have changed appreciably their form in so far as a series of new clouds has appeared. It seems as if extended condensations have taken place in the height interval between 26 and 28 km. This is still better seen on plate 8, giving

the successive pictures of the clouds in NW taken from the Oslo Station. (See section 14.)

Picture C—O, 33, 17^h 58^m 42^s M. E. T.

The same clouds about a minute later. A new small cloud (Point 7) has appeared and seems to be higher than the others.

Picture C—O, 34, 17^h 59^m 25^s M. E. T.

The same small cloud as in picture 29. On account of the very diffuse ends the height determination is not so reliable.

The following pictures Nos. 35 to 41 are all of the clouds in NW which change very rapidly, and continue to merge together to a larger cloud.

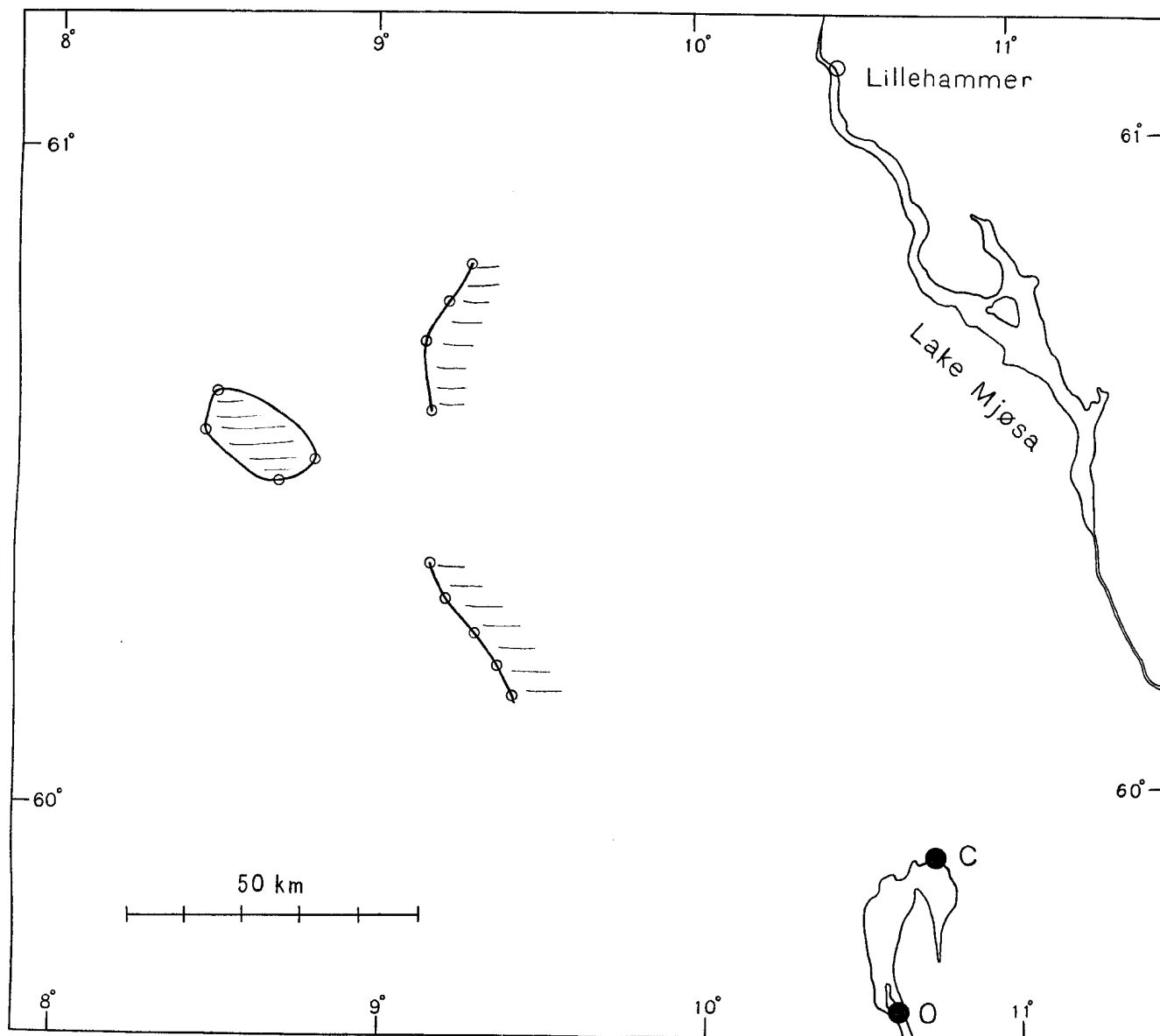


Fig. 13.

Picture C—O, 42, 18^h 07^m 53^s M. E. T.

This is a very fine set of another small cloud in W with the stars of the constellation Delphinus as reference stars. The height determinations are thus quite reliable.

Picture C—O, 43, 18^h 08^m 33^s M. E. T.

Also a very fine set, reproduced on plate 6. The next one equally fine.

Picture C—O, 45, 18^h 10^m 08^s M. E. T.

The same as No. 42. The cloud has now divided in two. Very fine.

In the following pictures 46, 47 and 48 the cloud in NW is becoming fainter and more extended.

The heights vary between 26 and 28.5 km for different parts of it. The two pictures 46 and 47 were measured a second time quite independently by my assistant Egeberg, whose results are given here, and, probably, are the most reliable.

Picture C—O, 49, 18^h 14^m 11^s M. E. T.

This set is taken of two small clouds in W, and is very good.

The pictures Nos. 50, 51 and 52 give the last measurements of the cloud in NW. The cloud is now still more feeble and extended and seems to evaporate.

In pictures 65, 67 and 68 is seen another cloud in W high up in the sky. The pictures are feeble but

Table 3. (Cont.)

No.	St.	P	p	h	a	H	D	Remarks	No.	St.	P	p	h	a	H	D	Remarks
27	C-O	8	11.2	12.3	123.2	26.8	117		41	C-O	1	8.8	10.8	131.0	28.5	141	Man height 28.1 km.
	"	9	12.4	14.3	124.7	27.0	103			"	2	11.1	13.3	128.3	27.4	111	
	"	10	9.5	12.3	138.0	26.6	116			"	3	9.4	11.2	128.6	28.1	134	
	"	11	7.7	9.8	140.3	26.4	143			"	4	9.5	11.1	125.6	28.4	137	
28	C-O	1	12.5	13.1	119.1	26.3	109	Mean height 27.4 km.	42	C-O	1	13.2	13.3	85.8	28.5	116	Mean height 27.9 km.
	"	2	9.7	11.6	132.2	27.1	125			"	2	13.5	13.3	83.0	27.8	113	
	"	3	10.1	13.3	138.2	26.7	109			"	3	14.4	14.1	79.3	27.3	105	
	"	4	8.8	10.5	133.0	27.3	139		43	C-O	1	9.3	10.7	130.8	26.6	133	Mean height 27.2 km.
	"	5	7.9	10.3	137.3	28.5	147			"	2	10.2	12.1	129.4	27.3	121	
	"	6	9.9	11.1	127.0	27.0	130			"	3	11.4	13.7	128.2	27.4	108	
	"	7	10.0	11.2	120.5	28.7	137			"	4	9.9	11.6	128.7	27.5	127	
29	C-O	1	10.1	10.0	73.6	27.2	144	Isolated cloud in W.		"	5	10.1	11.7	127.5	27.4	126	
	"	2	9.7	9.6	78.0	28.1	154	Mean height 27.7 km.		"	6	10.2	11.4	125.1	27.3	128	
	"	3	10.2	9.9	81.0	27.7	148		44	C-O	1	9.1	10.9	131.2	27.7	136	Mean height 27.7 km.
32	C-O	1	13.1	15.1	122.7	27.4	98	Mean height 26.9 km.		"	2	10.1	12.4	130.1	28.1	122	
	"	2	14.4	17.5	124.8	27.6	85			"	3	11.5	14.1	128.7	27.8	107	
	"	3	11.1	14.0	134.7	26.5	102			"	4	10.0	11.8	129.2	27.4	125	
	"	4	9.4	11.1	132.4	26.6	128			"	5	10.1	11.6	125.7	27.7	128	
	"	5	10.7	12.1	127.0	26.6	119			"	6	6.6	9.4	145.7	27.6	155	
	"	6	10.8	12.1	123.5	27.4	122		45	C-O	1	13.1	13.0	85.6	28.2	117	Mean height 27.7 km.
	"	7	9.6	11.1	128.9	27.1	131			"	2	13.6	13.2	83.4	27.4	112	
	"	8	9.0	10.0	130.9	25.9	138			"	3	14.0	13.8	82.3	27.6	108	
33	C-O	1	10.2	13.4	137.4	26.9	109	Mean height 27.1 km.		"	4	14.3	14.0	79.2	27.4	106	
	"	2	11.3	13.2	127.5	27.0	111		46	C-O	1	9.5	10.9	130.4	26.6	130	Mean height 27.2 km.
	"	3	11.7	12.9	123.6	26.7	112			"	2	10.8	12.9	130.0	27.0	113	
	"	4	10.1	12.0	129.1	27.6	124			"	3	13.0	15.8	128.1	27.1	93	
	"	5	9.2	10.8	130.4	27.3	135			"	5	9.3	10.9	129.8	27.3	134	
	"	6	8.6	10.7	137.7	26.4	132			"	6	10.6	13.1	128.9	28.4	117	
	"	7	9.1	10.6	128.0	28.1	141			"	7	10.1	11.0	126.0	26.3	128	
34	C-O	1	10.3	9.9	78.4	27.2	146	The same isolated cloud		"	8	11.2	12.1	119.7	27.4	126	
	"	2	10.7	10.5	72.3	26.8	136	in W.	47	C-O	1	9.3	10.9	130.9	27.1	133	Mean height 26.8 km.
								Mean height 27.0 km.		"	2	11.5	13.4	130.1	26.0	105	
35	C-O	1	12.2	13.3	121.3	26.7	109	Mean height 27.6 km.		"	3	13.3	16.5	128.5	27.4	90	
	"	2	8.8	10.6	130.7	28.2	141			"	4	8.9	11.1	137.7	26.2	126	
	"	3	9.4	10.9	127.5	27.9	137			"	5	10.4	11.3	125.8	26.3	124	
36	C-O	1	10.5	12.8	129.6	27.9	118	Mean height 27.4 km.		"	7	11.5	12.5	119.4	27.1	108	
	"	2	9.3	11.1	130.7	27.7	133			"	8	9.6	13.3	140.7	27.2	110	
	"	3	9.5	10.9	127.7	27.5	135		48	C-O	1	10.8	13.3	131.0	27.4	111	Mean height 27.0 km.
	"	4	8.1	10.1	138.6	26.5	140			"	2	13.7	16.4	128.9	26.1	86	
37	C-O	1	12.2	14.0	123.8	27.2	105	Mean height 27.6 km.		"	3	10.9	12.7	126.5	27.5	117	
	"	2	10.5	13.0	130.1	28.1	116		49	C-O	1	14.6	14.1	79.7	27.1	104	Mean height 27.2 km.
	"	4	7.6	10.0	139.2	27.9	148			"	2	14.6	14.4	78.0	27.4	103	
	"	5	9.4	10.7	128.0	27.3	136			"	3	12.7	12.0	92.7	26.9	121	
38	C-O	1	12.8	14.5	124.0	26.6	99	Mean height 27.2 km.		"	4	13.2	12.6	90.0	27.2	117	
	"	2	10.9	13.6	130.0	28.0	111		50	C-O	1	9.8	11.1	128.2	26.8	129	Mean height 27.6 km.
	"	3	10.7	13.6	132.7	27.6	110			"	2	12.7	16.1	130.2	27.7	93	
	"	4	10.3	11.7	127.7	26.7	123			"	3	9.3	12.2	138.9	26.7	118	
	"	5	8.2	10.4	138.1	27.0	138			"	4	11.3	13.7	126.3	28.4	112	
39	C-O	1	11.1	14.0	130.2	28.1	109	O picture not so good.		"	5	10.4	12.0	125.1	27.8	125	
	"	2	10.0	11.9	128.0	28.1	127	Mean height 28.1 km.		"	6	11.5	13.0	119.1	28.4	118	
40	C-O	1	12.9	14.9	123.4	27.3	99	Mean height 27.0 km.	51	C-O	1	10.0	11.6	128.0	27.4	127	Mean height 27.5 km.
	"	2	14.2	16.3	122.6	26.9	89			"	2	9.3	11.6	134.7	27.8	126	
	"	3	12.0	14.1	130.0	26.0	100			"	3	8.8	11.9	138.5	27.9	126	
	"	4	9.3	10.7	129.0	27.3	136			"	4	11.7	14.0	126.8	27.6	107	
	"	5	10.5	12.4	128.0	27.5	120			"	5	10.6	12.1	125.5	27.4	122	
	"	6	9.9	10.7	124.4	26.9	134			"	6	10.6	12.1	124.0	27.7	123	

Table 3. (Cont.)

No.	St.	P	p	h	a	H	D	Remarks	No.	St.	P	p	h	a	H	D	Remarks
51	C-O	7	11.9	13.0	119.5	27.3	113		68	C-O	1	18.8	18.6	78.7	27.5	80	Mean height 27.9 km.
53	C-O	1	10.5	12.4	128.2	27.4	119	Mean height 27.3 km.		»	2	17.8	17.7	81.3	27.8	85	
	»	2	9.8	11.4	129.3	27.2	128			»	3	16.9	16.5	84.1	27.3	90	
65	C-O	1	18.1	18.0	81.4	27.6	83	Mean height 27.6 km.		»	4	18.3	19.5	88.1	28.8	88	
	»	2	16.7	16.4	84.9	27.6	95			»	5	17.6	17.7	91.9	27.9	92	
67	C-O	1	18.9	18.4	78.7	27.1	80	Mean height 27.2 km.	Mean height of all points P equal to 27.41.								
	»	2	17.8	17.0	82.7	27.2	85										
	»	3	16.2	15.8	86.2	27.4	94										

the great parallax probably gives rather good measurements.

These were the last successful sets of pictures this night.

The mean of all the sets is 27.40 km, of all the chosen points 27.41 km.

From this is evident that the mother of pearl clouds on 29th January 1932 were situated in a mean about 3.4 km higher than on 12th February 1930.

13. New Determinations of Velocity of the Clouds, from Pictures Nos. 19 and 33 and from Nos. 9 and 29.

In section 11 we have made a first attempt to find the velocity of the clouds, and the result was a velocity of about *10 meters per second towards SE*.

We have tried to get more data from the following pictures.

We have first chosen a little cloud in NW in the two pictures Nos. 19 and 33.

The height has been supposed equal to 27.5 km and from the Oscarsborg pictures the geographical situation was found as seen in fig. 14.

Then measuring the displacement, from Nos. 19 to 33 we found *12 meters per second towards SE*.

Another determination was made, using the south-end of the small cloud in W, in pictures Nos. 9 and 29 from Oslo. See fig. 15.

The result was near those obtained before: *10.2 meters per second towards SE*.

14. Series of Successive Pictures from Oslo, to Illustrate the Rapid Changes of the Clouds towards NW.

It is of definite interest to give a good illustration of the successive changes of the mother of pearl clouds in NW from 16^h 46^m 57^s to 18^h 17^m 37^s.

We have therefore, on plates 7 and 8 put together the 41 successive pictures of these clouds taken from Oslo station (C) during that time. The 6 first ones are very clear, being taken on pancromatic plates with red filter. The following taken without filter, on Sonja plates, are good when the sky had become so dark that stars were visible. The contrasts of the first, however, were rather feeble, but by taking positives, and from these new reinforced negatives, C 11 to C 16 have been made from these. In these series the rapid changes are evident, with successive evaporations and condensations. For details, see the preceding sections. All these changes take place in the height-interval from 26 to 28 km.

15. The Photogrammetric Measurements of Captain Ween.

As mentioned before, Captain Ween measured the clouds with modern photogrammetric cameras and with a base-line of 5.7 km from Oslo to Nordstrand. He took 6 sets from 17^h 4^m to 17^h 20^m. His plates were, however, old, and the time of exposure often too short. The pictures are, therefore, not so good, and on account of the very short base-line, his measurements are not so reliable. He found values from 22.8 km to 30.4 km with a mean of about 26 km, at all events, of the same order of magnitude as ours. The geographical situation also fits in well with our measurements.

16. Visual Observations with Sketches and Single Photographs of the Same Clouds.

As mentioned before, more than 100 different letters were received about the nacreous clouds the 29th January, in particular from regions north of

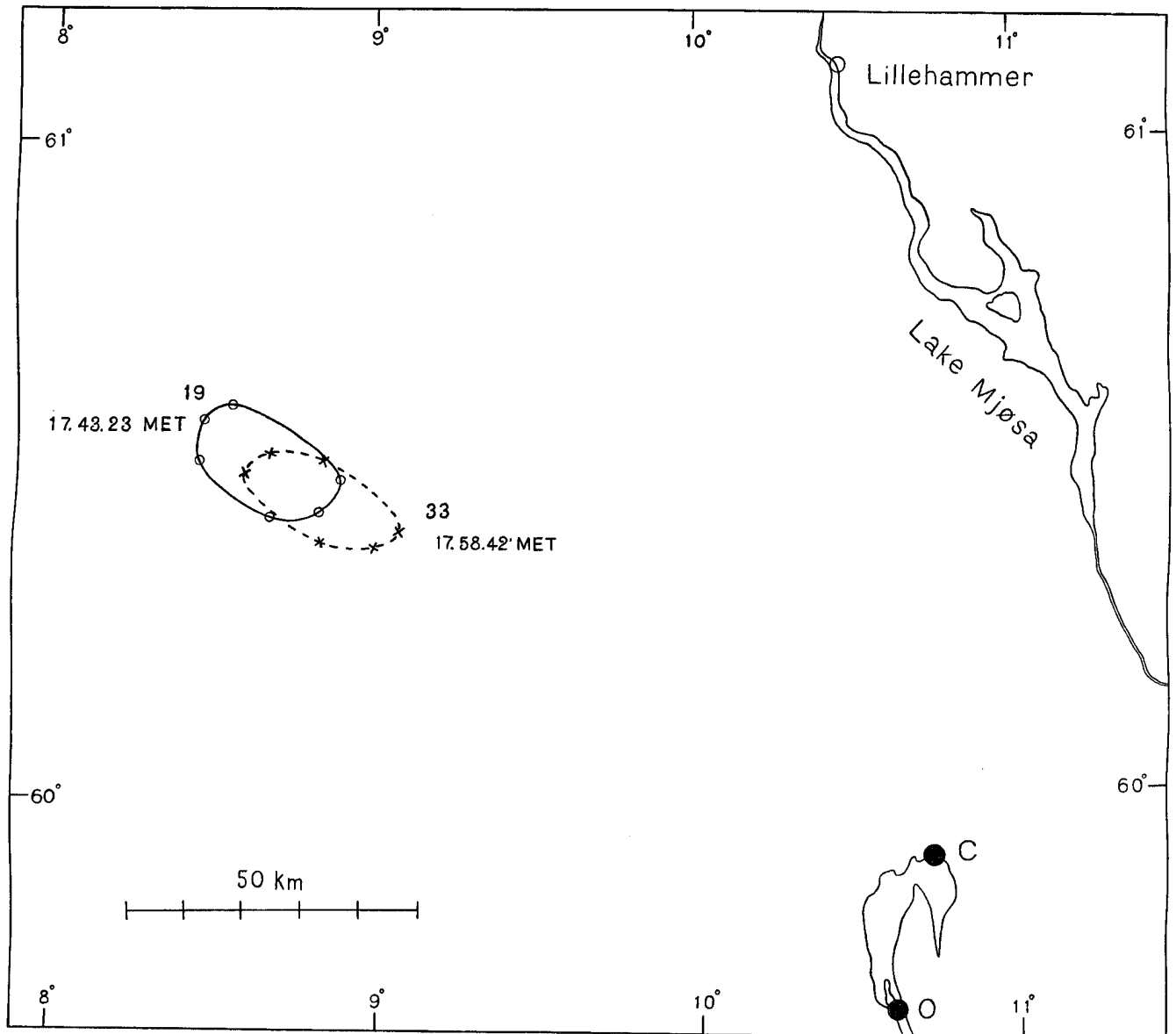


Fig. 14.

Oslo, where the colours were splendid. Among these, a series is given below. For orientation, a map of southern Norway with calculated situations of the clouds at $16^{\text{h}} 57^{\text{m}} 48^{\text{s}}$ and $17^{\text{h}} 06^{\text{m}} 44^{\text{s}}$ together with the places in question are given in fig. 16.

Observations by Mr. Olav Hassel, Darbu.

Mr. Hassel has sent a most interesting letter with very exact observations and drawings. He says: "When the sky became clear at about 16.30, there were some red clouds near the SE horizon where I had seen fine mother of pearl clouds in the morning from $8^{\text{h}}-8^{\text{h}} 45^{\text{m}}$. On the eastern part of the horizon, I saw some small thin mother of pearl clouds of

pale green colour. See figs. 17 and 18. In the northern sky, I saw a larger collection of true mother of pearl clouds".

In the following two sketches, figs. 19 and 20, Hassel has drawn the same clouds as we measured with base-line C—O. The observations also agree very well with the geographical situation of the clouds seen in fig. 16.

Of special interest is the following sketch of a small cloud in west, of gray colour, because it was observed almost simultaneously with our photograph C—O, No. 34. Hassel says that the cloud disappeared 2—3 minutes later. We have tried to use Hassel's

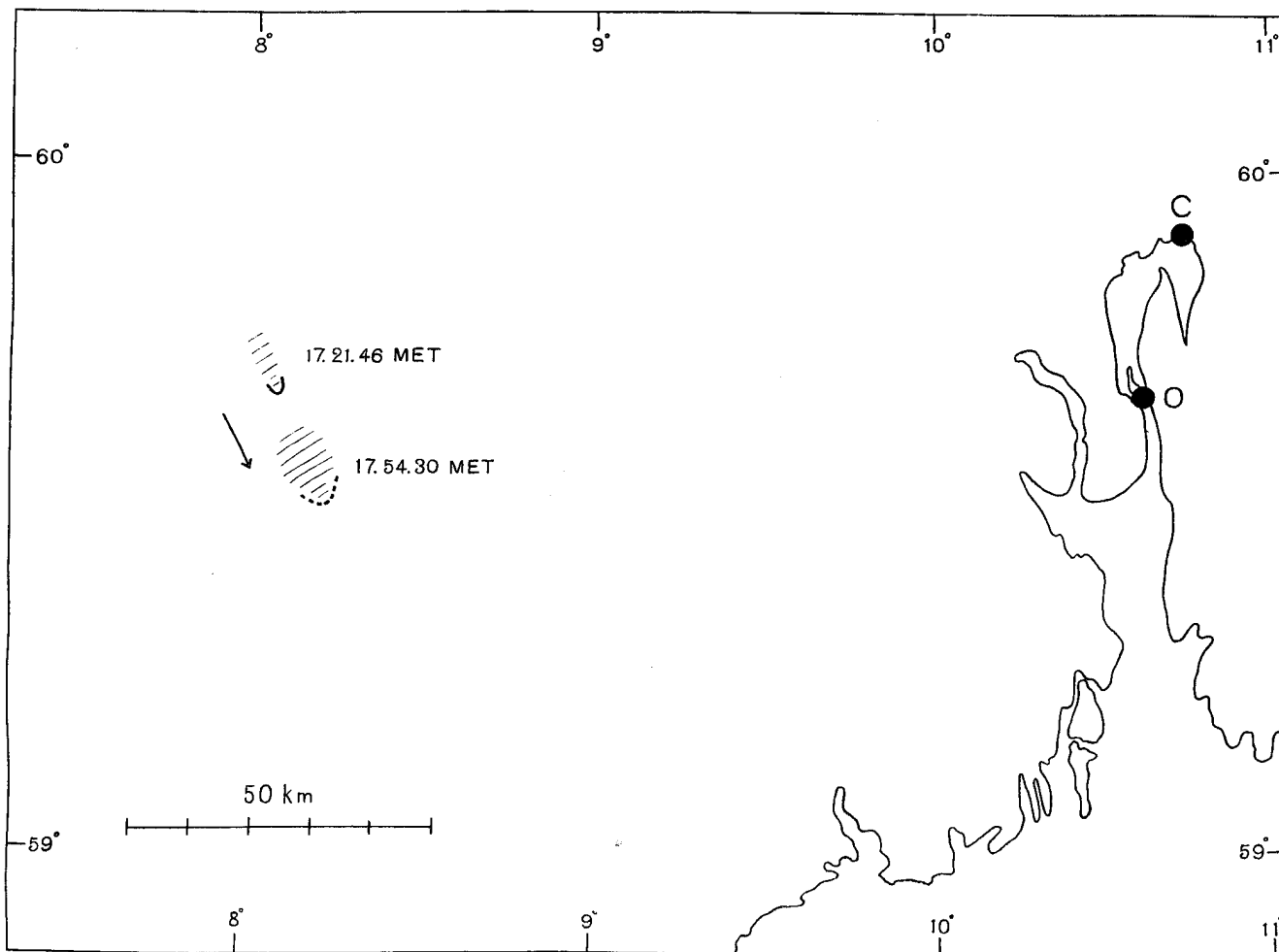


Fig 15.

observation together with the photograph C 34, for height measuring. The base line from Oslo (C) to Darbu is about 57 km. Mr. Egeberg who made the calculation found a parallax of $8^{\circ}.5$ and the height of the southern end of the cloud equal to 26 km, not very far from the value 26.8 found with base C—O. This height determination is only approximate but is sufficient to identify the cloud with the small cloud on No. 34.

In Hassel's letter there are also some drawings of clouds at $18^{\text{h}} 25^{\text{m}} - 18^{\text{h}} 30^{\text{m}}$ in the constellations Cygnus, Lyra and Hercules.

Observations from Olav Baraas, Eidsvold.

Mr. Baraas has sent 4 sketches of the colours in a cloud in WNW which must be the southern of the two clouds on map, fig. 16. He says:

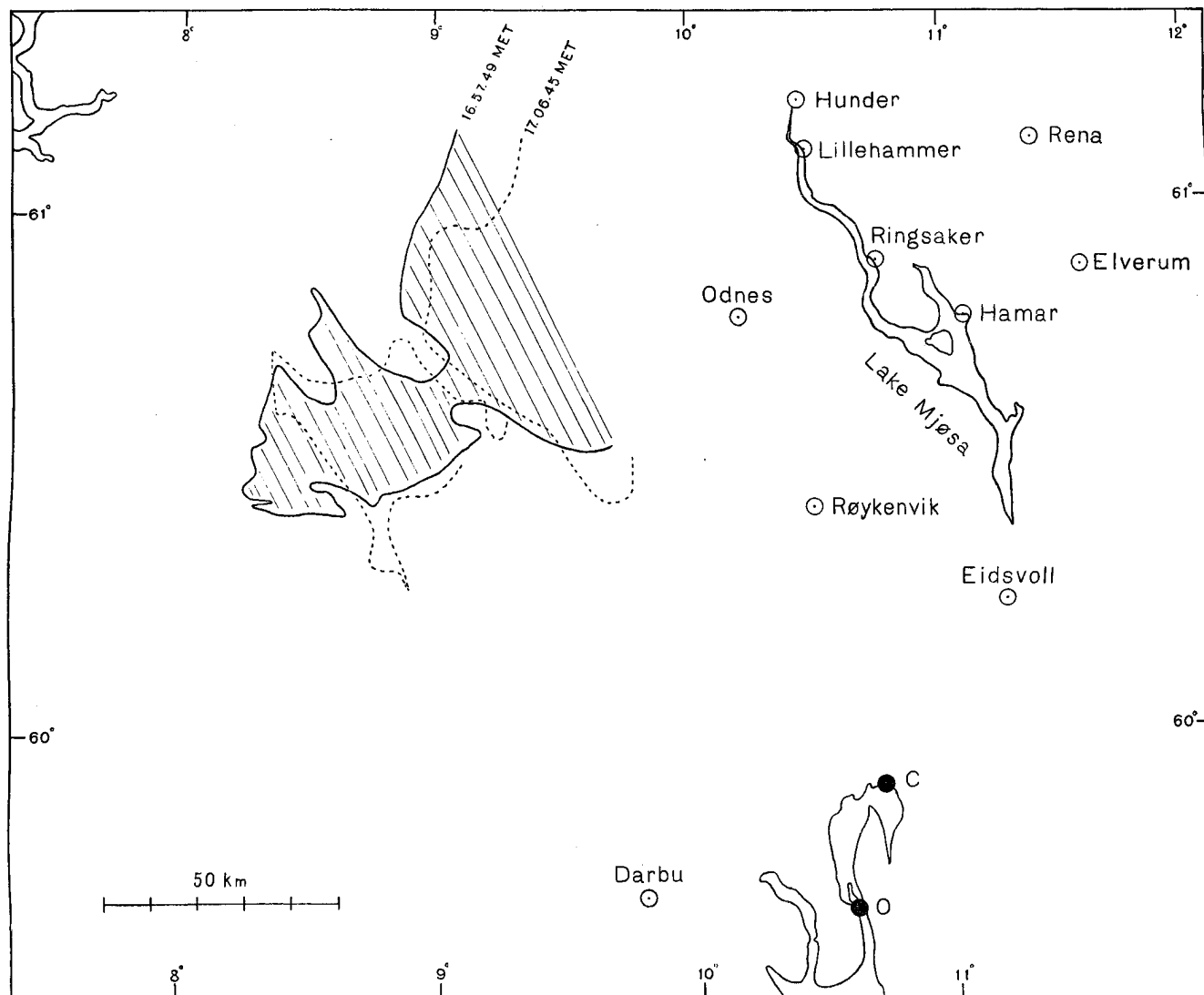
"The sketches are of a cloud seen on Friday January 29th. At 16^{h} it began to appear as a thin gray fog. At $16^{\text{h}} 10^{\text{m}}$ it showed very fine colours

like mother of pearl. The following minutes I took 4 sketches of it. The violet and green colours were very bright and shining. The colours changed continually and were most beautiful.

I observed in particular that the cloud remained at the same place till it disappeared, at $17^{\text{h}} 37^{\text{m}}$. Some red or rust-coloured small clouds were also visible, but these were in rapid motion towards SE".

From the sketches, it is evident that the colours and their distribution were rapidly changing. He says about the second sketch (10^{m} after the first one):

"The cloud at $16^{\text{h}} 20^{\text{m}}$ has nearly the same form as before and the same place, but the colours have completely changed in detail. The field on the right side of the cloud which on the preceding sketch was an extensive thin fog, has now changed into a field with several fine colours, with fine azure-blue and pink mixed with yellow, green and violet. It



[Fig. 16.

was as though looking at a piece of mother of pearl when moving it in different positions".

On fig. 22 is seen his last sketch, at 16^h 55^m.

Report from Mr. S. Oftedal, Elverum.

A sketch, given in fig. 23, shows that he also observed the two clouds photographed on C—O Nos. 1—8.

Report from Njaal Pharo, a student, Ringsaker:

Mr. Pharo sent me a fine picture of the clouds taken towards west from the parsonage of Ringsaker (see fig. 16). By comparing this picture with the picture taken at 16^h 40^m by Mr. Berge, Lillehammer, (see below) all details of the clouds can be recognized. The picture is reproduced on plate 9.

Observations from J. Løvberg, Rena:

We give only his sketch fig. 24 which is quite similar to sketch fig. 23.

Finally we give 3 reports from Lillehammer which amplify each other.

Report from Mrs. Sigrid Undset, Bjerkebæk, Lillehammer:

"Yesterday afternoon from about 16^h 30^m to 17^h 15^m we observed some exceptionally beautiful mother of pearl clouds here.

A wide field of mother of pearl clouds lay across the heavens from west and going north. (Venus was visible at the extreme edge of the field of cloud, the base of which lay somewhat lower down towards

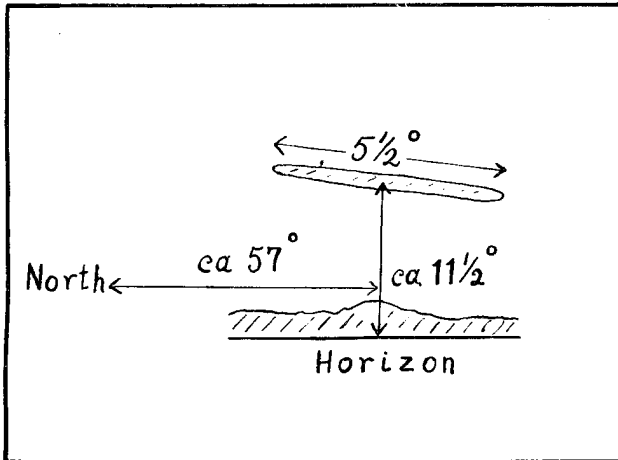


Fig. 17. Towards ENE. The cloud disappeared at 16^h 50^m.

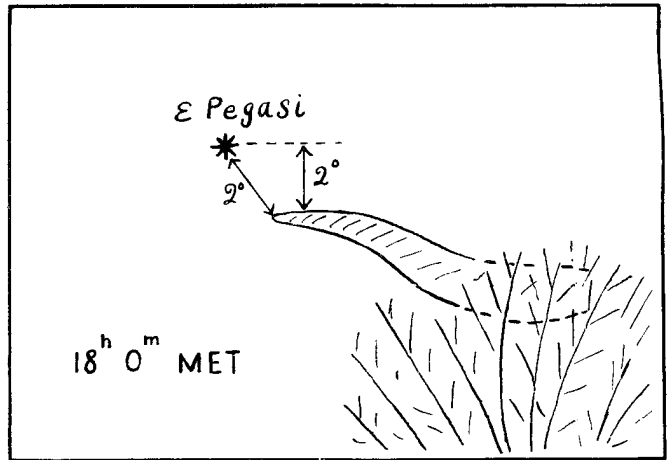


Fig. 21. Small cloud in W.

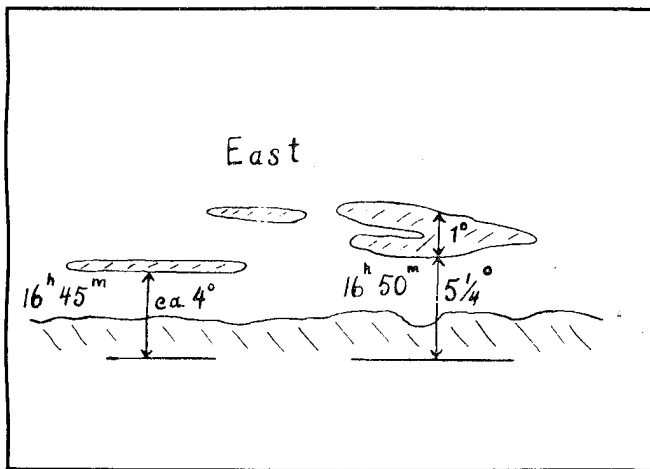


Fig. 18. Clouds towards east.

17^h 0^m MET

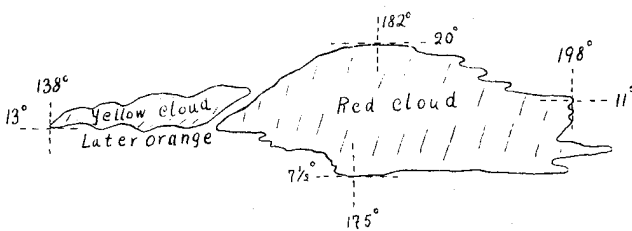


Fig. 19. Clouds on the northern sky.

17^h 5^m MET



Fig. 20. The same.

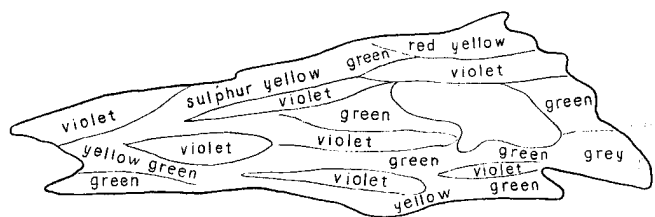


Fig. 22.

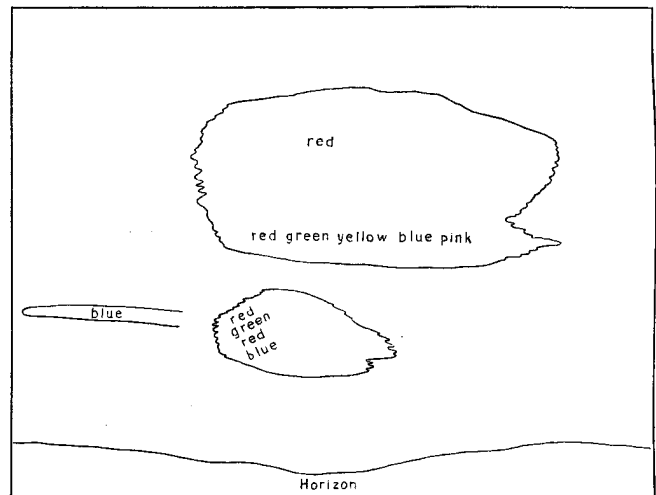


Fig. 23.

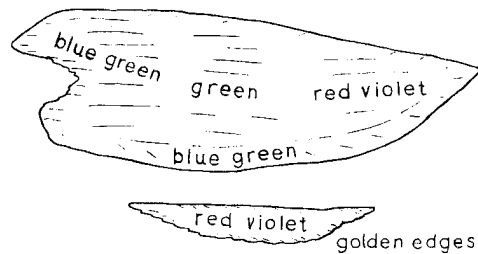


Fig. 24.

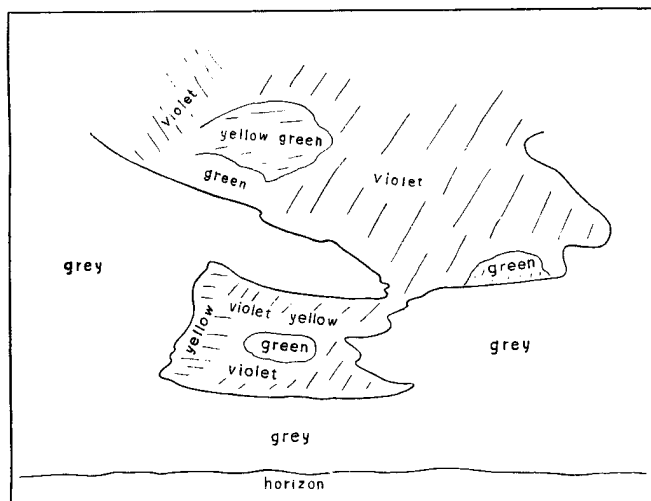


Fig. 25.

the mountain ridge.) From this point the clouds stretched away northward and up to the dome of the heavens.

Undermost lay a cloud, clearly lamella-shaped, elongated in the direction of the horizon. Its edge — particularly along the base and both “stems” — was distinctly rainbow-coloured in narrow bands which, towards the middle, changed from orange to yellow and pale gold around a centre of intense turquoise-green. Upwards, it partially merged into a larger cloud which, especially at its northern tip, was also clearly rainbow-ringed, the contour of the cloud being particularly clear to the north. Towards the middle, this cloud changed into innumerable red-violet, mauve-rose, red and orange coloured tones towards a golden centre. Up towards zenith and down in a southerly direction its contour was as if it had been rubbed out by the wind — around a fan-shaped field of turquoise-green with a golden edge, it was as if it had been smoothed out into the air.

Gradually, with the failing of daylight (towards the south the sky was quite clear with vivid golden afterglow following the sunset) the red colours predominated altogether and the blue and yellow fields disappeared. About 17 o'clock the reflection of these clouds on the roof of an out-house, thatch, with slates, gleamed quite like fire. A bank of low, dark and ragged fog clouds which came sweeping from the north and floated along the edge of the mountain ridge on the other side of Mjøsa, became a deep rust-red as it lay beneath the mother of pearl clouds.

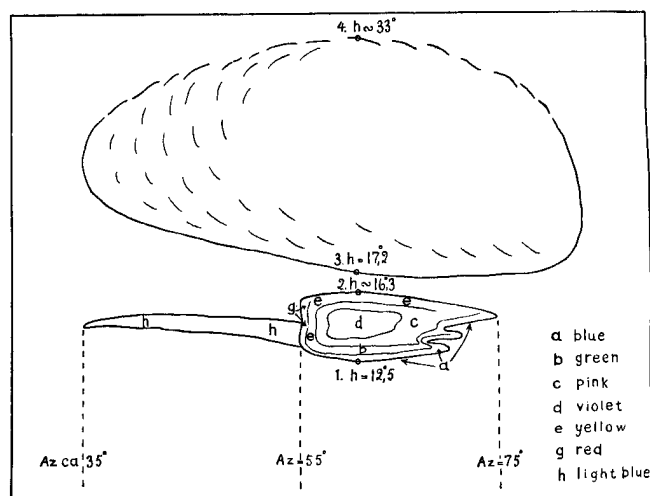


Fig. 26.

To the north, over Balbergkampen, and slightly down towards the east, lay groups of similar clouds, but quite slightly mother of pearl coloured.

About 17 o'clock, however, these became hidden by lower clouds which came drifting down northward from the valley and hid them from view”.

Report from Mr. Leif Aas, Lillehammer.

A very good sketch was sent by Mr. Leif Aas representing the same clouds at 16^h 45^m, see fig. 25.

Report from Mr. Berge, Lillehammer:

Mr. Berge has sent me 3 very good photographs. Two of them taken at 16^h 30^m and 16^h 40^m are reproduced on plate 9. As the visible horizon could be used for orientation, I asked Mr. Berge to measure height and azimuth of some points along this horizon. From the picture 16^h 30^m we have measured the geographical situation of the clouds, supposing the height to be 28 km. From this it is clear that the lowest cloud is the same as the southern cloud on fig. 16 and that it has been in motion towards SE with a velocity of about 15 m per second, a velocity of the same order as that found before.

Report from Mr. Erling Sobak, Hunder station:

This report is interesting in connection with that preceding, because it gives the colours of the lower cloud. He says:

“I saw the clouds at 16^h 10^m but it may be that they were there earlier. There were two clouds, the upper one was very big, and it was difficult to

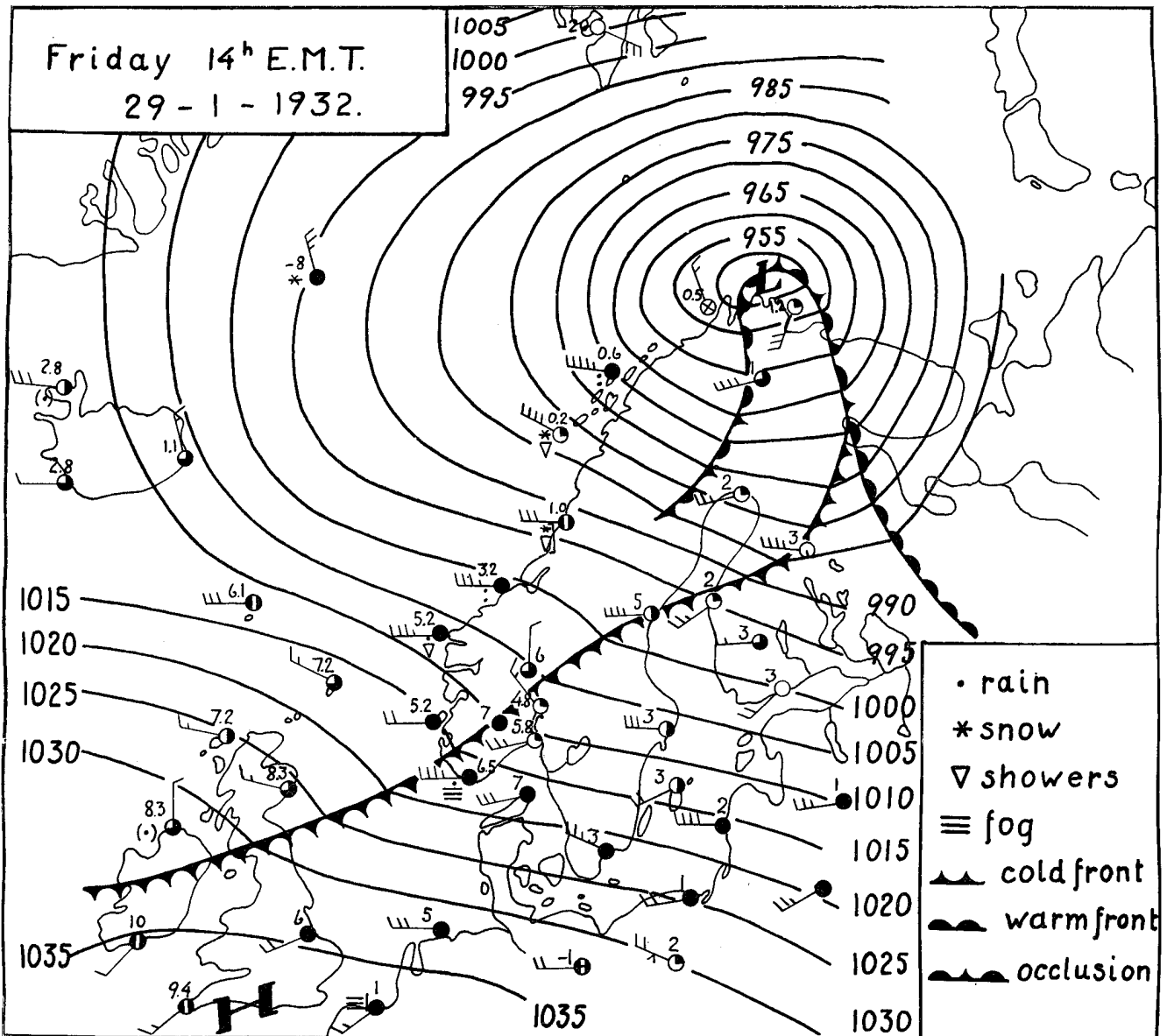


Fig. 27.

fix its boundaries because they were very diffuse. The lower cloud was smaller with sharp boundaries as seen on the sketch fig. 26, made at 16^h 35^m.

The same clouds as photographed from Oslo and Oscarsborg can be found again if we look at the map fig. 16.

The colours changed with time and were difficult to fix exactly, but the main features were as given on the sketch:

Lower border blue, going over to green. The dominating colour was red yellow with violet in the centre of the cloud. To the left, was a long blue tail.

He also gives some rough measurements of height and azimuth of different parts of the cloud which fit in well with the fact that the small cloud is the same as that mentioned in the preceding report and photographed from Oslo and Oscarsborg between 16^h 46^m and 17^h 07^m.

Finally, we give a newspaper report from the town Hamar.

Report from Hamar, published in the newspaper Hamar Stiftstidende 30th Jan., 1932:

In NW some wonderful clouds could be seen yesterday evening from 16^h to 17^h. After sunset, the ordinary clouds were copper-red but the mother

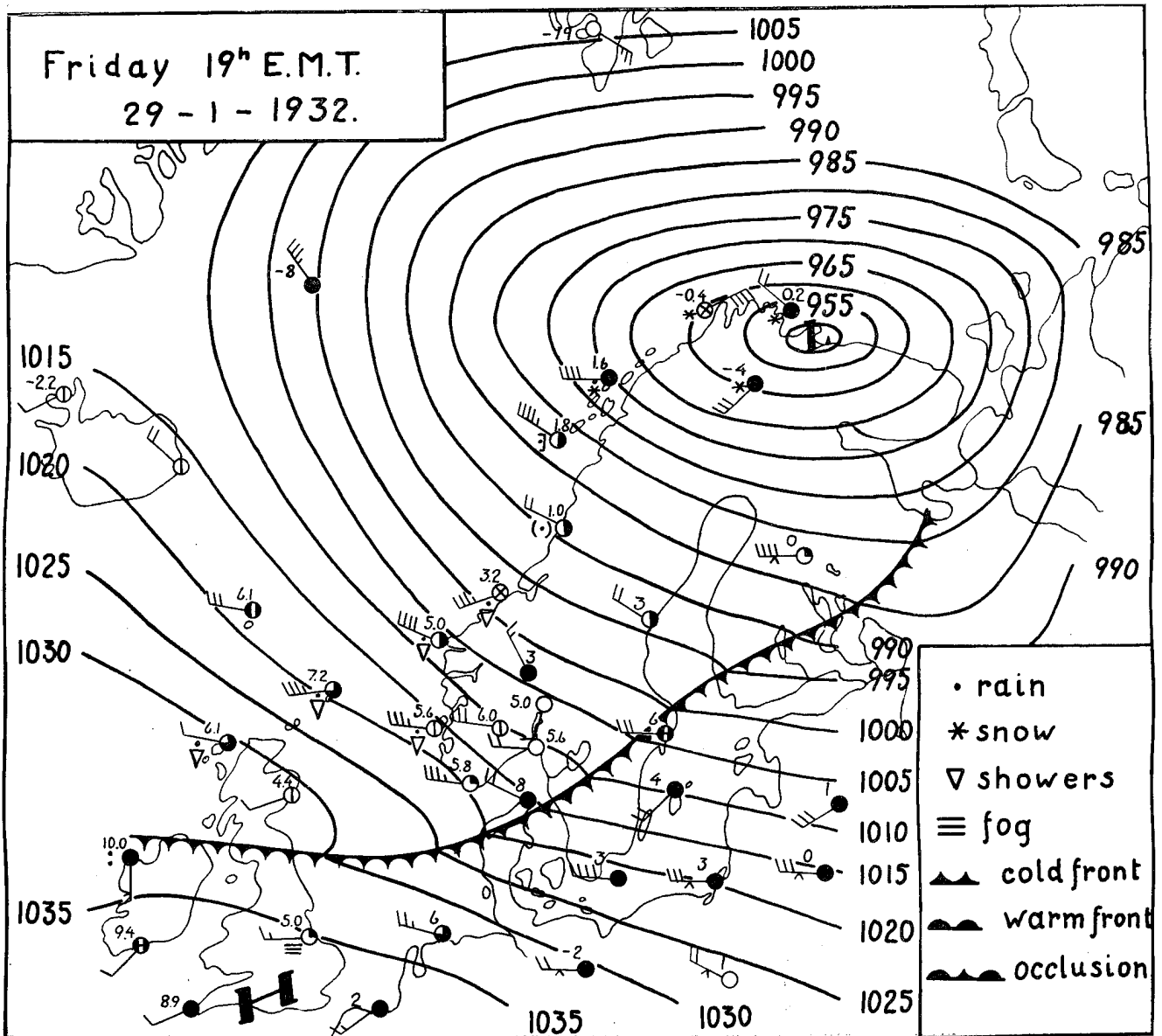


Fig. 28.

of pearl clouds formed a section over the others as a long formation parallel to Lake Mjøsa. To the right, was a long wedge with its apex towards SE. To the west of this, was a smaller cloud very similar to the first but with still more beautiful colours. This was observed at 16^h 30^m. The different layers of colours resembled eyes. The outer border was thin and blue-grey, then came all the colours of the spectrum towards the middle of the cloud: grass-green, lilac, violet and shining golden white in the middle, quite like mother of pearl; the colours followed each other in the most wonderful way. Towards 17 o'clock, all the colours changed to red, green and yellow-violet,

the shine from the clouds being so intense that it coloured houses and landscape in red-violet illumination.

Among the other reports of 29th January, afternoon, there is a special report from northern Sweden of similar clouds, with very fine small photographs of them taken by Mr. Albert Höckenström, an engineer from Stockholm. He sent me the following report:

During a journey in Norrbotten in the latter part of January, I chanced to see mother of pearl clouds. The first time was on the 20th January at 8^h 30^m near Boden, later, on the 29th January at the station

Förefors (latitude $65^{\circ}92'$, longitude $22^{\circ}66'$ E Grnw.), and this time the clouds were of exceptional beauty. During the dawn, I took some photographs of them. The sky was quite clear and without other clouds than the mother of pearl.

17. Weather Maps Corresponding to the Occurrence of the Mother of Pearl Clouds on January 29th 1932.

At my request Mr. Christensen, meteorologist of the Norske Meteorologiske Institutt, has drawn weather maps for the two moments 14^h and 19^h between which the clouds appeared. On figs. 27 and 28 these are reproduced with the necessary explanation. The weather conditions, already characterized by the late Professor Mohn and mentioned in the introduction, are here typically developed.

Mr. Christensen has added the following report to these weather maps:

"The weather conditions in the north-western part of Europe during the second half of January 1932 were characterized by high pressure over middle Europe and a zone with frequent passage of cyclones from Iceland across the northern-west part of Norway and farther to the east. A strong SW air-current swept over Scandinavia and, due to the föhn-effect, the south-eastern part of Norway had fair and mild weather. This situation was made more pronounced by outbreaks of cold air from NW after the passage of cold fronts.

The cyclone of the 29th January was centred over the north coast of Iceland at 8^h the 28th. It was moving rapidly in a NE direction and gradually deepening. At 14^h the next day when the pressure in the centre was approximately 950 mb it was moving in an easterly direction, slowly filling up. On the morning of the 29th, the cold front was running from Scotland across the west Norway over Dovrefjell and the northern part of the Baltic Bay, continuing northwards to the centre of the depression. The SE part of Norway experienced a SW wind with partly clouded skies, while the high level observatories reported W wind up to force 8.

As seen from the charts, the cold front passed SE Norway during the forenoon. The cold air behind the front was very unstable and was productive of

showers far down on the lee side of mountains, clear skies eventually appearing over the southern part of East Norway. In the afternoon Mother of Pearl clouds were observed in these districts".

18. Graphical Representation of the Heights Found on 29th January 1932 as Compared with Those of February 12th 1930.

It may be worth while to compare the heights found the two days. For that purpose we have enumerated on how many heights occur for each tenth of kilometers and have plotted these numbers horizontally out from a vertical scale as a thick line. In fig. 29, to the left, is seen the result for the Mother of Pearl clouds 29th January 1932 and, to the right, for the same on 12th February 1930. Under the latter we have also plotted the heights of the cirrus clouds. As can be seen, this diagram gives at a glance the principal results of the height measurements.

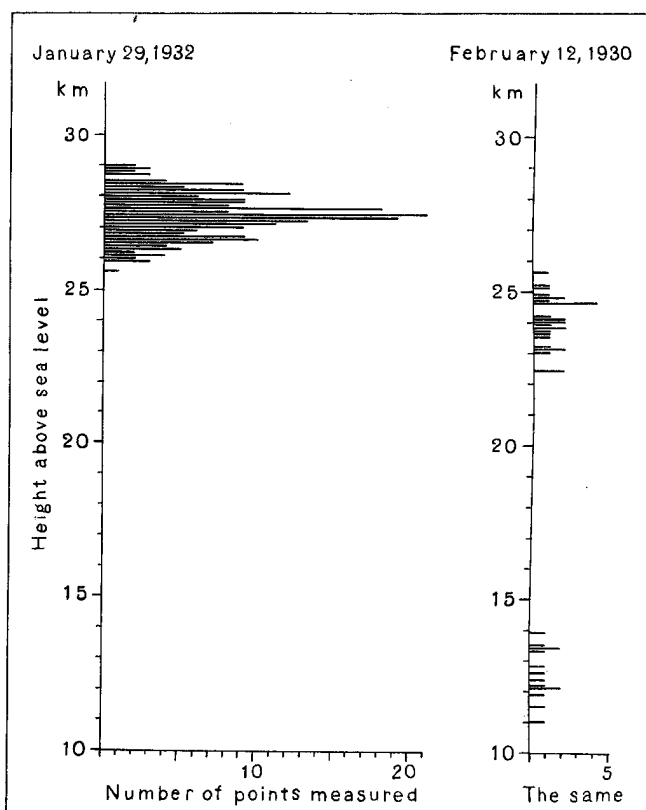


Fig. 29.

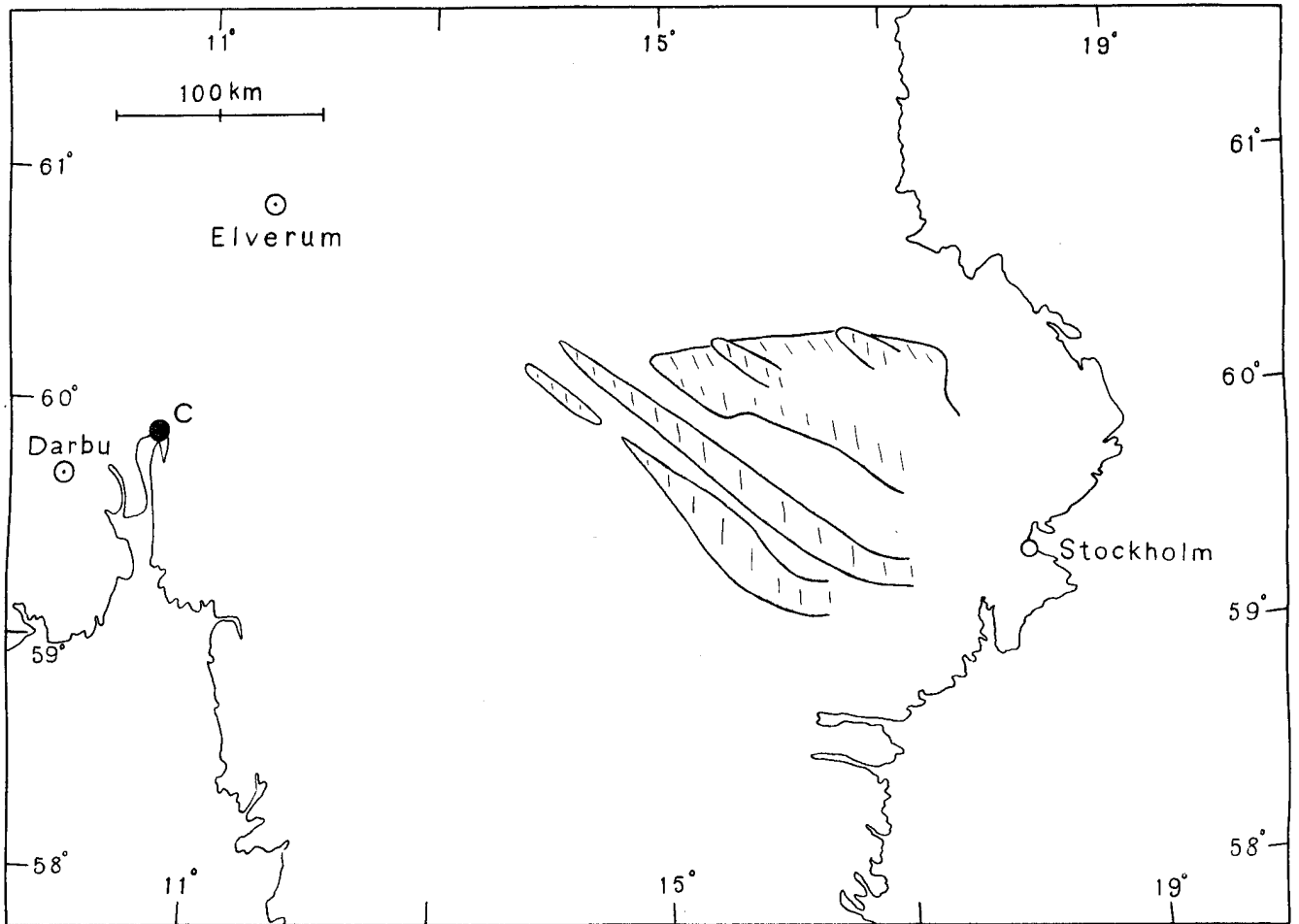
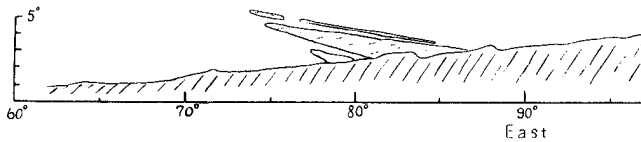
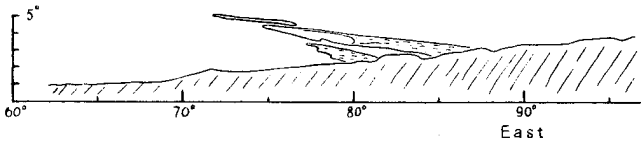


Fig. 30.

7.44-7.50 MET



7.55-8.00 MET



8.18 MET

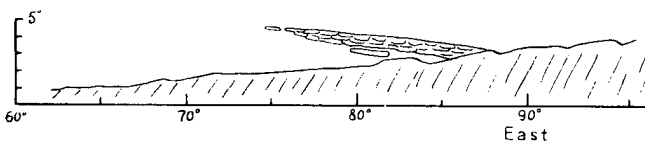


Fig. 31.

CHAPTER 4.

**Mother of Pearl Clouds
over Southern Norway in the Morning
of February 1st 1932.**

**19. Height Measurements by Means of a Picture
Taken in Oslo and One Taken in Elverum.**

As seen from the list in the introduction, interesting reports were also received on the morning of January 30th, but as no pictures were taken we proceed to the morning of February 1. During the night, 30th January—1st February, a very strong Föhn-wind with high temperature was raging over Oslo. As I hoped to see nacreous clouds before sunrise, I left my house for an open place in the neighbourhood at early as 6^h, while it was still dark. Watching the north-eastern horizon, I soon observed some clouds which had the characteristics of mother of pearl clouds, but still without any colours. I immediately went

home, took with me a common camera with panoramic plates and red filter and hastened to the auroral station on the eastern roof of the old observatory in Oslo. Being alone, and without telephonic connection with the other stations, I only took single photographs. About 8^h the clouds in NE were splendid; Two of the pictures are reproduced on plate 10. This time the clouds consisted of streams of small flocculi, each of these shining in a series of different colours. The main clouds continued in a tail towards south where it curved and disappeared behind the horizon.

Fortunately, Mr. O. H. Lømo at Elverum 117.8 km to the NE of Oslo, also happened to photograph the same clouds, but not quite simultaneously with my own. (See plate 9.) Nevertheless, it was possible to orientate the pictures from Oslo and from Elverum so that the necessary angles for height measurements

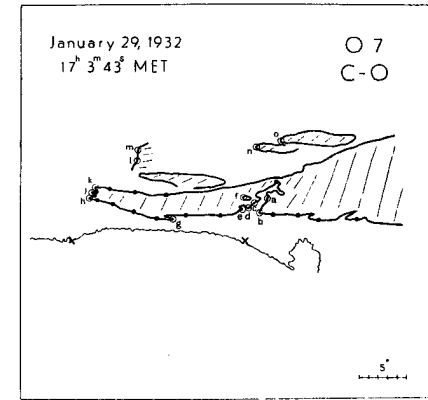
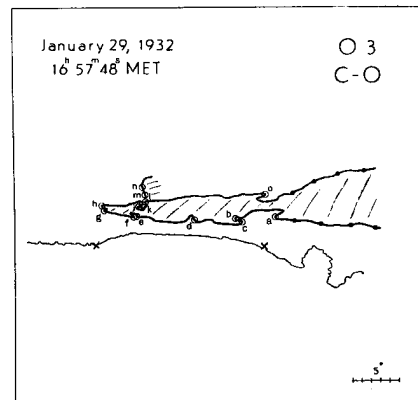
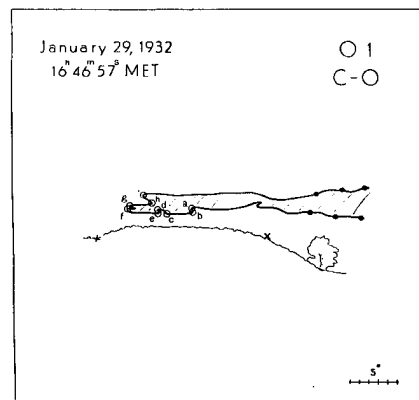
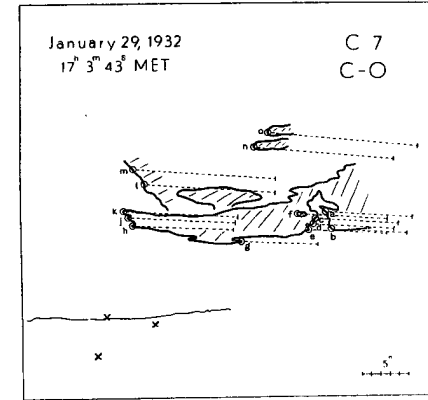
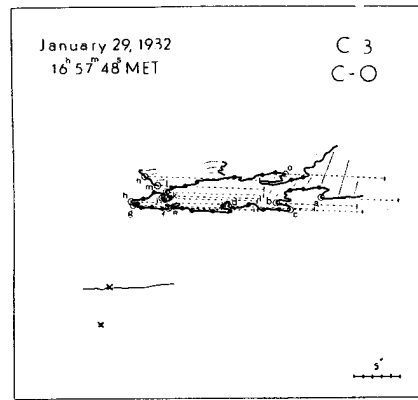
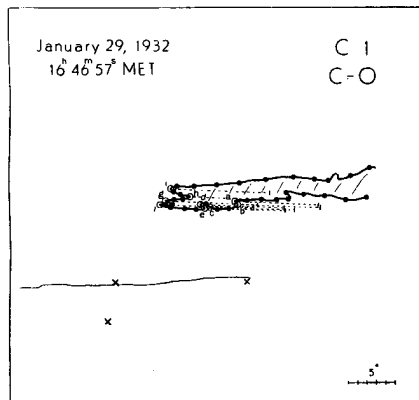
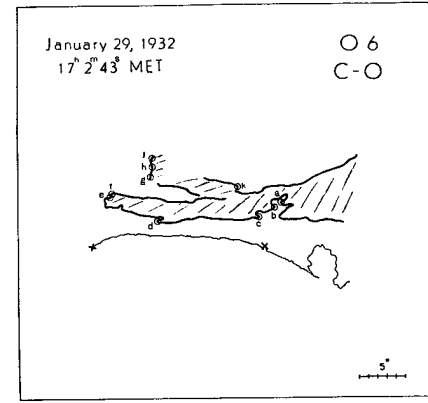
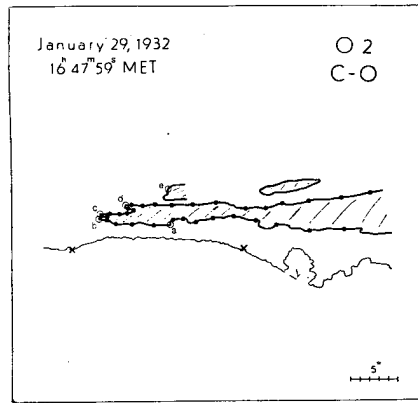
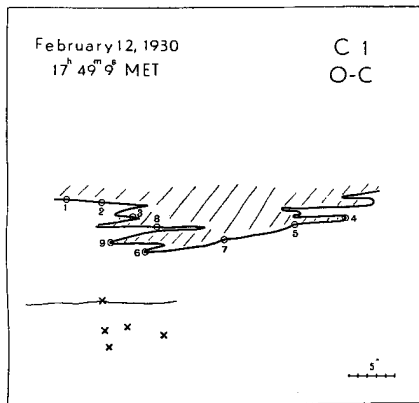
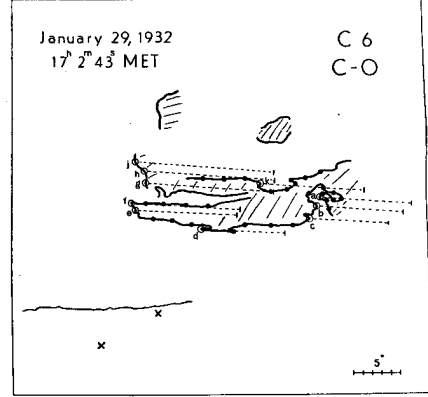
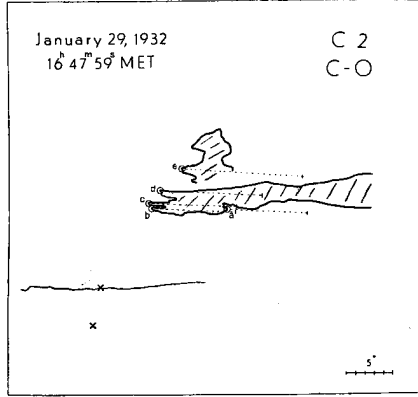
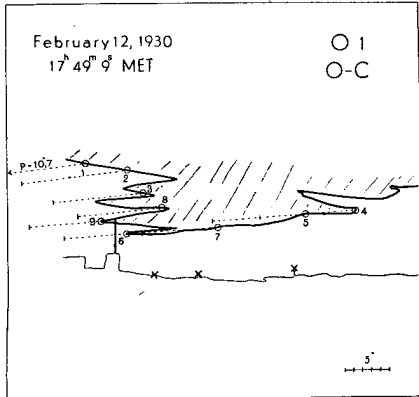
could be found. This gives at all events an idea of the approximate height and situation of the clouds. Egeberg who has tried to do this work, found the height somewhere between 21 and 26 km. On the map, fig. 30, are seen the situations over Sweden corresponding to the suppositions that the height was 23 km.

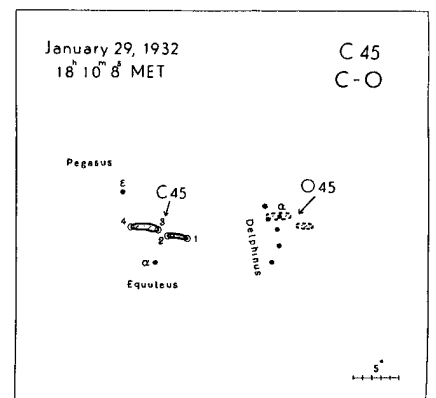
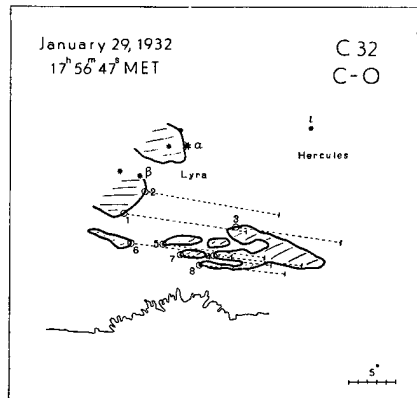
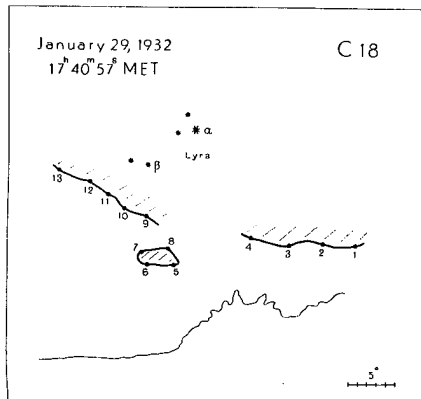
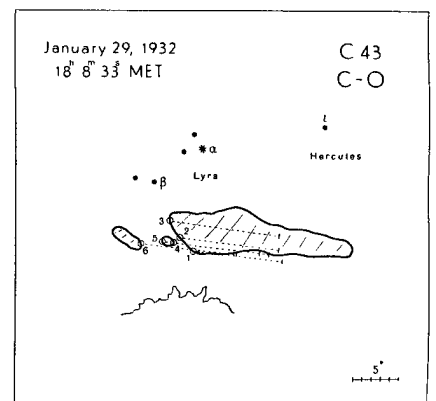
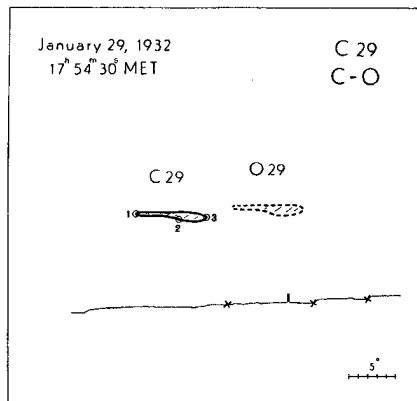
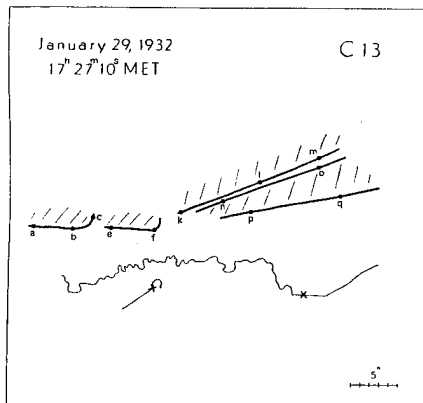
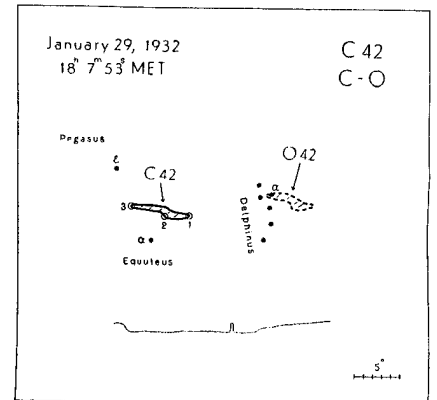
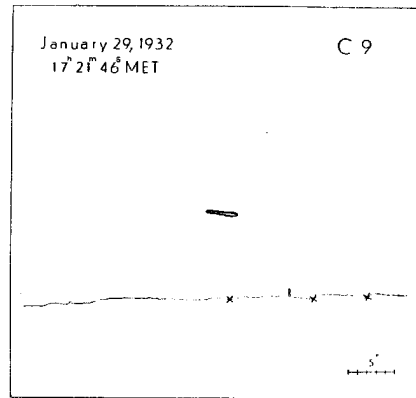
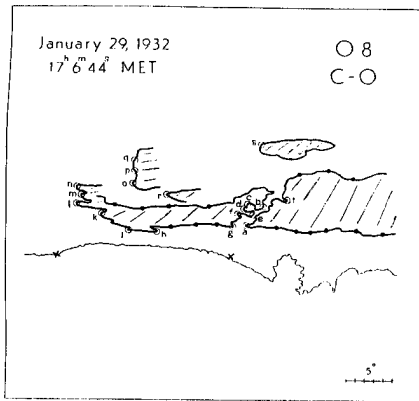
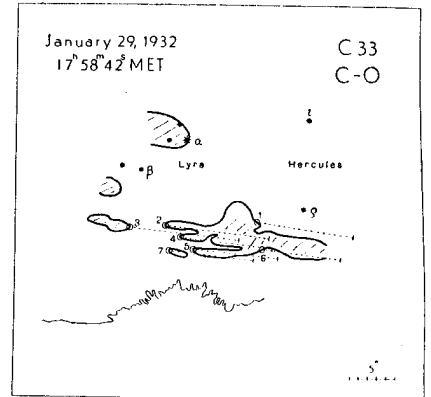
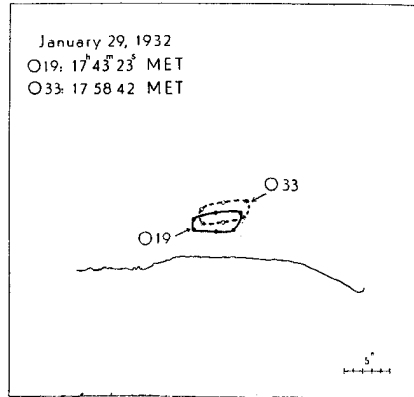
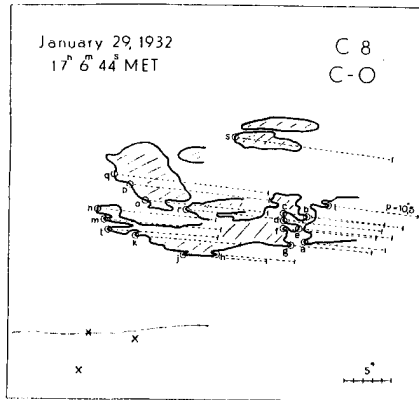
Among the other observations, those sent by Mr. Hassel in Darbu, near Kongsberg are very exact, some of them are seen in fig. 31.

These sketches correspond very well to the situation found from the photographs from Oslo and Elverum, and as an independent control the height was found to be 23 km.

In the next communication the very rich material from 19th—20th February 1932 and 6th February 1934 is to be published and discussed.

Printed September 30th, 1939.



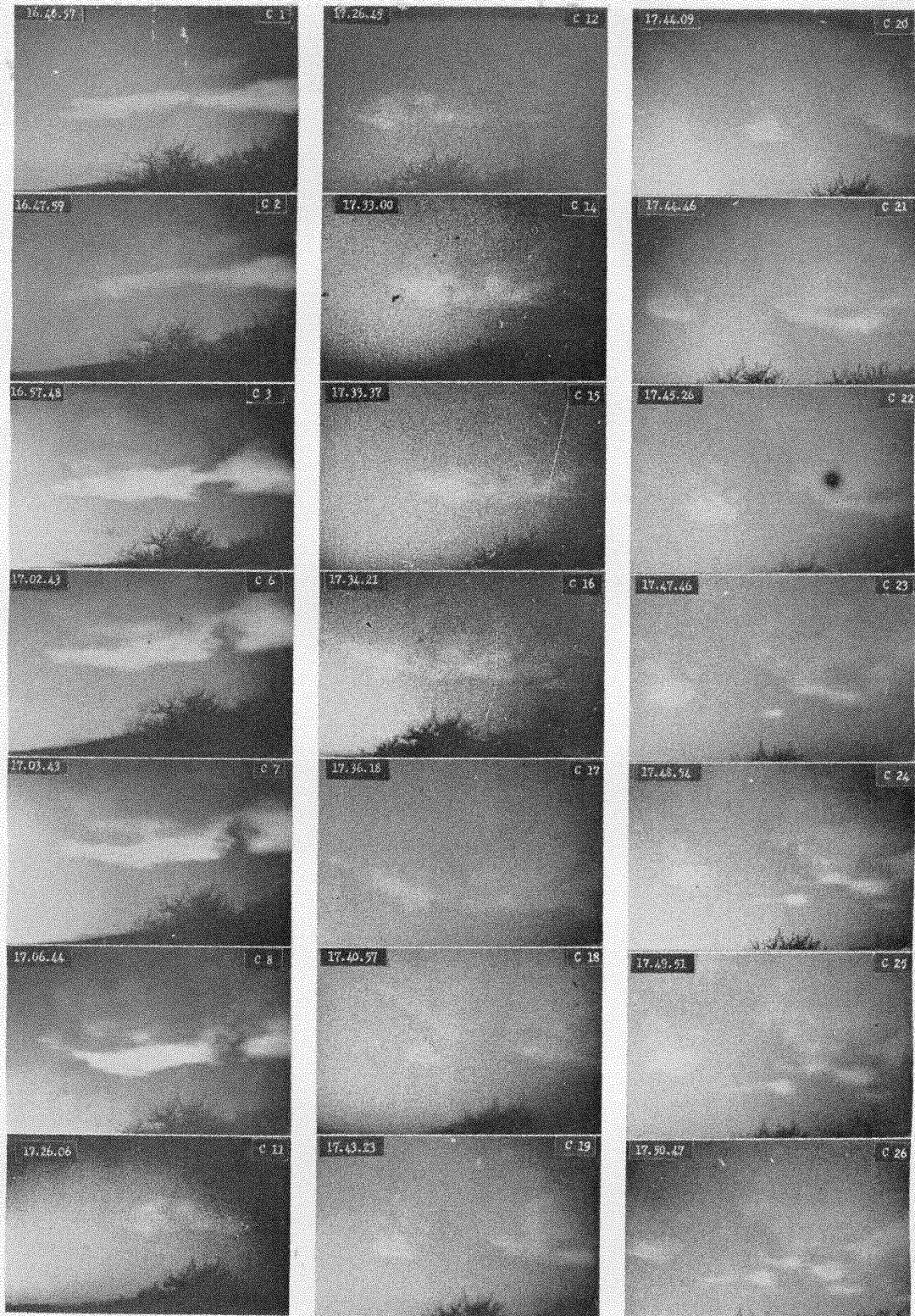


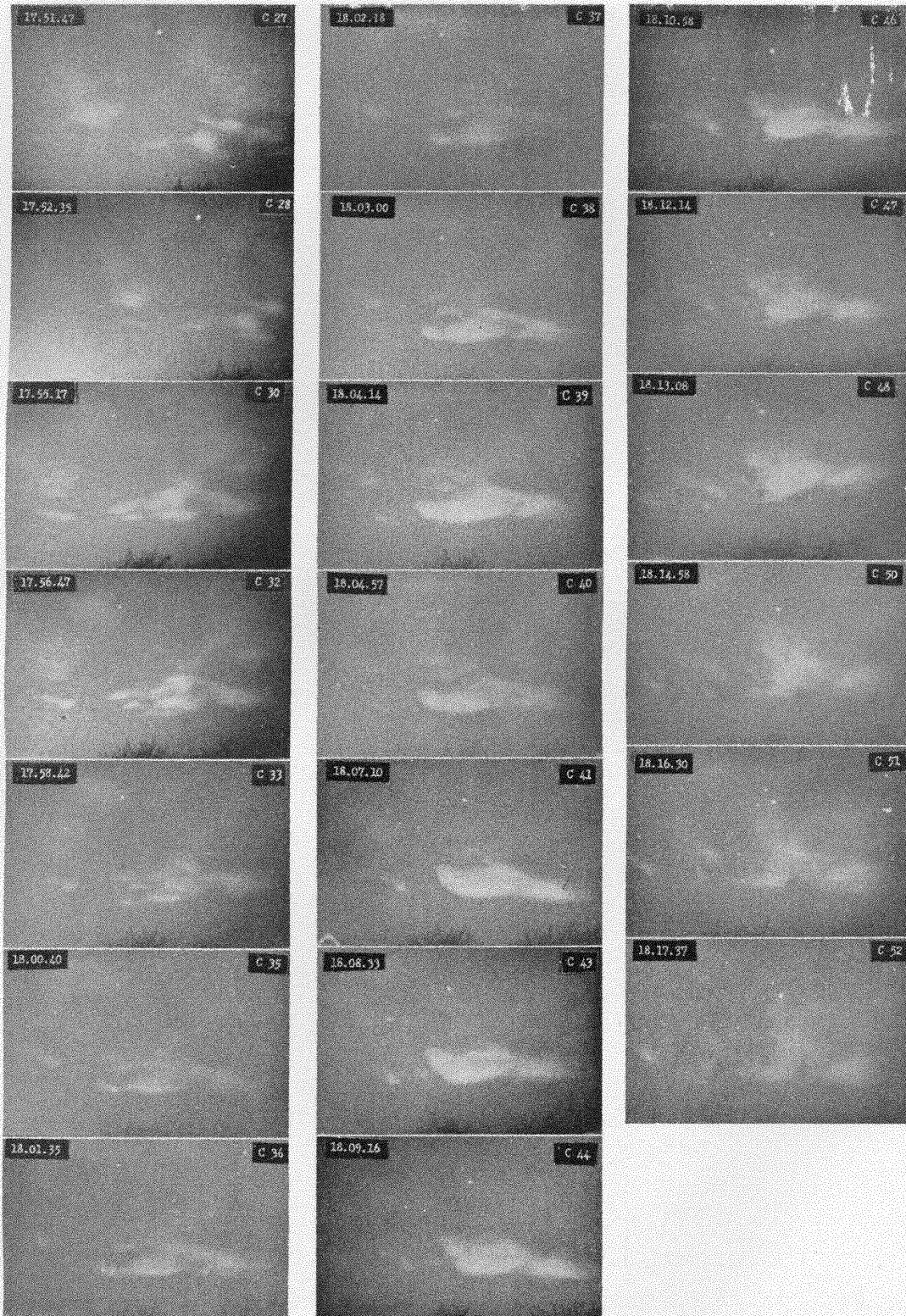














Mother of Pearl Clouds. Lillehammer, January 29th, 1932
(Upper picture taken 16^h 30^m, lower 16^h 40^m).



Same clouds from Ringsaker.



Mother of Pearl Clouds. Elverum, February 1st, 1932, 8^h 10^m.



Mother of Pearl Clouds. Oslo, February 1st, 1932, 7^h 59^m 20^s



The same, 8^h 4^m 20^s