SVERIGES GEOLOGISKA UNDERSÖKNING

AVHANDLINGAR OCH UPPSATSER

SER. C ÅRSBOK 52 (1958) N:O 2 N:O 559

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EXPERIENCES MADE WHILE PREPARING A SURVEY MAP

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STOCKHOLM 1958. KUNGL. BOKTRYCKERIET P. A. NORSTEDT & SÖNER

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Preface

The following paper is a summary of four previous works by the present author. They comprise the general part of the description of the survey map of the Quaternary deposits in Värmland (Sveriges Geologiska Undersökning, Ser. Ca, nr 38), the description of the map of the upper Klarälven valley (S. G. U., Ser. C, nr 550), a geochronological investigation (S. G. U., Ser. C, nr 551) and a presentation of C^{14}-determined samples from peat bogs (S. G. U., Ser. C, nr 554). The mapping formed part of the general mapping program of the Geol. Survey of Sweden during which the work was carried out. Thus, it has not been possible to elaborate any one of its constituent parts in detail; the aim being to give a general survey of the Quaternary history and deposits of Värmland as they may be interpreted from the observations made during the mapping.

The mapping was started in 1952 by the director of the Geol. Survey, professor N. H. Magnusson and was first entrusted to professor G. Lundqvist. On account of other tasks he could not devote any time to this work and the present author therefore took over the mapping.

The mapping was carried out jointly in its entirety by the present author and Mr. Carl Larsson. The geological assistents A. Klarström, I. Köhlin and H. Möller rendered assistance in some of the detail work. The special map of the upper Klarälven valley was prepared with the assistance of geological assistents G. Eriksson, G. Norin and J. Offerberg. During survey excursions many problems were discussed with professor N. H. Magnusson, professor G. Lundqvist, C. Caldenius, Ph. D., and Å. Sundborg, Ph. D. In this connexion the boulder countings were carried out by professor N. H. Magnusson. The drilling was planned together with B. Järnefors, Ph. Lic., and executed by mr G. Ekman.

Most pollen analyses were carried out by mr Carl Larsson. The chemical and mineralogical analyses were planned in co-operation with G. Assarsson, Ph. D., and B. Järnefors, Ph. Lic. The chemical analyses were carried out at Statens Lantbrukskemiska Kontrollanstalt (potash and phosphate) and at the chemical laboratory of the Geol. Survey (titanium and manganese). Determinations of the mechanical compositions of the earths, heavy mineral indices and salinity as well as differential thermal analyses were carried out at the soil-laboratory of the Geol. Survey. The X-ray analyses were made by A. M. Byström, Ph. Lic., and the diatom analyses by mrs U. Miller. Chemical analyses also were placed at my disposal by O. Arrhenius, Ph. D.

The data about soil thickness are compiled from information given by Kgl Väg- och Vattenbyggnadsstyrelsen, Statens Geotekniska Institut, AB Elektrisk Malmletning, Billeruds AB, Hellefors Bruks AB, AB Rottneros Bruk and Uddeholm AB, some of which have also submitted information about gravel occurrences etc.

The printing of the map and figures was supervised by M. Lundqvist, Ph. D., and later on by chief cartographer O. Hedbom. The drawing of the survey map was carried out by mrs Elisabeth Björk. The English was corrected by N. H. Edström, M. Sc., and Ch. Roering, B. Sc. In the reading of the proofs my wife, mrs Doris Lundqvist, has taken part.

To all these persons and institutions I express my sincere thanks.

Finally I wish to express my gratitude to my academic teacher docent Carl-Gösta Wenner.

J. Lundqvist

Previous works in Värmland

The Quaternary geology of certain areas in Southern Värmland has been treated in the descriptions appended to the older larger scale maps (Blomberg 1903, 1903 a, 1904, 1904 a, G. De Geer 1902, Granlund 1928 a, S. Johansson 1917, Magnusson and Assarsson 1929, von Post 1929, Sandegren 1916 a, 1920, 1920 a, 1922, 1927, 1933, 1937, 1956, Törnebohm 1870). Certain problems concerning the Quaternary geology of Värmland have been treated in special papers. The most important of these will be quoted in the following.

The deglaciation conditions in Eastern Värmland were treated by Granlund (1928). G. Lundqvist (1935) in his paper on the deglaciation in the region E of Värmland also discussed the special conditions within this county. The extraordinary ice movements W of Lake Vänern were described by W. Larsson (1945). G. De Geer (1909) and Wenner (1955) discussed the deglaciation in regions of the special type that characterizes i. a. Western Värmland. J. Lundqvist (1957 a) studied the deglaciation within the Bjurtjärn district in Eastern Värmland. A preliminary account of the deglaciation in Värmland as a whole was given by J. Lundqvist (1954).

The complicated problems concerning the land uplift were studied especially by von Post (1915, 1925, 1928, 1929 a, 1934, 1948). His results that implied that the uplift was rather irregular in Värmland, however, were criticized by E. Nilsson (1953). The latter showed that the results of von Post's might as well be applied to a quite regular shore-line system. Sandegren has contributed to this question by investigations in certain areas (1916, 1939, 1943). A detailed study of the highest marine limit (MG) was made by Gillberg (1952) who also gave a summary of old observations from several regions, i. a. Värmland.

The special conditions concerning deglaciation as well as land uplift and general geology in the upper Klarälven valley were treated first by Hollender (1900) and Dahl (1902). More detailed studies were made by S. De Geer (1906, 1911) and J. Lundqvist (1957). von Post (1948) published his results from the valley which, however, were only preliminary. Sundborg (1956) studied the fluvial processes and the sediments of the river. A detailed study of the formation of an abandoned loop (ox bow lake) was made by Falk (1957).

Studies of moraine forms in Värmland were made by G. De Geer (1895 and 1896; cf. also Torell 1896). The former paper treated drumlins, the latter the terminal moraine field at the Åråsviken bay (cf. also G. Lundqvist, 1954 a, and the recently published paper by Hoppe, 1957). Terminal moraines in the Arvika district were also described by J. Lundqvist (1954).

Aronson (1911) gave a description of an esker in central Värmland from which he also drew some conclusions concerning the deglaciation. Glacifluvial deposits from the eastern boundary of Värmland were treated by

Sundius (1922). The large Brattforsheden delta was thoroughly described by Hörner (1927). His opinion, especially about the location of the marine limit, was criticized by Granlund (1928).

Fine-grained sediments in Eastern Värmland were studied by Granlund (op. cit). Some special properties of the clays, i. a. in Värmland, were treated by Wenner (1949) and Soveri (1950). A more general account was given by J. Lundqvist (1957 a). Varve diagrams were published by G. De Geer (1940). The types of cultivated soils were shown by Ekström (1951).

The dune field of Brattforsheden was described by Hörner (op. cit.). He interpreted the dunes as transversal. Another interpretation of this field — that the dunes are longitudinal — was presented by Enquist (1932). The meteorological and climatological conditions of their genesis were treated by Hjulström (1955) and Sundborg (1955) whose results supported Hörner's opinion.

The different types of peat land within Värmland were shown on the map by von Post and Granlund (1926). The stratigraphy of i. a. bogs in Värmland and the problems concerning their development and chronology were treated by von Post (1928) and Granlund (1932). A special study of these problems along the lower Klarälven valley was made by Sandegren (1939). C^{14}-analyses from peat bogs in Värmland were presented by J. Lundqvist (1957 b). Certain contributions to the history of the vegetation within Värmland were given by von Post (1915 a, 1918), Malmström (1934) and Suneson and Sandegren (1948).

The occurrences of salt water mollusca were described by Rekstad (1922) and Hägg (1923, 1947, 1952).

The influence of the bedrock (especially the hyperites) on the fertility of the soil was studied by Tamm (1921) and also shown on Eklund's (1952) map.

Methods

The mapping mainly followed the same principles that were used on the previous survey maps, e. g. in the neighbouring county of Kopparberg (G. Lundqvist 1951). Since the geology of the two counties is very much the same it was considered as most convenient to use similar principles.

Thus, the mapping was carried out mainly along the roads and paths available. The frequency of these routes is shown in Sw. ed.[1] (fig. 1). The southern parts of Värmland are covered by older larger scale geological maps. Here only comparatively few observations were required. In the upper Klarälven valley a generalization of the map already published (J. Lundqvist 1957) was used. Where possible complementary observations were made with the aid of the aerial photos of Rikets Allmänna Kartverk.

The exposed areas of Archean bedrock and the mires were taken directly

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[1] In the following the description of the survey map of Värmland (J. Lundqvist, 1958) will be referred to as Sw. ed. (Swedish edition).

from the topographical map but it was necessary to make corrections based on field observations in order to obtain a composite picture of the whole province.

The mapping of the wave-washed moraine was one of the most difficult problems. It is only possible to give an account of the broad limits of its extension (cf. p. 26).

Of course it has been necessary to generalize the other types of deposits also, especially in the SW where there are rapid transitions between quite different deposits. To give an account of the degree of generalization a special map (Sw. ed., fig. 2) was made.

Numerous soil samples were collected during the mapping. Most of them were mechanically analyzed. These analyses were carried out at the Geol. Survey according to its standard methods (in most cases a combination of the old Atterberg and pipette methods; in some cases the new hydrometer method was used). A selection of the analyses was shown in Sw. ed. (p. 217). The fraction names used are the following:

Stones (Sw. sten) = 200—20 mm
Coarse gravel (Sw. grovgrus) = 20—6 mm
Fine gravel (Sw. fingrus) = 6—2 mm
Coarse sand (Sw. grovsand) = 2—0.6 mm
Sand (Sw. mellansand) = 0.6—0.2 mm
Fine sand (Sw. grovmo) = 0.2—0.06 mm
Very fine sand (Sw. finmo) = 0.06—0.02 mm
Coarse silt (Sw. grovmjäla) = 0.02—0.006 mm
Fine silt (Sw. finmjäla) = 0.006—0.002 mm
Clay (Sw. ler) = < 0.002 mm.

In many cases chemical and other analyses were also made on these samples.

The description of the survey map consists of two parts; one general and one descriptive. Thus, this paper is a summary mainly of the former.

Archean bedrock

The bedrock of Värmland is mainly of middle Archean (Gothian) age. It consists of three different parts: a central area with red gneisses, surrounded by mainly grey gneisses in the west and granites in the east.

Within the grey gneiss region a few small massives of Bohus granite occur. In this area the famous Gillberga syncline is situated. Here granites of the red Kroppefjäll and the grey Åmål types and greenstones are surrounded by a zone of Åmål porphyries and quartzites.

The boundary between the areas of grey and red gneisses consists of a broad mylonite zone (Magnusson 1937). The mylonized and schistose rocks are Åmål quartzite and Åmål-Kroppefjäll granites.

In the area of red gneiss numerous hyperite bodies occur. Here also are areas of the so-called Hammarö supra-crustal series.

Three main granite types form the eastern granite region: the grey, basic Kristinehamn granite, the red intermediate Filipstad granite and a red biotite granite. Together with the Åmål and Kroppefjäll granites these are called the Värmland granites. In the granite region an area of the older Archean leptite formation with leptites, hälleflintas, limestones, shales and ores occurs. Here the well-known ore fields of Nordmark, Persberg and Långban are situated. Within the granite region also the only oldest Archean gneissic granites occur. Bodies of Gothian porphyries and quartzites (Rämsberg quartzite) are rather numerous in the granite region. In the easternmost part of Värmland younger (Sub-Jotnian and Jotnian) Dala granites, porphyries and sandstone also occur.

The influence of the bedrock on the fertility of the soil was shown by Eklund (1952). Most of the rocks in Värmland have a rather unfavourable influence. The quartzites and Dala sandstone and porphyries have an especially unfavourable influence. Only the limestones, shales, greenstones and hyperites have a favourable influence. This, however, is of rather local importance.

Numerous fissure zones through Värmland had an important influence upon the Quaternary development. These were probably founded in Archean time (W. Larsson 1938) but movements have taken place along them at least as late as in Permian time.

Morphology

The morphology of Värmland has had a rather great influence upon the Quaternary development and consequently a short account of its main features will be given:

The largest part of Värmland belongs to the broken country of Northern Sweden. Southernmost Värmland, however, is a peneplain. Fossil finds in fissure fillings in this plain show that it must be the sub-Cambrian peneplain.

Through crustal movements in post-Cambrian time the peneplain has been broken into several blocks that may have been raised or lowered.

North of the coastal plain of the Lake Vänern mountains, rising above the peneplain, are numerous. Only along the large valleys may the peneplain be followed farther to the north.

Northernmost Värmland is a strongly broken terrain with differences in height of 200—300 m. A high plateau between the rivers Klarälven, Femtan and Halgån sharply contrasts with this broken country.

Flat surfaces, possibly representing older peneplains, may be seen in many districts, especially in Northern and South-Western Värmland. One of those forms the surroundings of the sandstone area at the river Svartälven and is probably the sub-Jotnian peneplain.

The most characteristic morphological feature of Värmland is the large number of fissure valleys. Of these the broader form the valleys of the water systems of the rivers Byälven, Norsälven and Klarälven. Most of the valleys form a concentric system around the Oslo field; some of them are radially orientated. The origin of the fissure zones is probably connected with the tectonic origin of the Oslo field (cf. p. 10).

The bedrock in the fissure zones is easily weathered and this must have had a great influence upon the formation of valleys. The most important agents, however, were probably the running water and the ice.

In the upper Klarälven valley three generations of valleys may be seen. The bottom of the oldest one forms a broad terrace about 80 m above the plain of the river. Earlier the younger and deeper valley generation had a rather narrow canyonlike bottom that has been found under the sediments at Klarabro at a depth of about 40 m below the river (cf. J. Lundqvist 1957, p. 7). The last generation was formed when glacial erosion widened the canyon.

The different kinds of rocks cause somewhat different morphology. The gneisses often form ridges in the strike direction. When a system of such ridges is cut across by a system of fissure lines a characteristic checkered pattern is formed as on the Isle of Hammarön. In the broad valleys the gneisses often form drumlinlike ridges, smoothened by moraine and sediments. The hard hyperite generally occurs as steep mountains, similar to monadnocks. The youngest granites in the east give a strongly undulating country. The area of Dala sandstone is very flat. Leptites and shales form a flat country with a rather rough surface.

Directions of ice movements

The main direction of the ice movement was from the north (fig. 1). Towards the south there was a distinct trend to the right, i. e. towards the open sea in the SW. Deflections of the same nature were caused by the two large basins of Lake Vänern. In Southern Värmland the striæ are directed towards these basins.

Divergences from the main direction occur in many places. In the valleys in South-Western Värmland the striæ often follow the valleys and rock forms in detail. The ice must have been very plastic, probably on account of a small content of moraine material.

Crossing striæ are common in the whole of Värmland except in the northern parts (fig. 2). Several essentially different types occur:

1) In the valleys in the SW one system at an oblique angle to the valley is often crossed over by a younger system that follows the valley. The latter was caused by ice lobes in the valleys immediately before the ice disappeared.

2) Considerable deviations of the ice movements were in some cases caused by larger land forms, as e. g. the relatively high country between Lakes Ö. Silen and Lelången. The ice, coming from the district E of Lake Ö. Silen, was deflected towards the NW or even N (cf. W. Larsson 1945).

3) In the broad low-lying valleys there were estuaries in the ice margin.

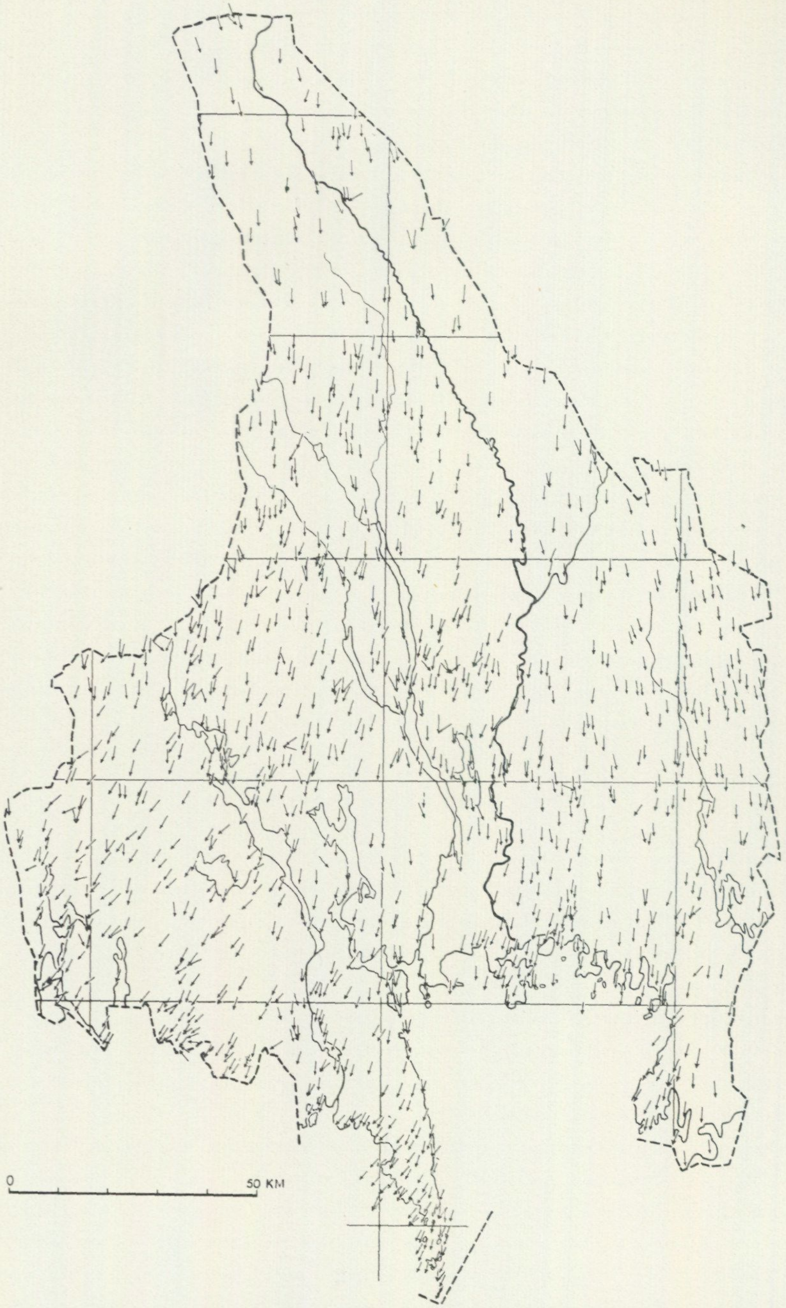

Fig. 1. Directions of the striæ in Värmland. A distinct turning to the right is seen towards the south. The crossing striæ are separately shown in fig. 2. From Sw. ed. (fig. 7).

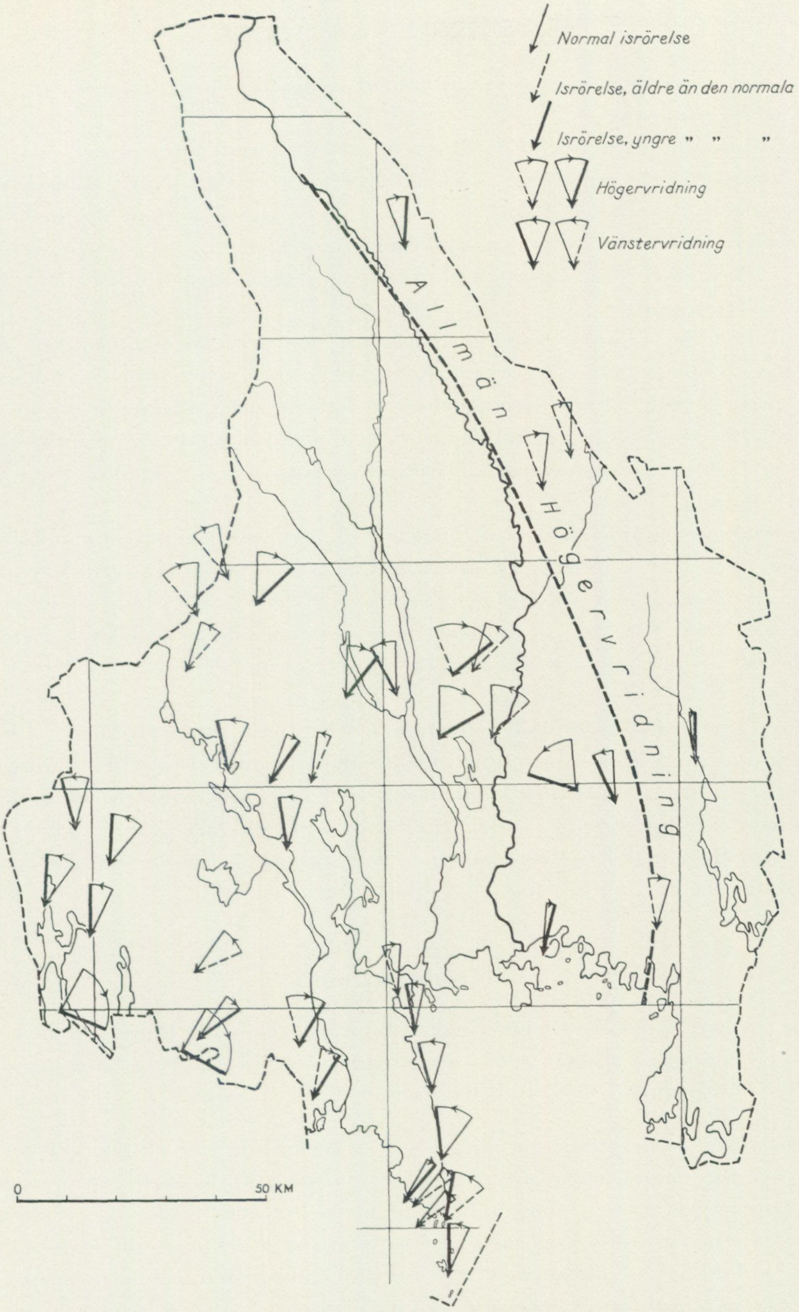

Fig. 2. The crossing striæ in Värmland in those cases where it has been possible to determine the age relations. In the district E of the broken coarse line there is a general turning to the right, earlier known from Eastern Sweden. W of the line local factors have affected the youngest ice movements. Broken arrows = striæ, older than the normal system. Coarse arrows = striæ, younger than the normal system. From Sw. ed. (fig. 8).

In those cases the last ice movement was directed at an oblique angle towards the valley.

4) The same deflections were obtained along the large eskers where there also were estuaries.

5) Along the Byälven—Glafsfjorden valley a system of striæ older than the common one sometimes occurs running from the NW. Probably this older system is connected with a more westerly ice shed than the most common striæ. When the ice originated from a more westerly ice shed it was more easily deflected by this valley than at a later stage, when it crossed the valley at a wider angle.

6) When the ice sheet was thick it could pass over the peninsula of Värmlandsnäs without being deflected. At a later stage when it was thinner the steep eastern side of the peninsula deflected the ice, coming from the NE, towards the S. On the western side of the peninsula the ice movement was directed a little more towards the western basin of Lake Vänern than at an earlier stage.

7) In Eastern Värmland the direction of the last ice movement was not influenced by the topography to the same extent as in Western Värmland. Here, as in large areas of Middle Sweden, there are two systems of striæ: one from the N or NW and a younger more easterly one. The latter originated when the ice shed moved towards the E (cf. Ljungner 1947).

Thus, there was a general deflection to the right in the whole of Central Sweden but in Western Värmland local topographical factors had a dominating influence. This is especially clear because of the fact that the original ice movement in this district crossed the topography at large angles. The rocks are distinctly gouged by the last ice movement which shows that the ice was still rather active at the time of deglaciation.

Deglaciation

The principles of the deglaciation mainly agree with those published by e. g. G. Lundqvist (1935, 1951; the County of Kopparberg) and Isachsen (1933), Holtedahl (1953) and Holmsen (1955; Norway).

Deglaciation below the marine limit (*MG*). Where the ice discharged in the open sea the deglaciation was dependent on ablation and frontal recession. The latter was a result not only of ablation but also of calving. The extent of the calving depended on the ratio between ice thickness and water depth. When ablation had diminished the ice thickness calving was increased. In this way a rhythmical recession could arise.

In many places terminal moraines originated when the ice front was stationary for some time. These are mainly of the »annual» type, though probably calving was also of some importance for the location of terminal moraines (cf. Hoppe 1948, p. 14, J. Lundqvist 1954, p. 52).

In the mouth of the subglacial discharge rivers the ice sheet was thinner. There the calving had a greater effect and estuaries in the ice front could develop.

These estuaries mostly seem to have been distinctly asymmetrical (cf. G. Lundqvist 1935, 1955 a, Järnefors 1956, J. Lundqvist 1957 a). Their western side was less oblique to the esker in their centre than the eastern side. The center of the estuaries was situated W of the esker. The first type probably resulted from the effect of the morning mists that protected the western side against the sun's radiation (G. Lundqvist 1935, p. 295). The second type may be a result of a more active calving in the deepest part of the valley.

The sub-glacial discharge rivers, however, were essential for the genesis of estuaries. In Western Värmland these streams were small on account of the broken country that divided them into many small streamlets. Hence the calving did not have the same importance here as in Eastern Värmland. Here there were ice lobes in the valleys instead of estuaries.

In the upper parts of the valleys where the water was shallower the calving ceased. Here there was a stagnation in the ice recession and marginal deltas were often formed. These deltas therefore depend mainly on topographical factors and must not be interpreted as a result of a stagnation in the ice recession in its entirety.

Deglaciation above the MG. Supra-aquatically the deglaciation was a result of ablation rather than recession. The highest mountains first appeared as nunataks. Gradually the ice sheet was divided into remnants isolated in depressions and valleys. In some cases the ice sheets in the higher depressions could move separately but mostly they were dead. In the valleys, however, the ice lobes were active. Therefore, active valley glaciers could co-exist with dead ices at higher altitudes. The sides of the large valleys as well as the peaks were free of ice.

G. Lundqvist (1935, p. 289) was of the opinion that the ice sheet in Värmland should have been dead already when its front crossed over Southern Värmland. That this was not the case is shown by numerous terminal moraines. This caused G. Lundqvist to assume a rapid ice recession, due to a great water depth. However, no proof of such a depth has been found during my work and the striæ around Lakes Fryken show that the ice was still active later than was assumed by G. Lundqvist. Probably Lundqvist's gradient value 1 : 550 was chosen too low, an opinion already presented by Mannerfelt (1945, p. 112).

Ice-dammed lakes. The conditions were favourable for the genesis of ice-dammed lakes in Värmland, especially where the land surface slopes towards the north. Those lakes, however, were generally small and of short duration. As the depressions were filled by dead-ice remnants the lakes were mostly narrow marginal ones. The formation of ice-dammed lakes is illustrated by the South Finnskoga Ice Lake (Sw. ed., fig. 11).

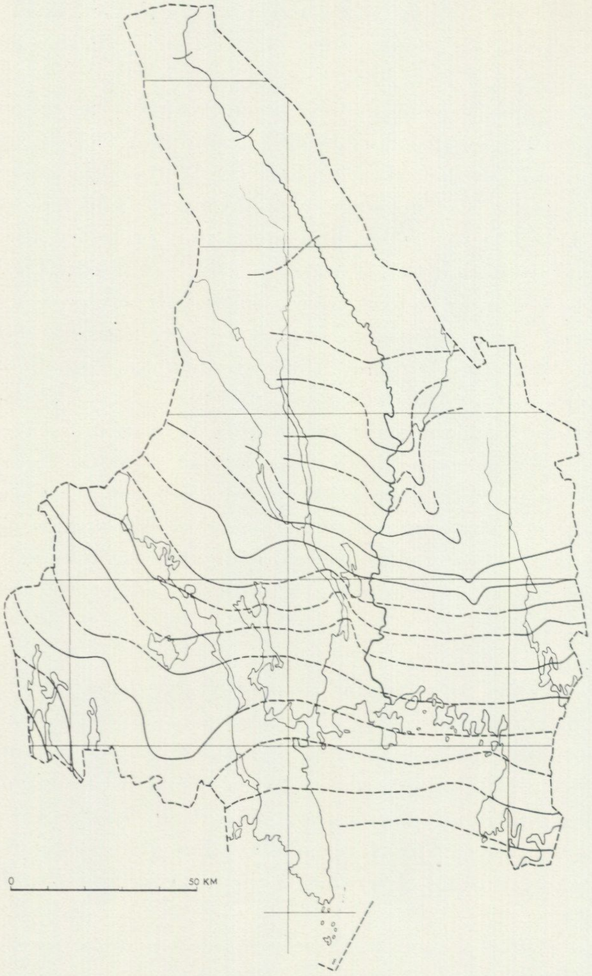

Fig. 3. Tentative lines of ice recession for every 50th year through Värmland. They have been constructed from the variations of the highest marine limit (MG). Only in the northern part of topo. map sheet 72 Nora are the lines exact (obtained from varve measurements). Where observations of the MG are lacking the lines are broken. The direction of the lines in the SW and the occurrence of estuaries or ice lobes in the valleys are to be observed. From Sw. ed. (fig. 14).

Lines of ice recession. Since varves are often lacking in the glacial clay it is not possible to obtain any recession lines from varve measurements in the greater part of Värmland. This has been possible only in the Bjurtjärn area (J. Lundqvist 1957 a). Here the lines show an annual recession of about 160 m, which correlates well with values obtained from the terminal moraines in some other parts of the county.

Tentative lines of recession have been constructed from the values of the marine limit (mostly from Gillberg 1952). This would be possible with knowledge of the rate of land uplift, the direction of the isobases and the gradient of isochronous shore-lines, synchronous with the MG. 10 m/year was assumed as a value of the rate of land uplift (cf. e. g. Granlund 1928, p. 25). The isobases and gradients were obtained from E. Nilsson (1953). An error in the first value will affect the frequency of the lines only, i. e. the rate of ice recession obtained. Errors in the other two factors would cause a misinterpretation of the whole picture of ice recession but the fact that this picture appears very probable also makes the isobases and gradients probable. Only in Eastern Värmland did the MG method give quite absurd results. This is, however, the district where varve measurements could be used so these more exact equisesses have been correlated with those obtained from the MG. The result is shown in fig. 3.

Some features in the picture should be observed:

1) In the west the lines distinctly turn to the NW or N. This agrees with the direction of the end moraine belt through Middle Sweden in Dalsland and with the estuary that probably existed around the Oslo fiord and also with the directions of the striæ towards the west in South-Western Värmland.

2) There is a large convexity of the lines between the Järnskog and Byälv valleys. This was caused partly by the height conditions, partly by the rate of recession. The latter was greater in the Väner basin than in the higher region to the west of it. The convexity arose when the ice there was still active, which is probably one reason to the striæ being orientated towards the NW in this district (W. Larsson 1945).

3) A large estuary existed in the Fryken valley. This makes the youngest striæ towards the valley (cf. p. 11) seem quite natural.

4) The lines form a distinct lobe N of the Brattforsheden delta.

5) The rate of recession was great in the Klarälven valley. Partly due to the small differences in height between the northern and southern part of the valley the ice lobe disappeared almost immediately on breaking afloat (cf. von Post 1948, p. 206).

The uplift of land

Well developed shore-lines are numerous in southern Värmland. They have been especially investigated by von Post (e. g. 1915, 1925, 1929 a, 1948) and Sandegren (1916, 1939). No special investigations of the shore-lines were made during the mapping but some new material and views were obtained:

The marine limit (*MG*). The MG in Värmland was studied by Gillberg (1952). He found that the general rise of the MG towards the north is interrupted by a somewhat steeper rise in Southern Värmland, followed by a descent. After this descent the MG again rises with the normal gradient. This MG-peak was called an »MG-anticline» and was claimed to be »due to isostatic retardations, implying three components: a short submergence, a short standstill and then a probably very rapid emergence» (Gillberg 1952, p. 71).

A critical examination of Gillberg's diagrams, however, shows that the steep rise of the MG-curves within Värmland is due only to a faulty method of projection. The values have been projected in an east—west direction and not along the isobases. In these parts of the curves the MG also has a steeper gradient than the corresponding isochronous shore-lines which is impossible. The descent of the MG-curves, however, is a reality but is not due to any universal stagnation of the ice recession. The causes are local and mainly to be found in topographical features. The line of stagnation which has been drawn by Gillberg (1952, fig. 16) has no reality.

Gillberg's opinion that the so-called MG-deltas are not available for exact MG-determinations, however, is correct. In many cases delta planes have been built up to levels distinctly higher than the MG. Sometimes this may be due to local dammings. In other cases the delta planes have not reached the MG but are essentially lower.

These divergences in the opinions about the MG, however, do not influence the general view upon the extension of the area that was covered by the sea. This area is shown in Sw. ed. (fig. 16).

Late- and Post-glacial shore-lines. These shore-lines have been investigated especially by von Post (cf. above). By means of a so-called relation diagram (von Post 1929 a, pl. 1) he identified ten different lines: VFG 1—VFG 5 older than the isolation of Lake Vänern and VG 1—VG 5 younger than the isolation. Especially the VFG lines are important levels — even outside the Väner basin. Due to the slower land uplift in the Väner area after the isolation, however, the last five lines are generally much better developed than the older ones.

With this diagram von Post also showed that the land uplift in Värmland was very irregular (1929, fig. 30).

As the diatom flora of the Väner basin was very uniform it is not of any use for the identification of shore-lines (von Post 1925) but pollen analysis was used in many cases. According to von Post seven lines are situated within his often poorly differentiated zone VI that entirely belongs to the time before the beginning of the *Alnus* curve (cf. p. 47). Among these shore-lines are VFG I, VG I and VG 2 that in almost all cases were used as reference lines in his relation diagram. As, however, new shore-lines now have been found between von Post's, his connexions of the observations within the diagram, as well as the irregular isobases, now have to be considered as rather doubtful.

E. Nilsson (1953) showed that von Post's shore-line observations might as well be incorporated into a distance diagram, founded on regular isobases in WNW—ESE. In this diagram several new levels were identified.

Though the shore-lines were not systematically investigated during the mapping some observations of importance were made:

1) Discontinuities of the land uplift might have taken place in Western Värmland. If von Post's (1929) observations from the Säffle district are put into a distance diagram a very confusing picture is obtained. However, this may also be an effect of the projecting. A small error in the course of the isobases used will have a great influence in such a rich material. It is also probable that the heights of the shore-lines may change with different exposition. As the Väner shore-lines in this district are situated quite close to each other, the latter condition will give shore-lines in almost all levels.

2) Observations of my own from the eastern side of the Väner basin and unpublished observations by Magnusson from the Nyed district may be fitted into a distance diagram. In this Nilsson's (1953) levels and some new ones can be distinguished.

3) On the geol. map sheet Otterbäcken Sandegren (1916) followed a distinct raised beach, the gradient of which suddenly changes. This might be a proof on an irregular land uplift. It is, however, possible that this beach is a combination of the closely lying VG 1 and VG 2 shore-lines. In Western Värmland von Post did not at once realize that the so-called Väner limit consists of two different shore-lines.

4) Sandegren (op. cit.) also described a stratigraphy indicating a transgression. Later on the same conditions have been observed in several other localities. They have been interpreted as the result of a great transgression in the whole Väner basin. Earlier papers by von Post and Sandegren have already, however, indicated another possibility: All the Väner shore-lines (VG 1—VG 5) were interpreted by von Post as due to small transgressions of Lake Vänern. Its surface must have been very susceptable to changes in the water supply and precipitation. This opinion is also supported by the fact that still more shore-lines have now been found. Thus the possibilities of the formation of transgression stratigraphies are very great. It is not necessary to postulate large retiltings of the Väner basin, resulting in transgressions. In some cases, however, true transgressions in local basins may have occurred.

Changes in sedimentation, too, may cause a similar stratigraphy. The material, sedimentated in deep water, was deposited from a suspension and the last sediments, deposited in shallow water, were transported as bed-load. In this way unconformities may have originated (cf. J. Lundqvist 1957 a, p. 6).

5) As was shown by Sundborg (1956) and J. Lundqvist (1957) von Post's preliminary interpretation of the shore-line system of the Klarälven valley can not be correct. This is due to the fact that von Post considered all the terraces in the valley as true shore-lines or equivalent to them, but this is not the case. A tentative interpretation of these shore-lines was made by J. Lundqvist (op. cit.).

The approximate extension of Lake Vänern at the time of its isolation is shown in Sw. ed. (fig. 17). This is based upon the determinations of VG 1 (or VG 2) in Southern Värmland, extrapolated northwards. As the land uplift was more rapid in the north the Väner limit becomes more vague towards the north.

Exposed bedrock and the thickness of the Quaternary deposits

Large areas of exposed bedrock are characteristic for South-Western Sweden SW of a line through Southern Värmland (fig. 4). The moraine cover is very thin and the areas with exposed bedrock or thin moraine interchange with only narrow crevices filled with thicker moraine or sediments — except from the broad sediment valleys. The crevices are often covered with peat land. On the general map areas with very thin moraine cover are also included in the »exposed bedrock» areas. On this map the Filipstad district also seems to have a thin cover. However, the moraine here is rather thick, though numerous small rocks outcrop.

It is not possible to solve the problem of the causes of the very thin moraine cover in this area within one county only. This must be done in a larger area. To some extent wave-washing may have had some influence but there must be other reasons since large parts of the district were never covered by the sea. In other cases areas that were covered even by Lake Vänern have a thick moraine or gravel cover, e. g. the eastern side of the lake. If the moraine cover ever had any greater thickness in the SW, wave-washed gravel etc. should have the same extension there. However, the finest sediments generally rest directly upon the bedrock.

It would also seem probable that the original moraine content of the ice was caught by the large valleys at right angles to the direction of ice movement, NE of the exposed area. However, this is not the case. The moraine has no greater thickness in those valleys and the deposits mainly consist of marine sediments.

What has here been said about the moraine also applies to the eskers. Even in the large valleys in the south-western district they are rather small.

NE of the area described the thickness of the moraine and other deposits increases. Fig. 4 gives some impression of this increase. The changes, however, are rather rapid. Similarly also it has not been possible to make a classification of the observations according to different kinds of deposits, but observations in distinct valleys have been distinguished from others. In general, however, the observations in the south-western area are referable to fine-grained sediments (in some cases including a thin moraine bed at the bottom). In other districts observations in the large valleys (the Klarälven, Fryken—Ljusnan and Rottnan valleys) are referable to marine — or lacustrine — sediments. Most other observations are referable to moraine. The moraine under the sediments in the valleys seems mostly to be rather thin, with the exception of the uppermost Klarälven valley.

The following features may be seen from the map:

1) In Southern Värmland the sediments outside the valleys are only seldom thicker than 20—25 m (but as a rule thicker than 15 m according to Wenner,

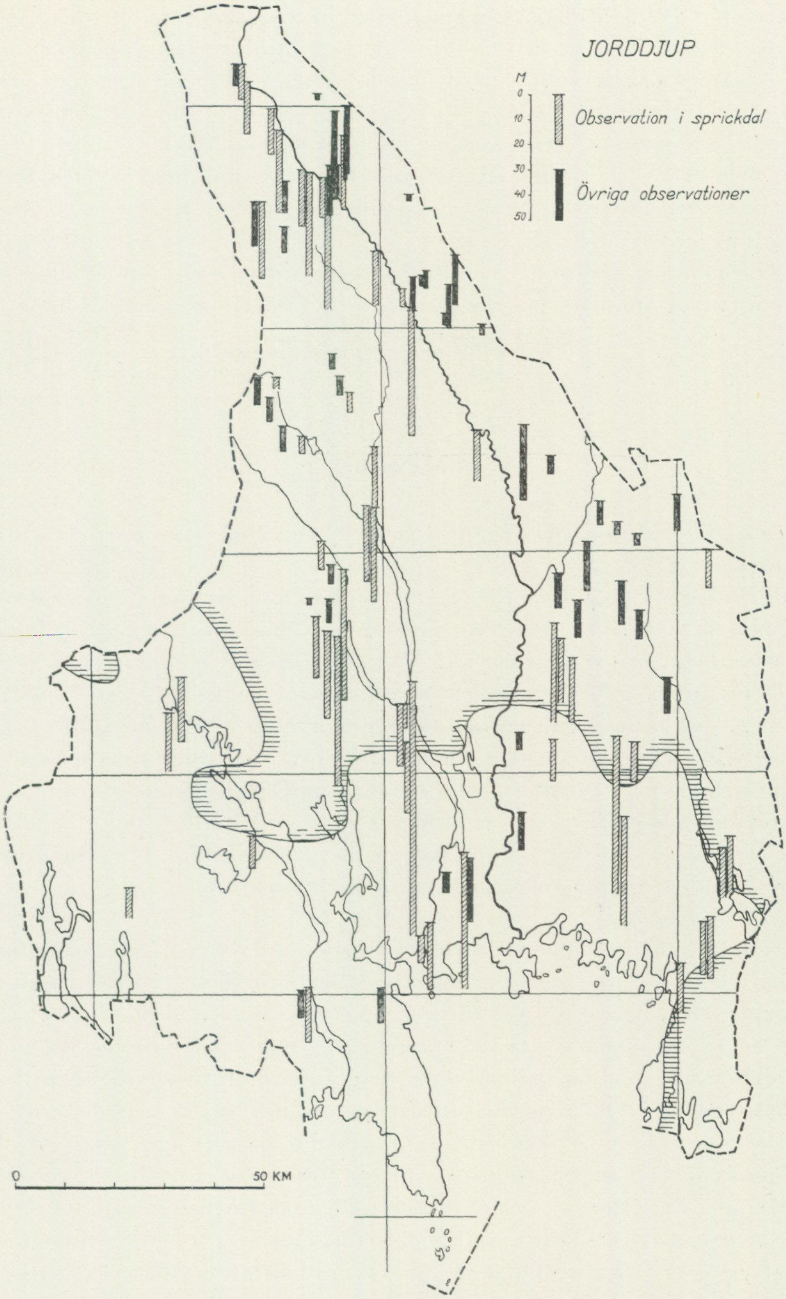

Fig. 4. Observations of the thickness of the Quaternary deposits in Värmland. On account of the broken country, the map only gives an approximate picture of this thickness. The shadowed line denotes the approximate border of the district in South-Western Värmland where the bedrock is covered only with very thin deposits. Obliquely lined piles = observations in fissure valleys, black piles = other observations. From Sw. ed. (fig. 18).

1949). In the SW the thickness is small even in the valleys. In the large valleys, however, it sometimes exceeds 100 m. In the Klarälven valley the recent maximum thickness of the sediments is about 50 m, corresponding to an original depth of at least about 90 m.

2) The thickness of the moraine increases from about 0 in the SW to about 30 m E of the upper Klarälven valley. In some high situated depressions, however, the moraine is very thin. W of the Klarälven valley the thickness is smaller than E of it.

3) The moraine does not — contrary to the sediments — show any distinct tendency to accumulate in the valleys. The thickness increases more continuously towards the NE.

Moraine

During the mapping G. Lundqvist's (1930, 1940) moraine classification was used:

Considering the superficial boulder content four moraine types were distinguished 1) »Moraine with large boulders» (Sw. »storblockig») = moraine rich in boulders, larger than 1 m. 2) »Moraine rich in boulders» (Sw. »blockrik») = moraine, rich in smaller boulders and with only few large ones ($>$ 1 m). 3) »Moraine with normal boulder content» (Sw. »normalblockig») = moraine with scattered small boulders and only few large ones. 4) »Moraine with low boulder content» (Sw. »blockfattig») = moraine with almost no boulders but sometimes rich in stones ($<$ 10 cm).

The first two types were combined on the general map. The moraine with normal boulder content in Värmland often tends towards the type with low boulder content.

Considering the fine material five main types of moraine were distinguished: 1) »gravelly» (Sw. »grusig»), 2) »sandy» (Sw. »sandig»), 3) »with fine to very fine sand» (Sw. »moig»), 4) »silty» (Sw. »mjälig») and 5) »clayey» (Sw. »lerig»). On the general map the types gravelly, sandy and »with sand to fine sand» (Sw. »sandig-moig») were combined and are represented by the light blue colour. The type »with fine to very fine sand» was designed with a darker blue colour. A certain type, »with fine to very fine sand» to clayey (Sw. »moig-lerig») in Northern Värmland was designated with a red-lined blue colour. In order to avoid the complicated English translations of the simple Swedish names, the simplified terms »coarse-grained», »fine-grained» and »clayey» will be used for these three types when it is referred to the groups as a whole.

Boulder content. The primary boulder content depends on: 1) the rock type, 2) the situation and 3) the transportation distance. The factors 2 and 3 are often closely related. The rock types affect the moraine in the following ways:

The granites produce moraines rich in large angular boulders. The boulders not only occur in the surface but also in depth.

The gneisses give moraines with high to low boulder content. The boulders are better rounded than the granite boulders and generally small; large boulders do not occur.

The porphyries and quartzites of the Åmål series are generally rich in fissures and easily splintered. Their moraines are rich in boulders or stones, but the boulders are always rather small.

The same moraine type is formed by the mylonites. When the mylonized rock is a granite, however, large boulders may also be formed if the mylonization is not too strong.

The hyperites give a moraine rich in boulders in close proximity to the outcrop. As the hyperite is a rather tough rock, however, the boulder quantity is too small to be of more than local importance. The boulders are resistant and are only slowly ground down.

The oldest Archean granites of Eastern Värmland are somewhat gneissic and do not produce such large boulders as the Värmland granites.

The moraines of leptites and hälleflintas are characterized by rather small boulders. The quantity, too, is generally small but the tough hälleflintas may also give rise to moraines rich in boulders and stones.

The shale moraines of Eastern Värmland generally have a very low boulder content.

The topographical influence upon the moraine is particularly distinct in the valleys. Here the moraine is generally very rich in boulders. The reason is to be found in the deglaciation conditions. In the valleys above or near the MG the last ice remnants were lobes. Material from the valley sides slipped down upon these lobes and this effect was probably increased by frost action. Probably this was the principal manner in which a primary thick surface moraine could be formed.

Especially in depressions on elevated ground dead-ice remnants were isolated. Originally the moraine content in their surface was low, as is seen on recent ice sheets. During the ablation, however, the material was accumulated in the surface layer and formed in this way a »secondary» surface moraine. When the ice below this ablation moraine melted the finest material could slip down and replace the ice easier than the boulder material. In this way there was an enrichment of boulders at the surface. Therefore ablation moraine, rich in boulders, is common in such depressions.

In Northern Värmland outside those depressions, the principles found by G. Lundqvist (e. g. 1940) determine the boulder content. Thus the content decreases towards higher levels. The highest parts have a low boulder content while the lee-sides of the mountains and hills have a specially high content.

Boulder material. In order to be able to form an opinion of the distribution of certain rock types in the moraine a number of boulder countings were made.

They were all carried out by N. H. Magnusson, partly in connexion with this mapping, partly earlier. The distribution is shown in Sw. ed. (figs. 20—31):

Grey gneiss boulders mainly occur in Western Värmland where the bedrock consists of this gneiss. The percentages, however, are often lowered by an intermediate gneiss type and granites, occurring within the grey gneiss area.

Intermediate gneiss boulders occur in the whole of Southern Värmland within the area of the grey gneiss as well as the red.

Red gneiss boulders often constitute nearly 60 % of the boulder material within the red gneiss area. The distribution also indicates that the border towards the granites in the east is not quite sharp and that red gneisses also occur within the grey gneiss area, e. g. W of Lakes Gla.

Veined gneisses occur among the grey as well as the red ones. The veined types dominate among the grey gneisses, i. e. W of the mylonite zone. In the red gneiss area they only occur S of a line Lake Ned. Fryken—Forshaga, W of the River Klarälven.

Värmland granite boulders dominate in the east with percentages often as high as 70. The percentages may only locally be reduced by other material e. g. Gothian porphyries. W of the western limit of the granites their boulders soon disappear. These granites also dominate in the north-western part of the mylonite zone. In the south-eastern part the percentages are lower due to a short distance of collection and possibly also due to stronger mylonization. W of the south-western granite area the boulders show that granites occur to some extent among the grey gneisses.

Gothian porphyry boulders occur sporadically over the whole of Värmland. The distribution shows that there must be more occurrences that are still unknown. The porphyry bodies in Northern Värmland only slightly increase the percentages. The reason must be that these bodies are very narrow.

Gothian quartzite boulders mainly occur in connexion with the quartzite areas around the Gillberga syncline, in the mylonite zone and at Rämsberg. The distribution shows that there must be more such areas than are now known.

Hyperite boulders mainly occur in close proximity to the outcrops (cf. p. 32). A few percent of hyperite boulders over the whole of South-Western and Southern Värmland indicate that the decrease in hyperite content among the boulders is due to dilution rather than crushing down.

Dala sandstone boulders occur in great quantities in Eastern Värmland and are strewn throughout the county except in the westernmost part. Thus the distribution towards the west is rather large. The sandstone area at the River Svartälven only slightly increases the percentages. The cause must be the flat bedding of the rock that protected it from a strong glacial erosion.

Dala porphyry boulders occur all over Värmland but the percentages are very low, compared with those of the Dala sandstone. As the boulders occur even in the westernmost parts the reason must be the same as in the case of the hyperite, i. e., the percentages decrease more due to dilution than to crushing down. The influence of the Svartälven porphyry area is clearly visible.

Öje diabase boulders occur in the whole of Värmland except the northern and western parts.

Caledonian rocks from the high mountain region occur as boulders especially in the north. The increase in their percentages S and SE of Sunnemo indicates that the moraine in this region is rather far-transported.

Grain size. The mean composition of the fine material of the moraines is shown in fig. 5.

From this figure it might seem somewhat improper that the type characterized by sand to fine sand (Sw. »sandig-moig») was associated with the coarse-grained group. The reason was, however, that the fraction »fine sand» physically coincides with the coarser sand rather than with the »very fine sand». On account of higher capillarity and lower water retention capacity the latter fraction forms a soil that easily becomes liquid. On the contrary a soil rich in »fine sand» and coarser fractions has a certain inherant capacity for self-draining.

The composition of the fine material of the moraine types characterized by different boulder content is shown in fig. 6. The type with large boulders (Sw. »storblockig») is surprisingly fine-grained. This is due to the fact that even a very fine-grained ground moraine may be covered with large boulders which in reality is an extremely thin surface moraine i. e. not directly comparable with the ground moraine itself. The moraine with normal boulder content (Sw. »normalblockig») closely resembles the type »with sand to fine sand». The moraine with low boulder content (Sw. »blockfattig») has no direct counterpart among the types characterized by different fine-material. The reason is that this type may be either more or less clayey or gravelly to stony.

In the moraine with large boulders the gravel, sand and fine sand fractions show great variations while the silt and clay content is constantly rather low. (cf. Sw. ed., fig. 38). In the boulder-rich moraine (Sw. »blockrik») the latter fractions have increased slightly. In the other two types this increase is still more distinct and the variations in the coarser fractions not so great.

From the parallelism between grain size and boulder content follow the differences in mechanical composition between moraines in valleys and on higher sites (fig. 7). The mean valley moraine is a sandy type, rich in boulders, the other type is a moraine with normal boulder content and with fine to very fine sand. In Southern Värmland, however, weathering of the thin moraine cover may have given it a somewhat finer composition than the primary one.

The main principle holds true especially in Eastern and Northern Värmland; less well in the SW. Here very fine-grained moraine is found also in the valleys, probably due to transportation over a longer distance and perhaps also to intermixing with older sediments (cf. Låg 1948, p. 94).

In a few cases the mineralogical composition of the clay fraction from such fine-grained valley moraines were determined from X-ray powder diagrams and by differential thermal analysis. When compared with true weathered moraines these analyses indicate that the valley moraines do not contain weathered material to any noticeable extent but of course pure mechanical sediments may be included.

The clayey moraine of Northern Värmland, which may be distinguished on the general map, seems to be a valley moraine of a special type. Though it is clayey it is also rich in sand and fine sand. It easily becomes liquid by stirring. The bluish to dark grey colour is most characteristic. This, to some extent, is possibly due to intermixing with a blue clay that has in one case been found as preserved beds in a »Kalix till» (cf. p. 28). Also the rock material may have contributed to the bluish colour. This moraine type contains, for example, greenstone material to a distinctly greater extent than the common — sometimes overlying — moraine of the same region.

Wave-washed moraine mainly occurs everywhere below the MG and especially in the region below the highest Väner limit. It is also common in the areas which were covered by ice-dammed lakes or even by narrow marginal lakes or lateral melt-water streams.

In the areas of wave-washed moraine on the general map the material is very heterogeneous. Unwashed moraine and pure sediments also occur as small spots everywhere.

The mean mechanical composition of the wave-washed moraine corresponds to a normal moraine with sand to fine sand in which the silt and clay fractions are lacking (Sw. ed., fig. 41).

Stratification and structure. As a rule the only stratification seen in the moraines is a distinct tendency towards higher boulder content at the surface (cf. p. 23).

The most common structural feature is the thin beds and lenses of sediments that may be observed in the ground moraine almost everywhere. They consist of well sorted sand, fine sand or gravel (cf. G. Lundqvist 1940, p. 30, 1951, p. 32). According to G. Lundqvist (1951, p. 56) they were formed in short open channels in the ice. Often these beds may be followed several meters. In these cases they are generally almost horizontal. Sometimes, however, they are folded, indicating that the ice was still moving just before it disappeared. The abundance of these beds indicates that the topography in Värmland was favourable for the formation of such open channels.

In connexion with the supra-marine eskers of Northern Värmland certain types of sediment beds are common in the moraine. These beds consist of gravel or sand. Through increased abundance of such beds continual transitions between moraine and glacifluvial gravel are formed (Sw. ed., figs. 43 and 44). The beds are often folded, indicating small oscillations of the ice.

Through oscillations of the ice border in some cases thicker sediment beds have been intermingled with the moraine material. They may be very fine-grained but the clay content is always low. This probably indicates that the sediments were deposited close to the ice border and that the oscillations might have been very small.

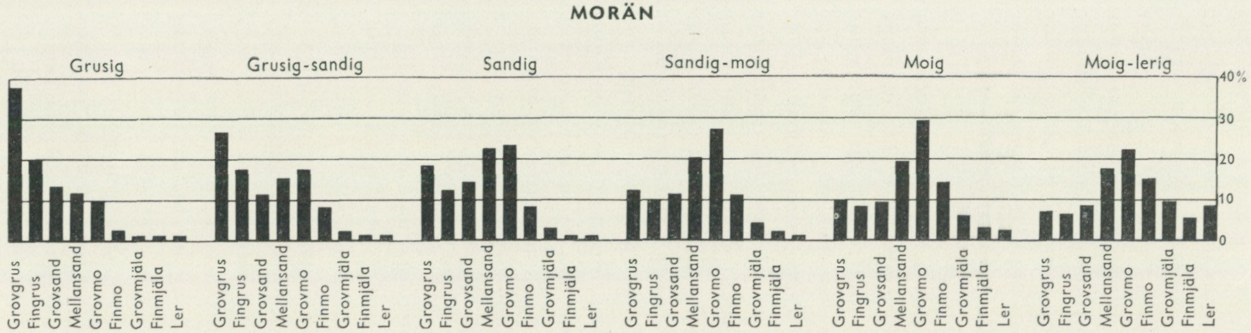

Fig. 5. Histograms showing the mean composition of the moraine types, characterized by different grain size. It is clearly seen that finer fractions dominate in the more fine-grained types. For explanations of fraction names see pp. 9 and 25. From Sw. ed. (fig. 33).

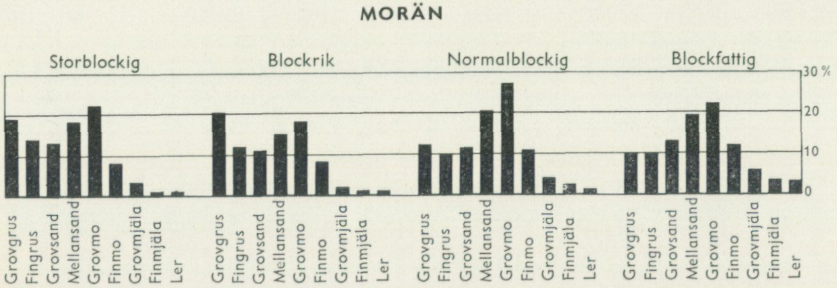

Fig. 6. Histograms showing the mean composition of the moraine types, characterized by different boulder content. Moraine with large boulders (storblockig) and rich in boulders (blockrik) has the same composition as the sandy type (fig. 5). Moraine with normal boulder content corresponds to the type with sand and fine sand. The type with low boulder content has no correspondence in fig. 5. For explanations of fraction names see p. 9. From Sw. ed. (fig. 37).

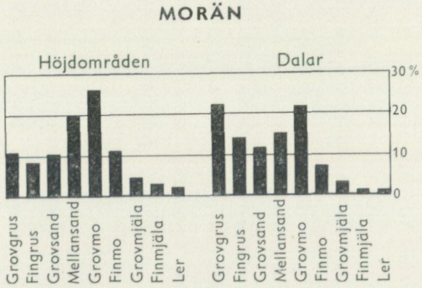

Fig. 7. Histograms showing the mean composition of high situated moraines (left) and moraines from the valleys (right). In the latter the percentage of gravel is higher and the percentages of silt and clay lower than in the former. For explanations of the fraction names see p. 9. From Sw. ed. (fig. 39).

The more coarse-grained beds of this type are to be found in Southern Värmland. They are interpreted by von Post (1929, p. 40) as sub-glacial. This opinion is supported by the distribution and the occurrence, especially at the southern end of mountains and smaller rises.

The latter moraine type is a transition to the so-called »Kalix till» that almost entirely consists of pure, more or less folded, sediments of fine sand (Sw. ed., figs. 44 and 45). This type is interpreted as an oscillation moraine by i. a. Beskow (1935, p. 123), G. Lundqvist (1943, p. 126) and Hoppe (1948, p. 67). On the topo. map sheet 94 Dalby other variations of Kalix till have been observed. In one locality the common folding was entirely lacking. Several faults and overthrust planes, however, were observed. This till was formed close to an outlet from the South Finnskoga Ice Lake (cf. p. 15). In another case even varved clay to silt was found among the coarser sediments of the till.

Only in one locality have undisturbed sediments under moraine been found (topo. map sheet 87 Fryksände). The topographical conditions show that the stratigraphy must be the result of an oscillation of the ice border.

Double moraine which may not be a form of surface and ground moraine have been observed only in connexion with the bluish clayey moraine of Northern Värmland. Near Bograngen this was covered with a normaly greyish to brownish moraine with lower clay content. The stratigraphy might be a result of oxidation only but the rock material of the gravel fractions indicates that there might be two quite different moraines (Sw. ed., p. 58). The upper moraine was probably deposited during one oscillation of the ice.

Foliation of different types occurs in many places. In the county of Kopparberg G. Lundqvist (1940, p. 38) found that this structure mainly pertains to the higher ground. In Southern and Western Värmland, however, it is generally found in the valleys. This difference depends on the deglaciation type: In this region the last ice remnants were mobile lobes in the valleys in contrast to the Kopparberg region.

Microscopical long axis determinations of the grains of a foliated moraine show that the grains are orientated parallel with the direction of ice movement but at an oblique angle to the foliation planes. This indicates that the foliation is probably a secondary feature.

Morphological features (fig. 8). In Western and Southern Värmland the moraine cover is too thin to form any surface forms of its own except for certain small forms. In the north and east where it is thicker it generally follows the salient features of the bedrock. The flat depressions located on high ground, however, are covered with ablation moraine (cf. p. 15) with quite different forms.

The ablation moraines of Värmland above the MG are probably due to the isolation of small dead ice caps from the ice margin or were formed in depressions where the ice was protected against the movements of neighbouring ice (cf. Ahlmann 1938, p. 28, G. Lundqvist 1940, p. 38). A combination of these types is most common. Below the MG intra-glacially formed ablation moraine occurs in the narrow valleys (cf. G. Lundqvist, op. cit.).

Three morphologically different types of ablation moraine occur in Värmland: 1) With sharp irregular forms and sharp-edged boulders. 2) With smoother irregular features and better rounded boulders. 3) With sharp regular forms, ridges and sharp-edged boulders (G. Lundqvist 1943, p. 23). Types 1 and 2 are most common. Type 3 — the so-called »Rogen type» — only occurs at Lake Örsjön in the north (cf. Sw. ed., figs 142 and 143).

The following detail features have been observed in the ablation moraine areas in Värmland: 1) Regular or irregular ridges. 2) Funnel-like hollows, rich in boulders. 3) Small pyramidal hummocks with numerous large boulders. 4) Even plateaus with steep sides and often low boulder content. (The rim ridges, described by Hoppe, 1952, do not seem to occur in Värmland.)

It seems clear that type 2 is a type of dead-ice hollow that was formed when a buried ice-boulder melted. Type 3 must have been formed by material which slipped down into crevasses in the ice. Type 4 consists of the sub-glacial moraine — ground moraine s. str. — with ice contact slopes, formed against isolated parts of the ice sheet.

The interpretation of the ridges is more complicated. Such ridges were interpreted as terminal moraines, among others, by A. G. Högbom (1894, p. 76, 1920, p. 94) and G. Frödin (1925, p. 135 ff.). Tanner (1915, p. 222) showed that this is not the case but that they were formed within the margin of a stagnating ice sheet. Tanner (op. cit.), G. Lundqvist (1943, p. 23 f.), Mannerfelt (1945, p. 212) a. o. considered the ridges as mainly formed from material that had slipped down into ice crevasses. Mannerfelt, however, pointed out that no general interpretation of such ridges may be given. Hoppe (1952, p. 54) was of the opinion that the material was squeezed into crevasses from below (cf. also Mannerfelt op. cit., p. 216).

In the Örsjö area it can be stated that the coarse bouldery material can never have been plastic enough to be squeezed according to Hoppe's hypothesis, however wet it might have been. The theory may, however, be applicable in some cases S of Lake Örsjön. Here Kalix till (cf. p. 28) was observed in several localities. Some squeezing may have taken place here though the folded beds indicate a horizontal rather than vertical pressure. The small thickness of the moraine covering may have favoured such a squeezing.

The orientation of the boulder material in the ridges is generally at right angles to the ridges (cf. Sw. ed., fig. 48). Hoppe (op. cit.) found that the boulders dipped towards the margin of the ridges. This orientation might indicate a slight earth flow after the disappearance of the ice rather than a squeezing (cf. G. Lundqvist 1949, Rudberg, 1958).

At Lake Örsjön a profile through a moraine ridge was observed that might be of some importance for the interpretation of the ablation moraine: a) $1^1/_2$ m surface moraine with large boulders b) $1—1^1/_2$ m glacifluvial gravel c) > 5 m ground moraine without boulders. The profile might be explained as 1) oscillation stratigraphy 2) erosion remnants of a thin delta or 3) crevasse filling. Especially from morphological reasoning the third alternative seems to be the only possible one.

Thus, the ridges generally seem to be crevasse fillings. The orientation of the ridges was determined by the crevasse systems of the ice sheet, i. e. the movement of the ice just before the stagnation (cf. G. Lundqvist 1941, p. 390, Mannerfelt 1945, pp. 136, 420 ff.).

The hummocky moraine that covers the bottom of some valleys even below the MG is probably G. Lundqvist's (1940, p. 39) intra-glacial dead ice moraine.

Other detail forms of the moraine are drumlins, radial moraines and terminal moraines. The drumlins mostly seem to consist of a rock core parallel to the ice movement with a rather thin moraine cover (rock-drumlins; cf. A. G. Högbom 1905, pl. VII, fig. 9). They mainly occur in the broad valleys of Central and Western Värmland. The boulders of the moraine are orientated parallel to the ridges. The same orientation is shown also by the superficial boulders though it is here less pronounced (Sw. ed., fig. 50).

The drumlins only occur below the MG. The corresponding supra-marine form are the radial moraines. Drumlins and radial moraines are often considered as synonymous forms. E. g. Tanner (1915), however, distinguished between these forms. The radial moraines consist of loose surface moraine or ground moraine. The former is probably a crevasse filling. The latter may have been squeezed into crevasses from below (cf. Granlund, 1943, p. 43, Hoppe 1952, fig. 30, Dyson 1952, p. 208 ff. and above, p. 29). The process is reminiscent of the one discussed in connexion with the ablation moraine but an important difference is that the radial moraines were formed by mobile ice. However, in many places they gradually change to ablation ridges (cf. Wahnschaffe 1909, p. 149).

Numerous terminal moraines occur, especially in the south-eastern part of the county. Their height never exceeds about 5 m. The boulder material is orientated at right angles to the ridges (cf. G. Lundqvist 1948, p. 22) which are all of the annual type in sense of G. De Geer. In some cases, however, calving may have contributed to their location as has been pointed out especially by Hoppe (1948, p. 14 ff.; cf. also G. De Geer 1932, p. 15 and J. Lundqvist 1954, p. 52). This may be the case N of the Åråsviken bay, where the ridges are sometimes rather irregularly orientated. Here they run almost parallel to the eskers in many places, thus forming estuaries.

The terminal moraines occur in large groups with a tendency to orientate parallel to the ice movement. This might be caused i. a. by a lobular movement even of the compact ice sheet (cf. also G. Lundqvist 1954, p. 36 ff.). Certain topographical features also favour the formation of terminal moraines. Where a valley narrows, the ice movements might be stronger and increase the capacity for forming terminal moraines. An ice-front with low moraine content upon a flat rock surface also seems to be favourable (cf. p. 29).

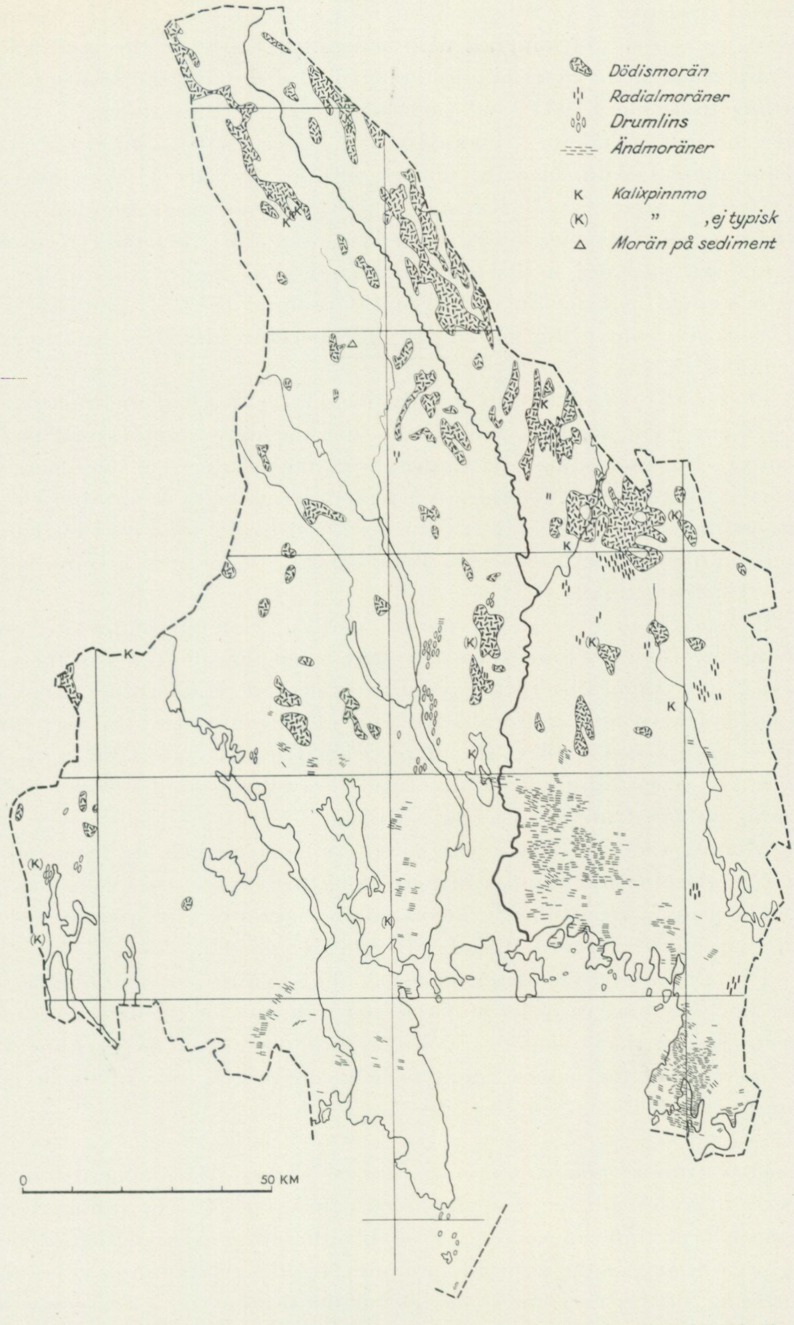

Fig. 8. The most characteristic surface forms of the moraine. Ablation moraine (dödismorän) mainly occurs in the north-east. At the southern border of this area radial moraines (radialmoräner) and drumlins occur. The latter are found only in the large valleys. Terminal moraines (ändmoräner) occur in large groups in the southern part of Värmland.
The map also shows the occurrences of Kalix till (Kalixpinnmo). They belong to the northern part of the county, but a few less characteristic occurrences (K within brackets) have been observed in the south-west. The triangle denotes moraine, resting upon undisturbed sediments. From Sw. ed. (fig. 49).

Chemical properties. A. Heavy mineral index (Sw. basmineralindex = percentage of minerals with a density > 2.680 in the sand fraction) is an important factor determining the fertility of the soil and was determined according to Tamm (1934) and Järnefors (1952; cf. also above, p. 10). The mean value is rather low — about 10. The hyperites that almost only consist of heavy minerals influence the indices only locally except from the eastern part of topo. map sheet 71 Karlstad where they are most abundant. Higher indices are caused by the presence of greenstones and other basic rocks at the Gillberga syncline and in Eastern Värmland. The high values in the north might be caused by Caledonian rocks (cf. Granlund 1943, p. 38). Low indices occur especially where the moraine is influenced by the Dala sandstone. (Cf. Sw. ed., fig. 52.)

B. Potash was determined as easily soluble K_2O in the fractions finer than 0.2 mm. The method, however, is not the most suitable and no comprehensive conclusions may be drawn from the results. The common value is about 2—5 mg/100 g. Western Värmland seems to be somewhat richer in potash in the south; in the north, Eastern Värmland is richer. High values seem to be due to the presence of Bohus granite, hyperites, greenstones and shales. (Cf. Sw. ed., fig. 53.)

C. Phosphate was determined as P_2O_5, soluble in lactate, in the fractions finer than 0.2 mm. What was said about the suitability of the potash method is also applicable to the phosphate method. High values occur especially in Northern and Eastern Värmland. The values are increased by the hyperites but probably they are more dependent on factors other than the bedrock. No general differences are observed between samples from cultivated and non-cultivated areas. (Cf. Sw. ed., fig. 54.)

D. Manganese. The manganese content, defined as the total percentage in the fine fractions, is highest along the broad part of the mylonite zone. The values are distinctly increased by hyperites and greenstones. Low values characterize Eastern Värmland. (Cf. Sw. ed., fig. 55.)

E. Titanium was determined as the quantity of extractable TiO_2 in the fine fractions in order to trace the influence of the hyperites over a greater distance than would be possible with the aid of heavy minerals. A slight increase of the values might be seen on the lee side of the hyperite-bearing zone. (Cf. Sw. ed., fig. 56.)

Connexion between chemical composition and the bedrock. The hyperites increase the percentages of all the elements investigated (fig. 9). The influence, however, is of local importance only. Probably the effect is strengthened by the strong weathering of the hyperite moraines. Besides relationships governed by the presence of this rock the following relationships occur: Grey gneiss seems to give the highest potash content while the red has the lowest. Grey gneiss, furthermore, seems to give a lower phosphate content than red gneiss and granites. The titanium content is especially low in the granite moraines. There are no variations between the manganese content in moraines of these rocks.

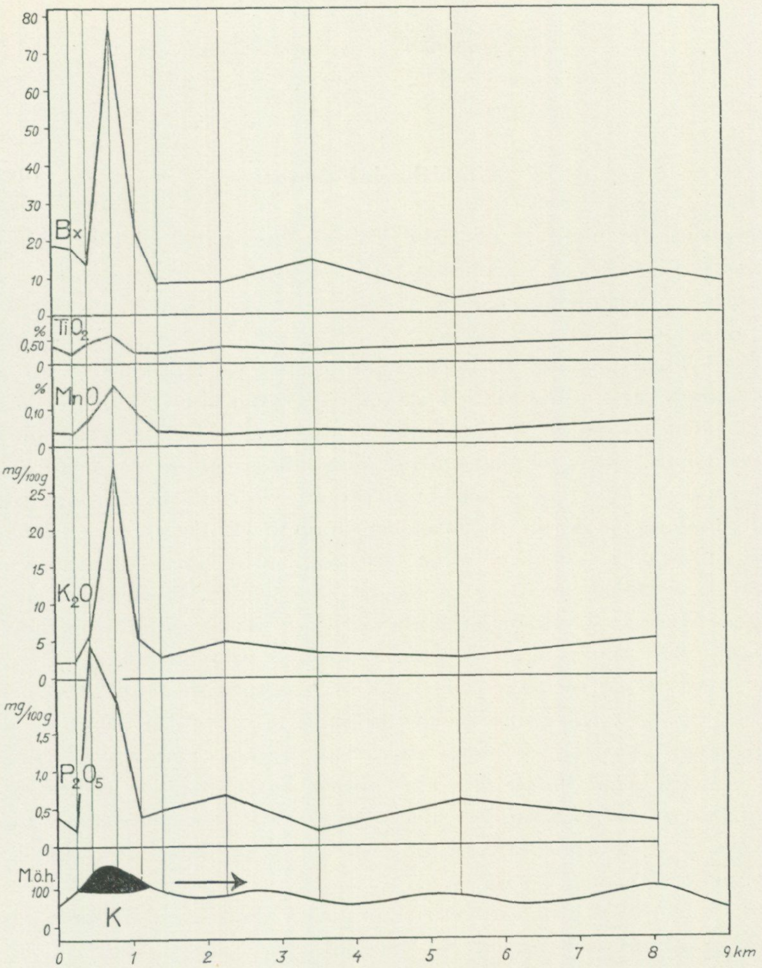

Fig. 9. The variations of the content of heavy minerals, titanium, manganese, potash and phosphate within a profile, parallel to the ice movement, across the hyperite mountain Kopparkullen (topo. map sheet 71 Karlstad). The hyperite outcrop is marked with black. A distinct increase of all the contents is seen at the hyperite body. However, this influence seems to be of very local importance. From Sw. ed. (fig. 57).

Arrhenius' (1956) investigations indicate that there is a distinct connexion between the bedrock and the resistivity (inversely proportional to the content of electrolytes) of the different soils. There are great differences within each soil type as well as between samples from dry or wet localities. Thus, one specific value is of no fundamental importance. However, the regional variations are of a more significant order of magnitude and follow the variations of the bedrock. This suggests that the regional variations shown by the figures cited might be real, even if factors other than the bedrock might be the most important.

Glacifluvial deposits

Except in the plain N of Lake Vänern the glacifluvial deposits mainly belong to the valleys. A common type consists of one sub-aquatic and one supra-aquatic part, separated by a delta near the MG. In the large valleys sometimes lateral terraces occur.

Eskers. There are three distinctly different types of eskers: sub-aquatic, supra-aquatic and sub-aërial. The sub-aquatic eskers are rather high — often more than 30 m. In spite of this height they are generally divided into short hills. The proximal ends of such hills are often very steep, indicating an ice-contact. This type of esker was probably formed at the outlet of a subglacial discharge river in the sea according to G. De Geer's classic theory.

The sub-aquatic eskers of some large valleys in North-Western Värmland do not show these variations in height. The width, however, varies rather strongly. Moraine boulders and material are very common on these eskers, indicating that they might have been formed sub-glacially.

The material of the eskers varies from coarse gravel to rather fine sand (Sw. ed., fig. 58). In comparison with eskers in other districts it is, however, rich in sand. The eskers often consist of a core of coarse gravel with a thick cover of more sandy material. The surface again may be richer in gravel. The surface gravel sometimes seems to be a result of wave-washing but sometimes it is probably primary. In some cases it is probably an outwash gravel, according to Wadell (1936).

Faults and overthrusts are very common in the eskers. In some cases they indicate oscillations of the ice (Sw. ed., fig. 59).

The supra-aquatic eskers sometimes consist only of a flat valley filling. In many other cases they form long sharp ridges, sometimes several parallel ones. Their material is a gravel with less sand and also less boulders than is the case with the sub-aquatic eskers.

The sub-aërial type of eskers consists of short, sharp ridges in the high parts of Northern Värmland. The positions often show that these eskers must have been formed in open crevasses in the ice. Their material is often surprisingly fine. It may even contain several percent of silt.

Engorged eskers (Sw. »slukåsar», Mannerfelt 1945, e. g. p. 215) seem to be rather common in Northern Värmland. They occur on the steep sides of many valleys at right angles to the slope and may have been subglacially or sub-aërially formed. The length of these eskers may be several hundred m while the width only seldom exceeds 10 m. Shorter and broader kame-like engorged eskers occur on the topo. map sheet 81 Filipstad. The material is sand to fine, sharp-edged gravel, sometimes with moraine material.

Deltas. In Southern Värmland a certain type of delta occurs which is merely the broader part of a large esker (e. g. the Sörmon, the Fryksta delta). They indicate a ceasation in the ice recession, probably depending on the relations between water depth and ice thickness rather than climatic variations (cf. p. 18). Also topographic conditions may have had some influence (cf. Wenner 1955), especially at the mouth of large valleys (Nelson 1910, p. 219) or in the upper parts of the valleys (cf. p. 15). In the latter case there was a stagnation while the deglaciation passed over from sub-marine to supra-marine conditions. Such was the genesis of the large Brattforsheden delta (Hörner 1927, p. 87).

The most common type of delta is the MG-delta. This type occurs especially where a »hanging valley» opens out into a larger one. The delta surfaces show very great morphological variations (cf. e. g. J. Lundqvist 1957). They may be flat or hummocky. In some cases dead-ice hollows or stream-channels occur. Large longitudinal or transverse eskers and kames also occur.

These deltas are approximately referable to the MG. However, the delta surface may be situated about 10 m above or below the MG (cf. p. 18, and Gillberg 1952).

The material of the deltas shows the same great variation as that of the eskers. Thus, it is rather rich in sand in the main part of the deltas. In the proximal part it is commonly very coarse.

A sub-aërially formed delta (outwash cone) occurs at the opening of the Mörkdalen valley (topo. map sheet 94 Dalby). On its surface there is a very low and sharp little esker. The material is a coarse gravel followed by a transition into boulders (diam. = 1 m) in the proximal part.

Lateral terraces. Large lateral terraces formed between the ice and the valley side, occur in some broad valleys in Western Värmland and e. g. in the Klarälven valley. Their surfaces may be flat or undulating, sometimes with shallow stream-channels.

A somewhat different type of terrace is formed by an esker that approaches a valley side. Examples occur at Hagfors and N of Kristinehamn.

The main part of the minute glacifluvial deposits of Western Värmland consist of very small lateral »terraces». Glacifluvial gravel is here attached to the steep valley sides and has in some cases been squeezed into small crevasses in the rock. This indicates that they were formed in narrow crevasses between a mobile ice lobe and the valley side. The numerous fissure valleys divided the sub-glacial discharge rivers into many small streams. Thus no large glacifluvial deposits could be formed.

The lateral terraces mainly occur on the eastern sides of the valleys. This is due partly to the general slope of the land surface and partly probably to the »morning mist effect» (see p. 15 and G. Lundqvist 1935, p. 295). The melting of the snow in recent time shows the same irregularity but here probably also different precipitation on the two valley sides may have some influence (cf. p. 43, and Sw. ed., fig. 63).

The material of the lateral terraces shows the same variations as that of the eskers and deltas but is often still more rich in sand. Only in the small terraces of Western Värmland does the gravel occur in greater proportion.

Erosive forms of the glacial discharge rivers. The most common traces of the erosion of the glacial melt-water in Värmland are the lateral — or extralateral — drainage channels (Sw. »skvalrännor»), and the chutes (Sw. »slukrännor»; erosive counterpart to the engorged eskers). Canyons, similar to less typical col gullies (Sw. »sadelskåror»), have been observed in a few cases.

The typical lateral channels and chutes are very small and occur grouped together in small areas especially within topo. map sheet 80 Uddeholm. In some large valleys, especially the Klarälven valley, the corresponding channels are very long and straight (cf. Gillberg 1952). It seems doubtful if they are really true lateral drainage channels. In some cases they continue just below the MG — even according to Gillberg (op. cit.). In some cases it is also evident that their origin is to be found in the bedrock or moraine forms. Anyhow they must have served as drainage channels to an ice lobe in the valley — and probably also to ice caps in the surroundings. In some cases they might, however, have been Late- or Post-glacially deepened. Thus, they may be used for MG-determinations only with greatest care.

The canyons similar to col gullies always seem to be related to fissure or fault zones in the bedrock. They generally cross over ends of heights or higher parts of valley bottoms and are somewhat more similar to the »kursu valleys» of Northern Sweden (Rudberg 1949).

Glacigenous sediments

On account of numerous transitions and doubtful cases it has not been possible to discriminate between glacial and post-glacial sediments on the survey map. There the finest sediments were only petrographically distinguished: heavy clays that have more than about 40 % clay and light clays with less clay content. On the map the latter were grouped together with the areally unimportant silt and very fine sand. In this general description, however, the genetically different sediments may be treated separately.

The glacigenous sediments are the most distal sediments from the glacial discharge rivers, i. e. the distal glacifluvial deposits. A continuous series is formed by the glacifluvial deposits, the glacial very fine sand (fiord sediments) and glacial silt and clay (fig. 10, cf. also Sw. ed., figs. 58 and 64). Generally the glacigenous fine sediments are well sorted which indicates that they were deposited from running water with rather continuously diminishing flow velocity.

The fiord sediments were formed in narrow valleys, especially the Klarälven valley, when these were occupied by long fiord-like inlets.

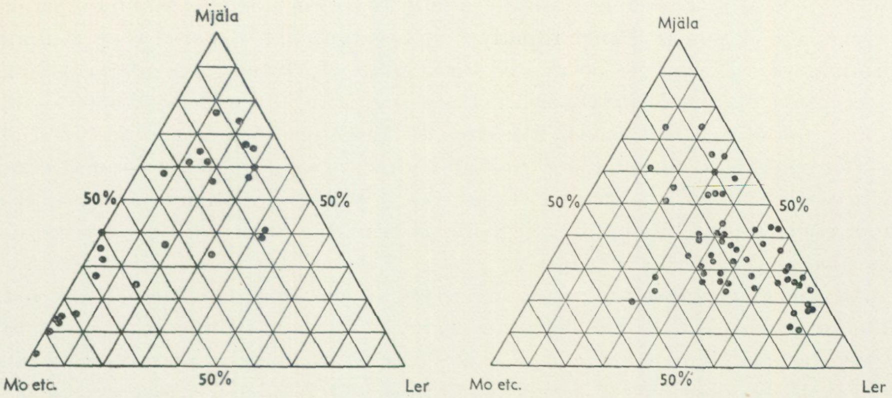

Fig. 10. Diagrams showing the variations in composition of the fiord sediments and glacial silt (left) and glacial clay (right). The difference between these two diagrams and the diagram of the post-glacial sediments (fig. 11) is obvious. Explanation of the fraction names see p. 9. From Sw. ed. (fig. 65).

During the deglaciation the water must have flowed rapidly in these inlets and the sediments are therefore coarser than the sediments deposited in the open sea. They mainly consist of very fine sand to silt and are commonly beautifully varved (Sw. ed., fig. 66). The original thickness of the fiord sediments in the upper Klarälven valley was about 90 m. Mostly, however, the fine sediments do not appear on the map. The reason is that the surface beds consist of coarser sand. While the fine sediments were deposited from suspension the surface sand is a bed-load deposit, formed when land uplift and sedimentation had brought the sediment and water surfaces close to each other.

Glacial silt is comparatively rare and was formed in some valleys where the flow velocity was lower than in the upper Klarälven valley and others with fiord sediments. It mainly occurs around the lower Klarälven valley, more marginal than the fiord sediments. The silt, too, is generally varved.

The glacial clay mainly occurs around the eskers of Southern Värmland. Outwards from the eskers it gradually becomes thinner. Two different types occur: the so-called red Bergslag clay and a more indifferent greyish type (cf. J. Lundqvist 1957 a, p. 4 ff.). The former is a rather heavy clay with often more than 60—70 % clay. It belongs to South-Eastern Värmland. The colour probably depends on the iron-rich rocks N of Filipstad and some red Dala rocks (sandstone, porphyry, granites). Often this clay is distinctly varved. Several different varve types occur (J. Lundqvist op. cit., p. 6 ff.).

The greyish type of the glacial clay dominates throughout Värmland W of the region S of Brattforsheden. Its colour may change to brownish or redish but never becomes as bright red as that of the first type. The clay may be heavy but the variations are greater than those of the eastern type. The mean clay content is about 50 %. Varves are common but generally not through the whole bed. Most common is an alternation between pure clay and more sandy layers. The clay may change rapidly from a varved to a symmict type. A thick drainage varve seems to occur over most parts of Western Värmland. It was interpreted by von Post (1929, p. 47) as originating from the draining of the Lower Glomma Ice Lake in Norway (cf. Holmsen 1915).

The varying composition is probably due to some extent to intermixing with wave-washed material (J. Lundqvist, 1957 a, p. 11). The often rather high content of silt and very fine sand often makes these clays become liquid on stirring (cf. p. 41).

All the glacigenous sediments described above were deposited in the sea. The sediments of the ice-lakes are generally beach sediments, formed by wave-washing. These are of the same type as many post-glacial sediments and will be described together with those. Only in few cases were glacigenous sediments deposited in the ice-lakes to a noticeable extent. The reason for their scarcity must be that these lakes in many cases were narrow marginal lakes only while the depressions were occupied by ice bodies (G. Lundqvist 1942). The observed sediments of this type are generally of a rather coarse bedded sand. Only N of Aamäk (topo. map sheet 88 Ekshärad) was very fine sand of the fiord type observed.

Post-glacial sediments

The term »post-glacial sediments» is here used collectively for all sediments, gravel to clay, that were formed by wawe-washing and transportation by Post-glacial streams. Since wawe-washing already began in Glacial time the term is not quite logical. As the sedimentation of this type did not dominate over the glacial one until the ice had to some extent retreated, however, and as the term is commonly used it will be retained.

Wave-washed gravel is the coarsest, most proximal sediment formed by wave action upon moraine or glacifluvial gravel. It consists of gravel and sand in varying proportions. The finer fractions are lacking. In some cases, however, a considerable quantity of them may be found. Sometimes the reason is that topographical conditions rendered their removal impossible. In other cases fine material may have been infiltrated into the gravel. The stratigraphy of the wave-washed gravel shows great variations. The dominating principle, however, is an increase in grain-size upwards in the succession.

This gravel occurs in connexion with ice-lake areas as well as in the whole region below the MG. In the former case it often belongs to certain levels between unwashed moraine. Below the MG it generally occurs at any levels but may often form distinct beaches.

Sand is the more distal sediment, formed by wave-washing. It occurs along most slopes in Southern Värmland and especially along the large glacifluvial deposits. Its composition shows great variations with changes between fine

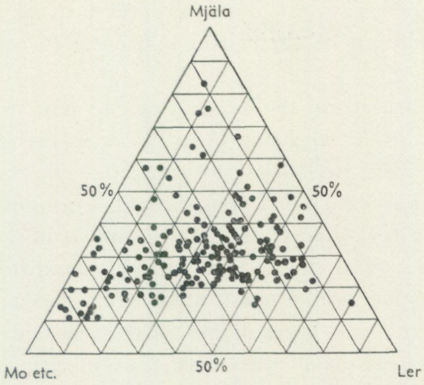

Fig. 11. Diagram, showing the variations in composition of the post-glacial clays. These clays vary directly from clay to very fine sand, while the pure silt is almost completely lacking (cf. fig. 10). For explanation of the fraction names see p. 9. From Sw. ed. (fig. 67).

gravel and fine sand. Especially the latter fraction is dominant in many sand occurrences in Värmland.

A certain type of sand was mentioned above (p. 37). This was transported as bed-load with streaming water and deposited on top of the finer sediments of broad valleys. This type of sand covers large areas, especially in the lowes Klarälven valley.

The sediments of ice-dammed lakes generally consist of a coarse and less well sorted sand.

Post-glacial clay. Two clay types — »Väner clay» and mud-clay — may be distinguished from the Post- (or Late-) glacial clay in general. The term »post-glacial clay» here includes the latter type only.

The diatom content shows that most of the superficial clays of Värmland are Post-glacial. They are the most distal sediments formed by wave-washing and transportation by rivers or streamlets. Only in Eastern Värmland, however, may they easily be distinguished everywhere from the glacial clay.

A triangular diagram containing all determinable post-glacial clays of Värmland (fig. 11) shows a distinct difference from the diagram of glacial sediments (fig. 10). While the latter vary from pure clay via pure silt to pure sand, the post-glacial clays vary from a somewhat lighter clay directly to sand. The difference is due to differences in sedimentation: The glacial sediments were deposited from a suspension in running water with gradually diminishing flow velocity. The post-glacial sediments were transported partly in suspension, partly as bed-load and deposited from a more irregularly flowing body of water. The flow conditions were dependent mainly on wind and topographical factors that must be rather irregular in broken country like Värmland. Thus, the post-glacial sediments became more irregularly composed. The pure silt that is deposited from a smoothly and regularly flowing body of water is lacking among the post-glacial sediments.

The colour of the post-glacial clays is greyish but may change to brownish or redish due to oxidation of their iron content.

»*Väner clay*» (a term used on the old geological map sheets; e. g. S. Johansson, 1917, Sandegren, 1920, and von Post, 1929) in this paper denotes a clay, very rich in fine and very fine sand (Sw. ed., fig. 69, cf. also von Post 1929, p. 51). It is a typical so-called »land upheaval sediment», i. e. an extremely sandy variation of the post-glacial clay. It mainly belongs to the region below the highest Väner limit (cf. p. 26). The land uplift conditions caused the special development of this clay. After the isolation of the Väner basin the rate of land uplift in Värmland was a result not of the real rate of uplift but of the difference in rate between each individual part of the county and the outlet of Lake Vänern. On account of this slower uplift the older deposits could be washed more thoroughly than before, the amount of sediments therefore becoming greater. On the other hand, the water was shallower than earlier and the sediments could not easily be washed away. Thus, many different fractions were deposited together.

The Väner clay shows an irregular bedding with numerous short layers of pure sand. It often rests discordantly upon the older clay (cf. p. 19). Its colour is grey without any red or brown shades. The thickness only seldom exceeds a few dm.

Mud-clay. In isolated bays with a small supply of sediments the postglacial clay was intermixed with microscopic organic remnants, mud (Sw. »gyttja»), to a noticeable extent. The content of organic material is generally about 4 % C.

The mud-clays of Värmland belong to two types: one greenish and one black. The black type is sometimes not a true mud-clay but the so-called »pitch-clay» (Sw. »becklera»), described i. a. by von Post (1929, p. 56). In other cases, however, the black colour is caused by FeS. The green type is always a true mud-clay the colour of which is caused by mud material.

The mud-clays are commonly very well sorted — in good agreement with the sedimentation conditions (Sw. ed., fig. 70).

Chemical and physical properties of the sediments

Mineralogical composition of the clays. No investigations of the mineral content of the clays have been made during this work. However, Soveri's (1950, p. 72) differential thermal and X-ray analyses may be mentioned. He found that the clays of Värmland consist to a large extent of mica-like minerals and weathered feldspars. A great part of these clays are thus composed of (Preglacially) weathered material. However, no information is given concerning the age of the clays investigated.

Liquid tendency of the clays, i. e. the tendency to become liquid, e. g. by stirring, is dependent on the content of silt and very fine sand (cf. also salinity, below). This property is due to the high capillarity, high capillary rising power and low water-retaining capacity.

In nature the liquid tendency may be observed mainly from the formation of ravines. These often occur close to the large glacifluvial deposits (cf. Sw. ed., fig. 71). Here the glacigenous sediments — the most proximal of glacial clays — are rich in the fractions mentioned. Ravines also occur in great quantity in the fiord sediment terraces of the Klarälven valley. As these terraces are narrow, however, the ravine areas here are small.

The terain conditions, too, have some influence upon the origin of ravines. When the clay rests upon a coarse-grained porous substratum water may be absorbed from below during freezing. When this water thaws it will make the clay liquid (Wenner 1941, p. 79; cf. also Beskow, 1935 a.).

Potash content of the sediments. This was determined in the same way as for the moraine. Thus the method was not the most suitable and each specific value is not of any great importance. From the map of the potash content (Sw. ed., fig. 72) it may be seen that the content is low in the north and east and within a zone in NW—SE across topo. map sheet 70 Arvika. Between these zones the content is higher.

The potash content generally increases with increasing clay content. Only in the extreme south-west of Värmland is the proportionality inverted. The reason might be that the potash-rich Bohus granite gives rise to a great amount of muscovite, especially in the coarse fractions (Sw. ed., fig. 73).

No general difference between glacial and post-glacial clay or between sediments from cultivated and non-cultivated areas was found.

Phosphate content of the sediments. These values are probably still more uncertain than the potash values. From the map (Sw. ed., fig. 74) it might be seen, however, that the phosphate content is highest in Eastern Värmland and especially low on the peninsula of Värmlandsnäs and NW of it.

Salinity of the clays was determined as the content of K and Na. The values obtained (Sw. ed., fig. 75) show:

1) The salinity is high in comparison e. g. with the Baltic region (Ståhlberg 1952). The H-quotients of Swedish clays published by Wenner (1949) indicate that the clays of Värmland have a medium salinity.

2) The salinity distinctly decreases towards the NE. This fact probably contributes to a somewhat higher liquid tendency of the clays in Western Värmland.

3) The salinity is very low in the lowest beds from where it rapidly increases to a maximum. It then gradually decreases upwards. The effect of the isolation of the Väner basin does not show, probably due to the fact that the water of the basin only gradually lost its connexion with the sea. The low salinity in the upper beds is an effect of leaching. The remaining low content is com-

parable with the potash content treated above and dependent on local factors and the mechanical composition of the sediment.

The rapid changes, observed e. g. at Grums, are caused by variations in current conditions. On account of these the salt content of the water, as well as the mechanical composition of the sediments, changes.

The varved clays show a distinctly lower mean salinity (0.51 ME/100 g) than the symmict ones (0.80 ME/100 g) (cf. J. Lundqvist 1957 a, p. 10). Where a faint varved character occurs the mean value is 0.63. Thus, the salinity of the water was probably one reason for the different developments of varves in different regions of Värmland.

Eolian sediments

The conditions were most favourable for the formation of eolian sediments immediately after the retreat of the ice. Such sediments especially occur on the large deltas close to the MG and were formed during a short period in Fini-glacial time (I. Högbom 1913, p. 156, 220 ff., 1923, Hörner 1927, p. 162). Younger deposits mainly occur on the large deltas of Southern Värmland and on the terraces in the Klarälven valley. Small recent deposits occur at or near the coast of Lake Vänern.

Four different dune types occur in Värmland: 1) large curved ridges, 2) long straight esker-like ridges, 3) low bank-like ridges and 4) small irregular hummocks or drifts.

Type 1 mainly belongs to the Brattforsheden delta. These dunes have their convex side to the SE. They were thoroughly described by Hörner (1927). They were interpreted by him as transversal and by Enquist (1932, p. 43) as longitudinal. The shape of the dunes — distinctly bent and often with a somewhat steeper side towards the S — as well as the climatic conditions (Sundborg 1955) make it rather clear that Hörner's opinion holds true.

The Brattforsheden dunes are rather gently curved. Sharper curved dunes occur in the Klarälven valley. Their shape may be similar to barchans but the convex side is always turned from the wind direction. Their height may be considerable: 20—30 m.

Type 2 only occurs in the Klarälven valley (J. Lundqvist 1957, p. 25). These ridges follow the sides of the valley and may be as long as 5 km. They attain a height of about 15 m. They were probably formed by winds from the NNW along the valley (cf. Sundborg, op. cit.).

Type 3 is found on the southern slopes of the delta plains of Southern Värmland. Possibly they were originally formed as banks. The material was then redeposited to some extent by the wind. It is quite similar to that of recent dunes.

Type 4 occurs in all dune-fields but is especially observed along the shores of Lake Vänern. This type thus occurs as recent dunes in contrast to the other types that form fossil dunes only.

On the height SW of the Brattforsheden dune field there are rather large deposits of so-called »windblown silt» (Sw. »flygmo»; according to the terminology used in this paper it is a fine to very fine sand). The meteorological and climatological conditions for its genesis and the problem of its geographic location were recently treated by Hjulström (1955) and Sundborg (1955). The windblown silt was deposited by »gradient winds from the northwest—northeastern quadrant over the district around the highest coastline» (Sundborg op. cit., p. 110). The surface wind that formed the sand dunes was deflected from the gradient wind and followed the topography. Thus, the dunes at Brattforsheden are orientated by winds from the NW—NNW. The fine material that reached higher levels was deposited by gradually more undeflected winds on higher levels, i. e. in this case towards the SW.

Minute deposits of windblown silt occur W of the upper Klarälven valley and W of the glacifluvial deposits along the river Svartälven. No surface forms have been observed; the windblown silt always consists only of a thin bed that may fill up small depressions.

The eolian sand is very well sorted. The dominating fraction is the sand or fine sand. In the so-called silt fine sand and very fine sand dominate. The bedding of the dunes is commonly rather regular, indicating that the strongest winds — which were dune-forming (Sundborg, op. cit., p. 107) — were regular and prevailing and came from the NW—NNW.

Alluvial sediments

In this work the term »alluvial sediments» is used to represent the recent or sub-recent sediments deposited by the water-courses partly along their banks at highwater, partly as deltas at their mouths. There is no sharp limit of course, between these sediments and older ones. The term alluvial sediments was therefore used where distinct surface forms indicate that the sediments were formed by flowing water.

There are two main accumulation forms, characterizing the alluvial fluviatile sediments of Värmland: levées (Sw. »älvbackar») and point bars (Sw. »älvvallar»). The levées are low banks along the shores of the water-courses. They were formed at high-water when the normal banks were overflowed. Thus, they may occur only where the region around the river is flat and the river not too deeply situated. Therefore they are rather rare in most parts of Värmland.

The point bars only occur in the meander section of the course of the river Klarälven. The material eroded away on the upstream side of the headland within a meander bend is redeposited mainly as a bed-load deposit on the downstream side. Here it forms banks of different orders, the highest of which is parallel to the shore. As the river lowers its course and moves downstream these banks gradually become more elevated in relation to the water surface. Suspended material is then deposited mainly on their crests. In this way more or less sharp ridges, parallel to the banks are created — the point bars. Their genesis has been thoroughly treated by Sundborg (1956; cf. also S. De Geer 1911 and J. Lundqvist 1957).

Other characteristic morphological features of the headlands in the Klarälven valley are the steps between higher and lower parts of the headlands (Sw. »näsavsatser») and abandoned loops. The former originated at times when the vertical erosion of the river was more rapid than the horizontal (cf. also S. De Geer, op. cit.). The abandoned loops, which are often filled with peat bogs, are especially abundant along the lower Klarälven valley. Sandegren (1939, p. 34) showed that to a great extent they originated at the beginning of the Sub-atlantic time when there was an increase in the discharge of the river.

The mechanical composition of the alluvial deposits described corresponds to a fine or very fine sand in the superficial parts. These fine sediments, interbedded with coarser layers, rest upon a coarser sand with one or more thin bottom beds of gravel (cf. Sundborg, op. cit., p. 272 ff. and J. Lundqvist 1957).

Large areas of alluvial gravel only occur in the upper Klarälven valley, partly as redeposited glacifluvial gravel at the tributary deltas, partly as a series of deltas N of Lake Vingängsjön (J. Lundqvist 1957, p. 32).

More fine-grained alluvial deposits were formed at high water in isolated bays etc. Numerous transitions to heavy mud-clay occur.

Characteristic for all the alluvial deposits is a certain amount of coarse organic material: wooden twigs, leaves etc. Sometimes these remnants may form thick beds (cf. Sandegren 1939, p. 11).

Peat land

The peat land reaches its greatest areal extent in Northern and Eastern Värmland. South-westwards the area decreases and most parts of Värmland have a rather small peat area. It should be observed, however, that in the south-westernmost part the exposed bedrock occupies a large area; if the peat land is compared only with the total area of Quaternary deposits this region appears rather rich in peat land.

Types of peat land. As a collective term for peat land of any kind in this paper the word mire will be used. According to their genesis the mires may be divided into paludification mires (Sw. »försumpningsmyrar») and encroachment (or basin) mires (Sw. »igenväxningsmyrar»). The former were created by peat-forming vegetation directly on a moist surface. According to Granlund (1932, p. 165 ff.) and G. Lundqvist (1928, p. 155, 1955) paludification was most intense during the third millenium B. C., the earlier part of the 2nd millenium B. C. and 500—1500 A. D. The first origin, however, is much older: from the time immediately after the deglaciation (e. g. Tamm 1931, p. 296). The encroachment mires were formed in a lake that was gradually filled up by mud and invaded by water vegetation (reeds, sedge etc.). Through both the main processes described the same kinds of mires may finally be formed.

According to von Post and Granlund (1926, pl. 10) and G. Lundqvist (1955) the paludification mires dominate in Northern Värmland. Southwards the encroachment mires increase in number and are, on the peninsula of Värmlandsnäs, entirely dominant.

The most convenient classification of the mires, however, is founded mainly on the vegetation. In this work the classification used by G. Lundqvist (1951) in the county of Kopparberg (a modification of Malmström's, 1940, classification) was used. Three types of mires were distinguished: bogs (Sw. »mossar»), mixed mires (Sw. »blandmyrar») and fens (Sw. »kärr»). G. Lundqvist's fourth type, spring mires (Sw. »källmyrar»), seems to be of rather small importance in Värmland. Only on topo. map sheet 71 Karlstad were numerous spring mires observed.

The term bog in this work denotes a mire characterized by numerous distinct *Sphagnum* hummocks with shrubs and often stunted pines. The bottom vegetation mainly consists of sedges, lichens (*Cladonia*) and small shrubs. The hillocks may be separated by wet hollows with sedges or *Sphagnum cuspidatum*. Sometimes the hollows are bare, with a surface of dy (chemically precipitated humus substance).

The bogs of Southern Värmland are generally raised bogs. The bog is then surrounded by a wet fen-like (cf. below) zone — the lagg — with sedges or open water or dy surfaces. The slope — the rand — from the lagg towards the central bog-surface, described above, may be rather steep. The vegetation here consists mainly of shrubs and trees on a *Sphagnum* bottom.

Mixed mires are characterized by small bog areas separated by wet areas with sedges (*Carex* species, *Eriophorum*, *Scirpus*). In these wet surfaces sometimes narrow ribs with a more bog-like vegetation occur. A wetter mire may have ribs with sedge vegetation separated by dy hollows. The ribs run parallel to the contour lines. The genesis of ribs was discussed i. a. by Auer (1920) and G. Lundqvist (1951, p. 98 ff.). According to the latter it is significant that the *Scirpus caespitosus* tussocks grow in rows. If these rows happen to be at right angles to the slope they may dam a small body of water. Then, according to Auer, a thrust caused by the ice may widen the hollows.

The fens are characterized by sedge vegetation. Also trees (mainly birch and alder) and shrubs occur. Detail forms except small tussock-like tufts are never observed.

The main part of the mires in Värmland are bogs. Mixed mires only occur in Northernmost and especially North-Eastern Värmland. The fens mainly occur in the southern and western parts (cf. von Post & Granlund 1926, pl. 10 and G. Lundqvist 1955, fig. 1).

Peat types. The classification of the peat in this work followed the principles of von Post, Granlund, Malmström and G. Lundqvist (ops cit.):

1. Sphagnum peat mainly consists of *Sphagna*. The huminosity (degree of decomposition) varies from H 1 (almost intact *Sphagna*) to H 10 (completely decomposed).

2. Forest moss peat (Sw. »skogsmosstorv») is a Sphagnum peat with high huminosity and rich in wood remnants.

3. Sedge moss peat (Sw. »starrmosstorv») consists of *Sphagna* and sedges (mainly *Eriophorum vaginatum* and *Scirpus caespitosus*). The huminosity varies from H 1 to H 10.

4. Sedge moss peat, rich in remains of shrubs (Sw. »rismosstorv»).

5. Sedge peat (Sw. »starrtorv») is formed by sedges (cf. above) and also contains dy and *Amblystegia*. The huminosity is generally of average magnitude.

6. Fen peat, rich in remains of shrubs (Sw. »riskärrtorv»).

7. Dy is a chemical precipitate of organic matter (humus). Sedge remnants occur and give transitions to sedge peat.

8. Birch or alder fen peat (Sw. »lövkärrtorv») is a dy rich in remains of these trees.

9. Equisetum peat consists of *Equisetum* (horse-tail) remnants with dy or mud.

10. Mud (Sw. »gyttja») in general is formed by organic detritus, diatoms etc. It occurs as a substratum under many mires. Hollow mud (Sw. »flark-gyttja») consists of *Sphagnum* and sedge detritus, diatoms and *myxofyceae*. It occurs as beds or lenses within the peat stratigraphy and was formed in wet hollows in the mire.

Stratigraphy. The stratigraphy varies from one mire to another. Some principal features may be seen, however:

The bottom beds, at least in some parts of the mires, always consist of dy or mud. Upon the mud substratum in some cases follows Equisetum peat. Generally, however, sedge peat rests upon the mud and dy. The sedge peat changes gradually towards the surface into sedge moss peat and nearer the surface into highly humified Sphagnum peat. Sometimes the sedge component may be lacking. In those cases the Sphagnum peat at the bottom may be developed as forest moss peat. In other cases all these kinds of peat may be replaced by birch or alder fen peat.

The Sphagnum peat becomes progressively less humified towards the surface. The transition is often rapid. Such a sudden change, denoting a change to wetter or colder climate, was called the »gränshorisont» (border horizon) by Sernander (e. g. 1909) and was claimed to be synchronous in all mires. G. Lundqvist (1928, p. 155, 1930, p. 155 ff.) and Granlund (1932, p. 70 ff.), however, showed that there were several such levels. Granlund (op. cit.) called them »rekurrensytor». In this work the verbative English translation »recurrence surfaces» will be used (see p. 48).

Thus the general development of the mires was from wetter to drier stages.

Pollen diagrams. The pollen diagrams, published in Sw. ed. were dated by aid of a few C^{14}-analyses (J. Lundqvist 1957 b) and older diagrams published by von Post (1930), Granlund (1931), Fromm (1938) and G. Lundqvist (1951). Attention was also paid to the diagrams in the descriptions to older geological maps (von Post 1929, Assarsson 1929 and Sandegren 1933, 1937) and to Fries' (1951) diagrams. The datings, however, were rather difficult since the diagrams from Värmland are not very well differentiated and since chronological displacements of the levels occur (J. Lundqvist, op. cit.). The main features of the different curves will be described below:

The *Picea* curve begins as scattered low parts on different levels as early as at the 7th millenium B. C. About 1000 B. C. the curve becomes coherent. At the same time the large rise of the curve (the rational *Picea* limit, according to von Post) occurred in Northern and Eastern Sweden (Granlund 1932, Fromm 1938). In South-Western Sweden it is dated to about 300 A. D. (e. g. Fries 1951). In Värmland there is a chronological displacement from about 500 B. C. or earlier in the central and northern parts to about 200 B. C. in the SW. Above this level maxima occur at about 600 B. C. and in the 16-17th centuries A. D. The former becomes some hundred years more recent towards the SW and the latter becomes more and more vague.

The *Pinus* curve is one of the dominating constituents of the pollen diagrams. It is, however, an old experience that this curve is not of much pollenanalytical use in its details. The curve is rather high at the level 6 000 B. C. From here upwards it decreases to the 4 000 B. C. level. A low maximum occurs before the rise of the *Picea* curve. After that the *Pinus* curve shows the inverse features of the latter.

The course of the *Betula* curve is mainly the inverse course of the *Pinus* curve. It is rather even but has sometimes maxima at the 5th and 4th millenia B. C. and just before 1 000 B. C. From the rise of the *Picea* curve it gradually diminishes towards recent time.

The *Alnus* curve is rather low. The beginning of the coherent curve — about 6 350 B. C. according to Fromm (1938) and G. Lundqvist (1956 a) — has been observed only in the Stentjärn mire. From that level the curve rises to a maximum at about 5 000 B. C. The details of the curve seem to depend on local factors mainly. E. g. about 3 000 B. C. there is a maximum in the east. Towards the SW this maximum changes to a minimum. About 1 000 B. C. there is a distinct rise of the curve in the SW. A low maximum occurs at 1 200—1 300 A. D. After that the curve is very low.

The *Corylus* curve is very low. Only at about 3 500—2 000 B. C. is the curve somewhat higher in the north. Towards the south this higher part of the curve becomes broader but also more vague. In the last centuries the curve is often completely lacking.

The curve of the mixed oak forest, too, is very low. It is coherent from about 6 000 B. C. and has a culmination about 3 000—2 000 B. C. This and other culminations become more distinct towards the SW. Here the curve is also chronologically displaced about 500 years towards more recent time (cf. G. Lundqvist 1951, p. 94).

Salix, *Fagus* and *Carpinus* pollens are too rare to be of much analytical use and this holds true to a still greater extent with non-arboreal pollens.

Forest evolution. Immediately after the deglaciation (about 7 500 B. C.) birch and pine were the dominating trees. However, a great deal of the *Pinus* pollen is probably long distance pollen. At least before 6 000 B. C., however, also alder, elm and hazel occurred. About 6 000 B. C. alder and birch increased. During the next millenia birch dominated the forests and oak and linden arrived. At this time also water chestnut (*Trapa natans*) occurred in Värmland (cf. Assarsson 1929, Malmström 1934, Fries 1951).

The warmth-requiring forests with oak, elm, linden and hazel began to flourish between 5 000 and 4 000 B. C. These forests occurred even in Northern Värmland until about 1 000 B. C. In Southern Värmland they flourished until about 500 B. C. when they reached their recent small extension.

The large increase of the fir occurred at about 500 B. C. in Middle Värmland and about 200 B. C. in the south (cf. p. 47).

During the last centuries there was a decrease in the mixed oak forest and birch. This might, however, be caused by the cultivation since the lowlands where these forests mainly grow became more and more cultivated.

Recurrence surfaces (cf. p. 46), occur in most mires in Värmland either as a transition from highly humified to less humified peat or as thin heath layers. The recurrence surfaces of Värmland were separately treated by J. Lundqvist (1957 b) to which paper reference is made.

The main result of that investigation was that these levels, as dated with i. a. C^{14}-analyses, show a tendency to chronological displacement towards more recent time in the SW. Granlund's (1932) five levels (RY I—RY V) were identified. Their displacement may be as great as 2—3 hundred years. However, it is a tendency only and probably rather irregular as regards detail.

Paludification and peat growth were also more thoroughly treated (J. Lundqvist, op. cit.). The results indicate that there was a rhythmic change between periods of relatively warm — dry, warm — moist, cold — moist and cold — dry climate. The recurrence surfaces were formed at the beginnings of the wet or cold periods.

The vertical peat growth was most intense during the warm — moist periods. According to Granlund (1932) paludification (= formation of new mires) was most intense during the periods that were cold and moist. Thus there is a certain difference between paludification and vertical peat growth.

Salt water mollusca

Sand with salt water mollusca occurs at several localities within Värmland. Among these are the highest and northernmost of the occurrences in Western Sweden. These occurrences were described by Rekstad (1922) and Hägg (1923, 1947, 1952). Their fauna is shown in a table in Sw. ed. (p. 117). It is characterized especially by *Macoma baltica*, *Mytilus edulis*, *Balanus crenatus* and *Saxicava arctica* — i. e. not by an extremely arctic fauna. The mollusca now probably occur on a somewhat lower level than where the animals lived. As the highest occurrences are situated only about 20 m below the MG the fauna must have invaded the region very soon after the deglaciation — a hypothesis that is supported by the fact that the valleys of South-Western Värmland were isolated and their water attained a low salt content very early. Therefore the conclusion may be drawn that the climate during the deglaciation was rather mild in Värmland or rather: The sea, which reached Värmland, did not have extremely cold water (cf. Hessland, 1943, p. 286 ff.).

Frost ground

The main type of frost phenomena seen in Värmland are the boulder depressions (Sw. »blocksänkor», A. G. Högbom 1905 a, G. Lundqvist 1937). These are flat depressions with boulders resting upon gradually finer material. The necessary conditions for their genesis are 1) a certain amount of boulders and 2) an impermeable bed of e. g. clay. The latter causes the water to stay in the depressions. On freezing the boulders are lifted up, and when thaw sets in the finest material is deposited first (cf. p. 23). Thus a sorting of the moraine material was obtained (G. Lundqvist, op. cit.).

In accordance with this theory the boulder depressions are most frequent in Eastern Värmland, where the granites make the moraine rich in boulders. The coincidence, however, is not complete. In the area, rich in boulders, E of the Råda valley no boulder depressions have been observed. N of Lesjöfors they are numerous in spite of the low boulder content. Most boulder depressions occur in areas where fine sediments occur: 45 % are situated within areas that may have been covered by ice-dammed lakes and 25 % below the MG.

The material of the boulder depressions seems to be quite stabilized. Possibly they are rather old: it seems probable that the frost action was most intense immediately after the deglaciation when still no vegetation protected the ground.

Other types of frost ground have been observed only around Ransby Gillersberg (topo. map sheet 95 Malung). These are stone pits (Sw. »stengropar») and fossil flow earth (Sw. »flytjord»). Their localization is due to the more favourable topographic and height conditions in the area mentioned.

Talus fields that are a result of mechanical frost bursting occur over the whole of Värmland but are rather rare.

Interglacial finds

The topography of Värmland seems to be favourable to the preservation of Interglacial deposits. In spite of this no such deposits in situ have been found.

The only true Interglacial remains are pieces of wood; fir from the Fryksta gravel pit described by von Post (1918). They were interpreted by him as Finiglacial. A C^{14}-analysis, however, showed that their age is more than 30 000 years. Since Värmland became free of ice only about 9 500 years ago (cf. G. Lundqvist 1954 b), this proves their Interglacial age. The gravel in which they were found, however, must be Finiglacial.

It therefore seems surprising that, according to von Post, abundant fir pollens were found in the glacial clay around the Fryksta delta. This fact might be explained in three ways: 1) A confusion between glacial and post-glacial clay may have been made. This is certainly the case in many other localities. 2) The fir must have been very abundant in this region in Interglacial time. In this case, however, more finds should probably have been made in the district (cf., however, Halden 1915, Sandegren 1948 and G. Lundqvist 1951, 1955 b). 3) The ice was rather inactive in this region, in which case even few Interglacial deposits could be preserved. This might explain the thin moraine cover of the region but seems rather improbable with regard to the lack of other Interglacial finds. The forms of the rocks in South-Western Värmland (p. 14) and the numerous terminal moraines (p. 30) also make this explanation less probable.

Suggestions for further work in Värmland

As was pointed out already in the preface the aim of this paper is to give a general account of the Quaternary geology of Värmland. Thus, there are still several problems that have to be solved or worked out more in detail.

One of the most urgent of these problems is the question about the chronological displacement of the pollenanalytical levels, especially the recurrence surfaces. This can hardly be solved without a large number of new C^{14}-analyses. Värmland, however, is a rather important region in this respect, as within this county the transition from the pollen diagrams of the Norrland type to the entirely different West Coast type occurs.

Another problem that has to be worked out is the land uplift. This, however, can not be done until the problem of the pollen diagrams has been solved. The pollen and C^{14}-methods seem to be the only possible ways to date the shore-lines. As it has now been shown that there are more shore-lines than were earlier known, however, frequent observations without too long interpolations will be necessary. A thorough study of the shore-lines and transgression stratigraphies also may give a contribution to the climatic history of Värmland.

Important problems that can not be solved within Värmland only, are the distribution of terminal moraines and the thickness of the Quaternary deposits. The first problem must be seen in connexion with the whole of Central Sweden. In the second, especially the thin moraine cover of South-Western Värmland is of interest. Here the conditions in the whole of South-Western Sweden and in Norway must also be considered.

Literature

In order to give a more complete list of the literature concerning the geology of the County of Värmland and relevant problems it was decided to include all the literature quoted in the Swedish edition (J. Lundqvist 1958) in this list.

G. F. F. = Geologiska Föreningens i Stockholm Förhandlingar (Transactions of the Geological Society of Stockholm).

S. G. U. = Sveriges Geologiska Undersökning (Geological Survey of Sweden).

Ahlmann, H. W:son, 1938: Über das Entstehen von Toteis. — G. F. F., 60.

Andersson, Gunnar, 1902: Hasseln i Sverige fordom och nu. En geologisk — växtgeografisk undersökning belysande frågan om klimatets förändring sedan litorinatiden. — S. G. U., Ser. Ca, N:o 3.

Arbman, H., 1945: Käringsjön. Studier i halländsk järnålder. — K. Vitt. Hist. o. Antikv. Akad. Handl., 59: 1.

Aronson, Georg, 1911: En sjötappningskatastrof i Värmland jämte några allmänna kvartärgeologiska iakttagelser från området i fråga. — G. F. F., 33.

Arrhenius, O., 1953: Vissa ämnens fördelning i marken i Kopparbergs län. — S. G. U., Ser. C, N:o 518.

— 1956: The Corrosion of Steel in Soil. — Tekniska Skrifter utg. av Svenska Teknologfören., nr 159.

Asklund, Bror, 1935: Gästrikländska fornstrandlinjer och nivåförändringsproblemen. — S. G. U., Ser. C, N:o 391.

Assarsson, Gunnar, 1929: »Torvmarker» i Beskrivning till kartbladet Nyed av Nils H. Magnusson och Gunnar Assarsson. — Ibid., Ser. Aa, N:o 144.

Auer, Väinö, 1920: Über die Entstehung der Stränge auf den Torfmooren. — Acta Forestalia Fennica, 12.

Beskow, G., 1935: Praktiska och kvartärgeologiska resultat av grusinventeringen i Norrbottens län. — G. F. F., 57.

— 1935 a: Tjälbildningen och tjällyftningen. Med särskild hänsyn till vägar och järnvägar. — S. G. U., Ser. C, N:o 375.

Blomberg, Albert, 1903: Beskrifning till kartbladet Loka. — Ibid., Ser. Aa, N:o 118.

— 1903 a: Beskrifning till kartbladet Kristinehamn. — Ibid., Ser. Aa, N:o 122.

— 1904: Beskrifning till kartbladet Björneborg. — Ibid., Ser. Aa, N:o 124.

— 1904 a: Beskrifning till kartbladet Skagersholm. — Ibid., Ser. Aa, N:o 128.

Caldenius, Carl, 1942: Gotiglaciala israndsstadier och jökelbäddar i Halland. — G. F. F., 64.

Dahl, Carl G., 1902: Några geologiska observationer i Klarelfvens förmodade forna dalgång. — Ibid., 24.

De Geer, Ebba Hult, 1955: Geokronologi eller Småmoränologi? — Ibid., 77.

De Geer, Gerard, 1895: Ett för Sverige nytt slag af radialmoräner. — Ibid., 17.

— 1896: Ändmoräner vid Venerns ostligaste bugt. — Ibid., 18.

— 1902: Beskrifning till kartbladet Strömstad med Koster. — S. G. U., Ser. Ac, N:o 1.

— 1909: Dal's Ed. Some stationary Ice-borders of the last Glaciation. — G. F. F., 31.

— 1932: Stockholmstraktens kvartärgeologi. — S. G. U., Ser. Ba, N:o 12.

— 1940: Geochronologia Suecica Principles. — K. Sv. Vet. Akad. Handl., Tredje ser., Bd 18, N:o 6.

De Geer, Sten, 1906: Om Klarälfven och dess dalgång. — Ymer, 26.

— 1911: Klarälfvens serpentinlopp och flodplan. — S. G. U., Ser. C, N:o 236.

von Drygalski, Erich, 1897: Grönland-Expedition der Gesellschaft für Erdkunde zu Berlin 1891—1893, unter Leitung von Erich von Drygalski. Bd 1.

Dyson, James L., 1952: Ice-ridged Moraines and their Relation to Glaciers. — Am. Journ. of Science, 250.

Egede Larssen, Kari, 1950: Pollenanalytiske undersøkelser i indre Østfold. — Univ. Bergen Årsbok 1949, naturvit. rekke, Nr 13.

Eklund, Josef, 1952: Bergarternas betydelse för markens bördighet. — Atlas över Sverige utg. av Sv. sällsk. f. antropol. o. geogr., Stockholm. Bl. 9—10.

Ekström, Gunnar, 1927: Klassifikation av svenska åkerjordar. — S. G. U., Ser. C, N:o 345.

— 1951: Åkermarkens matjordstyper. — Atlas över Sverige utg. av Sv. sällsk. f. antropol. o. geogr., Stockholm. Bl 63—64.

Enquist, Fredrik, 1932: The Relation between Dune-form and Wind-direction. — G. F. F., 54.

Falk, Åke, 1957: Stärnäs och Knappnäs. Morfologi och utveckling. — Geographica, 31.

Florin, Sten, 1944: Havsstrandens förskjutningar och bebyggelseutvecklingen i östra Mellansverige under senkvartär tid. I. Allmän översikt. — G. F. F., 66.

Fries, Magnus, 1951: Pollenanalytiska vittnesbörd om senkvartär vegetationsutveckling, särskilt skogshistoria, i nordvästra Götaland. — Acta Phytogeogr. Suecica, 29.

Fromm, Erik, 1938: Geochronologisch datierte Pollendiagramme und Diatoméenanalysen aus Ångermanland. — G. F. F., 60.

— 1945: Om isrecessionen i sydöstra Dalarna. — Ibid., 67.

Frödin, Gustaf, 1916: Über einige spätglaziale Kalbungsbuchten und fluvioglaziale Estuarien im mittleren Schweden. — Bull. Geol. Inst. Upsala, XV.

— 1925: Studien über die Eisscheide in Zentralskandinavien. — Ibid., XIX.

Gillberg, Gunnar, 1952: Marina gränsen i Västra Sverige. — G. F. F., 74.

Granlund, Erik, 1928: Senglaciala strandlinjer och sediment i västra Bergslagen. — S. G. U., Ser. C, N:o 349.

— 1928 a: »Kvartära bildningar» i Beskrivning till kartbladet Filipstad av Nils H. Magnusson och Erik Granlund. — Ibid., Ser. Aa, N:o 165.

— 1931: Kungshamnsmossens utvecklingshistoria jämte pollenanalytiska åldersbestämningar i Uppland. — Ibid., Ser. C, N:o 368.

— 1932: De svenska högmossarnas geologi, deras bildningsbetingelser, utvecklingshistoria och utbredning jämte sambandet mellan högmossbildning och försumpning. — Ibid., Ser. C, N:o 373.

— † 1943: Beskrivning till jordartskarta över Västerbottens län nedanför odlingsgränsen. — Ibid., Ser. Ca, N:o 26.

Haglund, E., 1910: Om vivianit och ett par värmländska förekomster däraf. — Sv. Mosskulturfören:s Tidskr.

Halden, Bertil E:son, 1915: Det interglaciala Bollnäsfyndets stratigrafi. — G. F. F., 37.

— 1923: Svenska jordarter. — Teknologernas Handelsförenings publ. nr 53. Ser. A. Nr 21. Stockholm.

Hedström, Herman, 1893: Om hasselns forntida och nutida utbredning i Sverige. — S. G. U., Ser. C, N:o 134 och G. F. F., 15.

Hessland, Ivar, 1943: Marine Schalenablagerungen Nord-Bohusläns. — Bull. Geol. Inst. Upsala, 31.

Hjulström, Filip, 1955: Problems concerning the Deposit of Windblown Silt in Sweden. I. The Problem of the Geographic Location of Windblown Silt. An Attempt of Explanation. — Geogr. Ann., XXXVII.

Hollender, A., 1900: Om Klarelfvens dalgång. — G. F. F., 22.

Holmsen, Gunnar, 1915: Brædæmte sjøer i nordre Østerdalen. — Norges Geol. Unders., Nr 73.

— 1955: Hallingdal. Beskrivelse til kvartærgeologisk landgeneralkart. — Ibid., Nr 190.

Holtedahl, Olaf, 1953: Norges geologi. — Ibid., Nr 164.

Hoppe, Gunnar, 1948: Isrecessionen från Norrbottens kustland i belysning av de glaciala formelementen. — Geographica, 20.

— 1952: Hummocky Moraine Regions. With Special Reference to the Interior of Norrbotten. — Geogr. Ann., 34.

— 1957: Problems of Glacial Morphology and the Ice Age. — Ibid., 39.

Hägg, Richard, 1923: Västra Sveriges nordligaste och högst belägna skalbank. — G. F. F., 45.

— 1947: Cyprina islandica från Värmland och nordligaste Dalsland. — Ibid., 69.

— 1952: Kvartära skalförekomster i Värmland, Dalsland, Västergötland och Halland. — Ibid., 74.

Högbom, A. G., 1894: Geologisk beskrifning öfver Jemtlands län. — S. G. U., Ser. C, N:o 140.

— 1905: Studien in nordschwedischen Drumlinslandschaften. — Bull. Geol. Inst. Upsala, VI.

— 1905 a: Om s. k. jäslera och om villkoren för dess bildning. — G. F. F., 27.

— 1920: Geologisk beskrivning över Jämtlands län. Uppl. II. — S. G. U., Ser. C, N:o 140.

Högbom, Bertil, 1914: Über die geologische Bedeutung des Frostes. — Bull. Geol. Inst. Upsala, XII.

Högbom, I., 1913: Finiglaziale Flugsandfelder in Dalarne. — G. F. F., 35.

— 1923: Ancient Inland Dunes of Northern and Middle Europe. — Geogr. Ann., 5.

Hörner, N. G., 1927: Brattforsheden. Ett värmländskt randdeltakomplex och dess dyner. — S. G. U., Ser. C, N:o 342.

Igelström, L. J., 1868: Jättegryta vid sjön Wermelen i Wermland. — Öfvers. af Kongl. Vetenskaps-Akad. Förhandl., 25: 9.

Isachsen, Fridtjov, 1933: Isavsmeltningen och de kvartærgeologiske forutsetninger for bebyggelsen i Numedals og Hallingdals øverste bygder. — Norsk Geogr. Tidskr., IV: 7.

Johansson, Simon, 1917: »Jordlagren» i Beskrivning till kartbladet Furuholmarna av Simon Johansson och H. E. Johansson. — S. G. U., Ser. Aa, N:o 136.

Järnefors, Björn, 1952: A Sedimentpetrographic Study of Glacial Till from the Pajala District, N. Sweden. — G. F. F., 74.

— 1956: Isrecessionen inom Uppsalaområdet. — Ibid., 78.

Larsson, Walter, 1938: Die Svinesund—Kosterfjord-Überschiebung. Ein Beitrag zur postgranitischen tektonischen Geschichte des nördlichsten Bohuslän. — S. G. U., Ser. C, N:o 411.

Larsson, Walter, 1945: Zur Kenntnis der spätglazialen Eisbewegungen westlich des Wenersees, Schweden. — Ibid., Ser. C, N:o 466.

Ljungner, Erik, 1947: Isdelarstudier i Övre Dalarna. — G. F. F., 69.

Lundqvist, G. och Thomasson, H., 1924: Sjön Lekvattnet i Värmland. En limnologisk orientering. — S. G. U., Ser. C, N:o 323.

Lundqvist, G., 1928: »Jordlagren (Kvartärsystemet)» i Beskrivning till kartbladet Skövde, 2. uppl., av Henr. Munthe, A. H. Westergård och G. Lundqvist. — Ibid., Ser. Aa, N:o 121.

— 1930: »Jordlagren» i Beskrivning till kartbladet Malingsbo av A. Högbom och G. Lundqvist. — Ibid., Ser. Aa, N:o 168.

— 1932: »Jordlagren» i Beskrivning till kartbladet Nya Kopparberg av N. H. Magnusson och G. Lundqvist. — Ibid., Ser. Aa, N:o 175.

— 1932 a: Tidvattnet och försumpningsetapperna. — G. F. F., 54.

— 1933: Bergslagens marina gräns. — Ibid., 55.

— 1933 a: »Jordlagren» i Beskrivning till kartbladet Grängesberg av N. H. Magnusson och G. Lundqvist. — S. G. U., Ser. Aa, N:o 177.

— 1935: Isavsmältningen inom Bergslagen. — G. F. F., 57.

— 1935 a: Blockundersökningar. Historik och metodik. — S. G. U., Ser. C, N:o 390.

— 1937: »Jordlagren» i Beskrivning till kartbladet Smedjebacken av G. Lundqvist och S. Hjelmqvist. — Ibid., Ser. Aa, N:o 181.

— 1940: Bergslagens minerogena jordarter. — Ibid., Ser. C, N:o 433.

— 1941: En lokalglaciation i Övre Dalarna. — G. F. F., 63.

— 1942: Var äro issjöarnas sediment? — Ibid., 64.

— 1943: Norrlands jordarter. — S. G. U., Ser. C, N:o 457.

— 1944: De svenska fjällens natur. — STF:s handböcker om det svenska fjället. 2. Stockholm.

— 1948: Blockens orientering i olika jordarter. — S. G. U., Ser. C, N:o 497.

— 1949: The Orientation of the Block Material in certain Species of Flow Earth. — Geogr. Ann., 31.

— 1951: Beskrivning till jordartskarta över Kopparbergs län. — S. G. U., Ser. Ca, N:o 21.

— 1954: »Jordlagren» i Beskrivning till kartbladet Västerås av P. H. Lundegårdh och G. Lundqvist. — Ibid., Ser. Aa, N:o 196.

— 1954 a: Åråsviken. — Natur i Värmland. Uppsala.

— 1954 b: Räfflor, ändmoräner och isrecessionslinjer. — Atlas över Sverige utg. av Sv. sällsk. f. antropol. o. geogr., Stockholm. Bl. 21—22.

— 1955: Myrar. — Ibid., Bl. 41—42.

— 1955 a: Räffelriktningar och rullstensåsar. — G. F. F., 77.

— 1955 b: Stocken i Öje. Ett säkert interglacialfynd. — Ibid., 77.

— 1956: »Jordlagren» i Beskrivning till kartbladet Uppsala av P. H. Lundegårdh och G. Lundqvist. — S. G. U., Ser. Aa, N:o 199.

— 1956 a: »C14-metoden i kvartärgeologien» i Åldersbestämning med hjälp av kol-14 av Göte Östlund, Nils-Gustav Gejvall och G. Lundqvist. — Ymer, 76.

Lundqvist, Jan, 1952: Bergarterna i Dalamoränernas block- och grusmaterial. — S. G. U., Ser. C, N:o 525.

— 1954: Ett ändmoränområde i Arvikatrakten. — G. F. F., 76.

— 1957: Övre Klarälvsdalens kvartärgeologi. — S. G. U., Ser. C, N:o 550.

— 1957 a: Geokronologiska undersökningar i Värmland. — Ibid., Ser. C, N:o 551.

— 1957 b: C^{14}-dateringar av rekurrensytor i Värmland. — Ibid., Ser. C, N:o 554.

— 1958: Beskrivning till jordartskarta över Värmlands län. — Ibid., Ser. Ca, N:o 38.

Lundqvist, Magnus, 1953: Landytans brutenhet. — Atlas över Sverige utg. av Sv. sällsk. f. antropol. o. geogr., Stockholm. Bl. 3—4.

— 1955: Myrar. — Karta i G. Lundqvist, 1955, Ibid., Bl. 41—42.

Låg, J., 1948: Undersøkelser over opphavsmaterialet for Østlandets morenedekker. — Medd. fr. Det norske Skogforsøksvesen, N:o 35.

Magnusson, Nils H., 1929: »Kvartära bildningar» i Beskrivning till kartbladet Nyed av Nils H. Magnusson och Gunnar Assarsson. — S. G. U., Ser. Aa, N:o 144.

— 1937: Den centralvärmländska mylonitzonen och dess fortsättning i Norge. — G. F. F., 59.

— 1957: »Berggrunden» i Sveriges Geologi av Nils H. Magnusson, G. Lundqvist och Erik Granlund. — Stockholm.

Malmström, C., 1934: Trapa natans L. i Lysvik (Värmland). Några ord om vårt lands nordligaste hittills kända fyndort för fossila sjönötter. — Sv. Bot. Tidskr., 28.

— 1940: Korta anvisningar för bedömning av torvmarkens lämplighet för skogsdikning. — Skogliga rön, Nr 6.

Mannerfelt, Carl M:son, 1938: Das Hervorschmelzen des Städjan-Berges aus dem absterbenden Inlandseis. — G. F. F., 60.

— 1945: Några glacialgeologiska formelement och deras vittnesbörd om inlandsisens avsmältningsmekanik i svensk och norsk fjällterräng. — Geogr. Ann., 27.

Munthe, Henr., 1940: Om Nordens, främst Baltikums, senkvartära utveckling och stenåldersbebyggelse. — K. Sv. Vet. Akad. Handl., Tredje ser., Bd 19, N:o 1.

Nelson, Helge, 1910: Om randdeltan och randåsar i mellersta och södra Sverige. — S. G. U., Ser. C, N:o 220.

Nilsson, Erik, 1953: Om södra Sveriges senkvartära historia. — G. F. F., 75.

Nilsson, Tage, 1935: Die pollenanalytische Zonengliederung der spät- und postglazialen Bildungen Schonens. — Ibid., 57.

Osvald, H., 1937: Myrar och myrodling. — Stockholm.

Pettersson, O., 1913: Klimatförändringar i historisk och förhistorisk tid. En studie i geofysik. — K. Sv. Vet. Akad. Handl., Bd 51, N:o 2.

von Post, Lennart, 1915: »Översikt av Vänerns postglaciala nivåförändringar» i K. E. Sahlström: Om Västergötlands stenåldersbebyggelse. — Akad. Avhandl., Stockholm.

— 1915 a: Ett fynd av fossil Trapa natans i västra Värmland. — G. F. F., 37.

— 1918: Ett finiglacialt granfynd i södra Värmland. — Ibid., 40.

— 1925: Vänerfrågans nuvarande läge. — Ibid., 47.

— och Erik Granlund, 1926: Södra Sveriges Torvtillgångar. I. — S. G. U., Ser. C, N:o 335.

— 1928: Svea älvs geologiska tidsställning. En pollenanalytisk studie i Ancylustidens geografi. — Ibid., Ser. C, N:o 347.

— 1929: »Kvartära bildningar» i Beskrivning till kartbladet Säffle av Nils H. Magnusson och Lennart von Post. — Ibid., Ser. Aa, N:o 167.

— 1929 a: Vänerbassängens strandlinjer. — G. F. F., 51.

— 1930: Norrländska torvmossestudier. II. Några huvudpunkter i skogens och myrarnas postarktiska historia inom södra Norrland. — Ibid., 52.

— 1934: Bonäslinjen. En lednivå bland Siljansbäckenets senkvartära strandlinjer. — Ibid., 56.

— 1948: Övre Klarälvsdalens fornfjord. Ett meddelande från en pågående undersökning rörande nivåförändringar och isavsmältning. — Ibid., 70.

Rekstad, J., 1922: Kvartære avleiringer i Østfold. — Norges Geol. Unders., 91.

Repo, R., 1954: Om förhållandet mellan räfflor och åsar. — Geologi, N:o 5, Helsingfors.

Rudberg, Sten, 1949: Kursudalar i Norrbotten. En preliminär översikt. — G. F. F., 71.

Rudberg, Sten, 1958: Some Observations Concerning Mass Movement on Slopes in Sweden. — Ibid., 80.

Sandegren, R., 1916: En postglacial strandlinje vid östra sidan av Vänern. — S. G. U., Ser. C, N:o 270.

— 1916 a: »Jordlagren» i Beskrivning till kartbladet Otterbäcken av R. Sandegren och H. E. Johansson. — Ibid., Ser. Aa, N:o 145.

— 1920: »Jordlagren» i Beskrivning till kartbladet Värmlandsnäs av R. Sandegren och H. E. Johansson. — Ibid., Ser. Aa, N:o 143.

— 1920 a: »Jordlagren» i Beskrivning till kartbladet Mässvik av R. Sandegren och H. E. Johansson. — Ibid., Ser. Aa, N:o 148.

— 1922: »Jordlagren» i Beskrivning till kartbladet Väse av Ragnar Sandegren, Alvar Högbom och Fredr. Svenonius. — Ibid., Ser. Aa, N:o 151.

— 1927: Beskrivning till kartbladet Lurö. — Ibid., Ser. Aa, N:o 166.

— 1933: »Jordlagren (Kvartära bildningar)» i Beskrivning till kartbladet Karlstad av N. H. Magnusson och R. Sandegren. — Ibid., Ser. Aa, N:o 174.

— 1937: »Jordlagren (kvartära bildningar)» i Beskrivning till kartbladet Forshaga av R. Sandegren och N. H. Magnusson. — Ibid., Ser. Aa, N:o 179.

— 1939: Nedre Klarälvsdalens postglaciala utvecklingshistoria. — Ibid., Ser. C, N:o 422.

— 1943: Några nya bestämningar av högsta marina gränsen i Dalsland och sydvästra Värmland. — G. F. F., 65.

— 1945: »Torvgeologisk och pollenanalytisk undersökning» i H. Arbman: Käringsjön. Studier i halländsk järnålder. — K. Vitt. Hist. o. Antikv. Akad. Handl., 59: 1.

— 1948: »Långselefyndets flora» i Interglacialfyndet vid Långsele av N. Sundius och R. Sandegren m. fl. — S. G. U., Ser. C, N:o 495.

— 1956: »Jordlagren (Kvartära bildningar)» i Beskrivning till kartbladet Vårvik av Walter Larsson och Ragnar Sandegren. — Ibid., Ser. Aa, N:o 187.

Sernander, Rutger, 1909: De scanodaniska torfmossarnas stratigrafi. — G. F. F., 31.

Sjörs, Hugo, 1946: Myrvegetationen i övre Långanområdet i Jämtland. — Ark. f. Bot., Bd 33 A, Nr 6.

Soveri, U., 1950: Differential Thermal Analyses of some Quaternary Clays of Fennoscandia. — Ann. Acad. Scient. Fennicae, Ser. A, III, Nr 23.

Ståhlberg, Sten, 1952: The Distribution of K, Na, Ca and Mg in the Marsta Hydrologic Clay Series. — Acta Agricult. Scandinavica, II: 1.

Sundborg, Åke, 1955: Problems concerning the Deposits of Windblown Silt in Sweden. II. Meteorological and Climatological Conditions for the Genesis of Æolian Sediments. — Geogr. Ann., XXXVII.

— 1956: The River Klarälven. A Study of Fluvial Processes. — Ibid., XXXVIII.

Sundius, Nils, 1922: Om de glacifluviala avlagringarna i Grythyttetrakten. — S. G. U., Ser. C, N:o 308.

Suneson, Svante och R. Sandegren, 1948: Ett fynd av fossil mistel, Viscum album L., i Värmland. — Sv. Bot. Tidsskr., 42.

Svenonius, Fredr., 1917: Några ovanliga svenska källor. — G. F. F., 39.

Tamm, O., 1921: Om berggrundens inverkan på skogsmarken. Med specialstudier inom Värmlands hyperittrakter. — Medd. fr. Statens Skogsförsöksanstalt, 18.

— 1931: Studier över jordmånstyper och deras förhållande till markens hydrologi i nordsvenska skogsterränger. — Ibid., 26.

— 1934: En snabbmetod för mineralogisk jordartsgranskning. — Svenska skogsvårdsfören:s Tidsskr., 32.

Tanner, V., 1915: Studier öfver Kvartärsystemet i Fennoskandias nordliga delar. III. Om landisens rörelser och afsmältning i finska Lappland och angränsande trakter. — Bull. Comm. Geol. Finland, N:o 38.

— 1930: Studier över Kvartärsystemet i Fennoskandias nordliga delar. IV. Om nivåförändringarna och grunddragen av den geografiska utvecklingen efter istiden i Ishavsfinland samt om homotaxin av Fennoskandias kvartära marina avlagringar. — Ibid., N:o 88.

Tarr, Ralph S., 1908: Some Phenomena of the Glacier Margins in the Yakutat Bay Region, Alaska. — Zeitschr. f. Gletscherkunde, III.

— 1909: The Yakutat Bay Region, Alaska. Physiography and Glacial Geology. — U. S. Geol. Surv., Prof. Paper, 64.

Teiling, Einar, 1916: Upplysningar till en djupkarta över Stora Gla. — S. G. U., Ser. C, N:o 272.

Torell, O., 1896: Yttrande med anledning af De Geers föredrag om moränerna vid Åråsviken i Venern. — G. F. F., 18.

Törnebohm, A. E., 1870: Några ord till upplysning om Bladet »Åmål». — S. G. U., Ser. Aa, N:o 34.

Wadell, Hakon, 1936: Volume, Shape, and Shape Position of Rock Fragments in Openwork Gravel. — Geogr. Ann., 18.

Wahnschaffe, Felix, 1909: Die Oberflächengestaltung des norddeutschen Flachlandes. 3e Aufl. — Stuttgart.

Wenner, Carl-Gösta, 1939: Börjesjön — en växtpaleontologisk studie av en fornsjö med Trapa natans. — G. F. F., 61.

— 1941: Ravinundersökningar i Gustafs. — Geogr. Ann., 23.

— 1947: Pollen Diagrams from Labrador. A Contribution to the Quaternary Geology of New Foundland—Labrador with Comparisons between North America and Europe. — Ibid., 29.

— 1949: Fakta om Sveriges lerförekomster. — G. F. F., 71.

— 1955: Några ord om glacifluviala avlagringar på Västkusten. — Ibid., 77.

Werenskiold, W., 1943. Högmossarnas välvning i södra Sverige. — Ibid., 65.

Wickman, Frans E., 1951: The maximum height of raised bogs and a note on the motion of water in soligenous mires. — Ibid., 73.

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