SVERIGES GEOLOGISKA UNDERSÖKNING

SER. C NR 605 AVHANDLINGAR OCH UPPSATSER ÅRSBOK 59 NR 5

KAJ NILSSON

GEOLOGICAL DATA FROM THE KRISTIANSTAD PLAIN, SOUTHERN SWEDEN

With nine plates in a separate folder

STOCKHOLM 1966

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This paper has been edited by R. Becker

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ABSTRACT

In 1955 SKH (Cooperating Committee of Hydrological Research of the Kristianstad plain) started an investigation of the hydrological conditions of the Kristianstad plain in southern Sweden. The necessary geological investigations were performed by the Geological Survey of Sweden.

The investigated area is about 700 sq.km, and the material consists mainly of samples and logs from well drillings. The number of evaluated drillings is over 900 (Pl. I), and samples exist for about 120 of these, which are presented in the form of well sections (Pl. II). With the aid of the bore-hole material supported by field work, maps and sections have been constructed for:

the surface of the Archean and the occurrence of kaolin (Pl. IV),

the sub-Quaternary surface and the extension of the Cretaceous deposits (Pl. III),

the distribution of the Tertiary diatoms and silicoflagellates (Pl. VIII and IX),

the distribution and composition of the Quaternary deposits (Pl. VI and VII),

the extension and levels of some important water-bearing layers in the Cretaceous (Pl. V).

The text is mainly a commentary on the maps but the subdivision of the rocks is discussed as are the causes of errors in the maps and sections.

Introduction

In 1955 SKH (Cooperating Committee of Hydrological Research of the Kristianstad Plain) started an investigation of the hydrological conditions of the Kristianstad plain in southern Sweden. The following institutions take part in the investigation: The Swedish Meteorological and Hydrological Institute (SMHI), the Department of Land improvement and Drainage at the Royal Institute of Technology (KTH) in Stockholm, the Department of Water Supply and Sewerage at the Chalmers Institute of Technology (CTH) in Gothenburg, the Department of Geography at the University of Lund, the Water and Sewerage Department at the National Swedish Road Board and the Geological Survey of Sweden (SGU).

The contribution of SGU was to report on the thickness and composition of the Quaternary deposits, the geological structure of the bedrock, the sub-Quaternary surface and general tectonic conditions.

The investigations made by SGU were led by H. Tullström, state geologist until September 1961, and later by the present writer. A report was presented to SKH in September 1963.

During the work many new geological facts were collected and were sufficiently numerous to justify the publication of the present paper.

The Quaternary deposits of the Kristianstad plain have (except for Ekströms general map of 1946) only been dealt with previously in geological maps printed between 1877 and 1899. These maps are now out of date.

Modern studies on the Cretaceous of this area include a monographic description by Lundegren (1934) and an account of a bore-hole through the Cretaceous at Åhus by Hessland (1950). An occurrence of Tertiary clay has been described by Cleve-Euler and Hessland (1948).

The present investigation

The main purpose of the present investigation was to assist in the evaluation of groundwater conditions on the plain, which in effect means studying the area of the Cretaceous rocks, which is about 700 sq.km.

The material investigated mainly consists of samples and logs from well drillings. Most of it was collected by E. Mohrén, state geologist but lay untouched in the collections of SGU. An inventory of wells was made by SGU in 1959—1960. Samples and logs of wells drilled in recent years have been received from S. Holmberg, geologist, Lund and C. Åberg, fil. lic., Lund. A few test holes have been put down by G. Ekman, technician, SGU, partly in cooperation with an engineering firm, Sydsvenska Ingenjörsbyrån, Malmö. Finally, some bore-hole information has been obtained from the literature. Laboratory investigations have been carried out at the soil laboratory of SGU under the direction of A.-G. Berg and B. Henriksson, engineers and micropaleontological determinations by U. Miller and M. Bevaqua, geologists at SGU. By the courtesy of professor Hessland at the University of Stockholm, we have had access to samples of a core through the Cretaceous at Åhus. Field work has been carried out by C. Åberg. Some brief survey travels has been made by the author. Contours over the plain have been supplied by the Geographical Survey Office of Sweden. Maps and sections have been drawn by Mrs Greta Hellström. Mr R. Becker, SGU, has assisted in editing the plates. P. Padget, avd.dir. at SGU, has made corrections to the English of the manuscript.

In presenting the investigated material I have tried as far as possible to express the results in the form of maps and sections and let these speak for themselves. The text is mainly a commentary on the maps but the subdivision of the rocks is discussed as are the causes of errors in the maps and sections.

1. Evaluation of the bore-hole material

The localities and distribution of the wells is shown on Pl. I. A division has been made between bore-holes supported by samples and those without. The first group gives better data than the later. The number of bore-holes supported by samples is about 120. Bore-holes without samples but with a journal giving some information about the geological sequence number more than 800. The distribution of wells is fairly uniform over the plain with some concentration on the economic map-sheets Kristianstad and Fjälkinge. Wells are more rare on the Vittskövle and Linderöd sheets.

Most wells have been drilled after 1940, but much older ones exist, the oldest well being from 1879. The dominant drilling firm is Malmbergs i Yngsjö AB.

The holes were put down to provide water and were terminated when the yield was large enough. This usually happens in the upper part of the Cretaceous but sometimes in the Quaternary. Only exceptionally in peripheral parts of the plain do they reach the Archean. The quality of the bore-hole information varies. Often, for instance, the location of the well is second hand and then sometimes as "at the farm X", "some hundred metres south of the church Y", etc. Careful localization of the bore-holes is important especially for the estimation of levels. Wrong information about the locality often causes serious errors when estimating the level of the bore-hole.

Most bore-holes were put down by percussion drilling and pipe driving the broken material being collected in a bailer, or by washing. The consequences concerning the soil samples are often:

a) a too low frequency of stones and boulders,
b) a sorting of tills so that the samples look like watertransported sediments,
c) the presence of fine material in coarse sediments (for instance gravel and sand) due to crushing,
d) underrepresentation of fine material in the samples due to washing.

To some extent the same sources of error also occur in samples from the Cretaceous, especially when the rock is poorly consolidated.

The best soil samples are usually obtained by boring in sedimentary clays. The stratification is certainly disturbed but the distribution of grains is approximately right.

Still greater difficulties arise in interpreting the bore-hole journals. In cases when the journal was handed over long after the hole was finished the memory has often failed the driller. A uniform soil and rock classification does not exist for diverse reasons and therefore a certain soil type can have several different names. Another circumstance that contributes to uncertainty in the journals is the difficulty of establishing the boundary between the Quaternary and the Cretaceous.

2. Laboratory investigations

A) Visual examinations

All the samples (more than 1 300) have been examined visually. In this connection the grain distribution, rounding, colour and most frequent rock fragments have been noted.

The examination of the rock samples has included grain distribution, facies, colour, proportion of glauconite and Archean rocks, rounding of the grains and frequency of macrofossils.

B) Mechanical analyses (hydrometer method)

Only a few analyses of this type have been made on the bore-hole samples, because these are not representative. However, some clay samples have been analysed as well as some till samples collected in open cuts.

C) Determinations of the carbonate content

The analyses have been made volumetrically with the Passon apparatus. The principle is that carbon-dioxide develops when calcareous samples are treated with acid. The volume of carbon-dioxide is measured and the equivalent quantity of calcium corbonate computed. Part of the manganese carbonate occurring in the samples is included in the calculated values. However, from earlier investigations it is known that the proportion of $MgCO_3$ in the Cretaceous of the Kristianstad plain is only about 1 % of the $CaCO_3$ content (Lundegren 1934, p. 272). The carbonate determinations are therefore supposed to express the carbonate content with an accuracy of ± 1—2 % which is enough in the present case.

The carbonate content has been determined for most samples and the results used for establishing petrographically the boundary Quaternary-Cretaceous and for distinguishing various types of clay.

D) X-ray (diffractions) and differential thermal analyses

These methods have been used in some cases for the investigation of clay samples of different origin.

E) Investigations of the microfossils

A great number of microfossil analyses have been made in order to get information about age relations and stratigraphy. The microfossils examined include foraminifera from the Cretaceous samples and diatoms from a clay which is supposed to be of Tertiary age.

3. Soil and rock classification in the well sections

All bore-holes with soil or rock samples are presented in the form of well sections (Pl. II, a—d). The sections are based on bore-hole samples and journals. The sampling has in many cases been very sparse and a sample weighing a few hundred grams sometimes represents deposits with a thickness of ten or twenty metres. The sparser the sampling, the greater the importance of the bore-hole journal. As mentioned above, the samples can not be considered quite representative for the stratum they come from and therefore the soil determinations have been especially difficult. The lower part of the Quaternary sometimes consists almost entirely of redeposited Cretaceous rock fragments (especially when the Cretaceous rocks are poorly consolidated). The establishment of the Quaternary-Cretaceous boundary was therefore uncertain in some cases but a valuable aid was given by microfossil (foraminifera) determinations. In Quaternary samples there is an irregular mixture of Cretaceous fossils while these occur in a more regular way in samples from the Cretaceous.

For the reasons mentioned above it is obvious that some errors in the well sections exist and therefore the accuracy of the different sections varies.

A) Classification of the quaternary deposits

The soil classification used in Sweden is based on the grain distribution with some additions. The nomenclature used nowadays was drawn up in 1953 by the Royal College of Forestry, the National Road Research Institute, the Swedish Geotechnical Institute and SGU (see in "Kompendium i geoteknik, Statens geotekniska institut, meddelande nr 5").

For reasons given above it has been necessary to use a more schematic classification in this work. Except for peat, which is of little importance in the present connection, the soils have been divided into 4 groups (see Pl. II, legend) based on permeability: group I (stones-fine sand) with high-moderate permeability, group II (silt) with low permeability, group III (clay) with very low permeability and group IV (till and boulder clay) with low — very low permeability. It is not possible to give exact values for the permeability but the following limit values have been used:

high — moderate permeability	$>$ 100—0.5 cm/h
low permeability	0.005—0.5 cm/h
very low permeability	$<$ 0.005 cm/h

B) Classification of the bedrock

The substratum of the Cretaceous has been divided into Archean rocks, kaolinized Archean rocks and kaolin.

The classification commonly used for the Cretaceous of the Kristianstad plain is partly paleontological, partly petrographic. Lundegren's (1934) classification is as follows:

Paleontological classification	Petrographic classification
Mucronata chalk	Åhus sandstone Shell fragment chalk and shell fragment limestones, conglomerates
Mammilatus chalk	Shell fragment chalk and shell fragment limestone, conglomerates
Granulatus chalk	?
Westfalicus chalk	Shell fragment limestone with conglomerates (Ringeleslätt)
Basal deposits (submarine and supramarine)	Terrigenous sands and clays, sandstone (Holma and Ryedal sandstone)

In the petrographic classification shell fragment chalk and shell fragment limestone have been separated on the basis of particle size. However the division between the two limestone types must be considered unsuitable and out of date. It appears, for instance, from Lundegren's (1934, p. 270) table that in fine shell fragment chalk gravel and sand are missing and the content of fine-grained material (smaller than 0.06 mm) is about 90 %.

It is difficult to construct a logical and practical classification for the Cretaceous of the Kristianstad plain. However it seems attractive in principle to combine the soil classification with one based on the carbonate content (for example; a sandy silty limestone would have sand and then silt as dominating particle sizes and a carbonate content between 90 and 100 %).

In the present investigation it has not been possible to make a petrographic classification of the Cretaceous according to Lundegren or to the proposal offered above. The reason is that the rock material in the samples is always more or less crushed. Instead it has been classified according to decreasing carbonate content as follows: limestone, sandy limestone, calcareous sandstone and sandstone. The sandstone has a carbonate content of less than 10 %. Furthermore, conglomerates have been distinguished. The occurrence of glauconite has been noted and the rock has been designated as weakly glauconitic (g) or glauconic sandstone (Gss). The glauconite contents have been estimated by visual examination and are not determined quantitatively.

Archean rocks and kaolin (Pl. IV)

The Archean rocks west of an approximate line Råbelöv—Tollarp petrographically consist of reddish-grey gneisses of the same kind as in the whole of southwestern Sweden from the ridge of Linderöd, through Småland, Västergötland up to Värmland. The region east of the line is dominated by gneisses but of more varying types. Characteristic for the region are the red, usually coarse-grained granites which penetrate the gneisses and build up hills such as Fjälkinge backe and Lilles backe.

In the central part of the plain the nature of the Archean rock is known only at one point. Hessland (1950) mentions that in the bore-hole in Åhus (Åhus: 100) the Archean rock found at a depth of 182.74 m, consists of a coarse-grained granitic gneiss, partly kaolinized.

With respect to the origin of the kaolin deposits I quote from Mohrén (1949): "After this terrain of Archean rocks had been sculptured out by foldings and faults, the rock surface was subjected to a thorough weathering of mechanical and chemical nature by which mighty kaolin deposits were formed. There are different opinions concerning the time for this kaolin formation but it can be established that it in any case took place before the later part of the Cretaceous, the Senonian.

When the sea during this period covered the present Kristianstad plain the highest knobs of rock appeared as islands in the Cretaceous sea. This sea, which reached or possibly exceeded the border of the province of Småland, redeposited on its transgression the earlier formed raw-kaolin.

The finest sediment was washed away and constituted clays (Axeltorp), while the coarse material remained and formed sandstones (Holma and Ryedal sandstones). At protected spots the kaolin could be preserved in situ (Ivö). But even if waves and streams of the Cretaceous sea redeposited the kaolin, their action did not often penetrate the whole thickness of the weathered rock down to the unweathered bedrock. Borings often indicate a kaolinized zone above the hard, unweathered Archean bedrock" (translation by the present author).

As mentioned above, the surface of the Archean below the Cretaceous is incompletely known. However it seems possible that an offset from the ridge of Nävlinge to the southest near Åhus divides the plain into two large basins, one in the north and one in the south. The surface of the Archean is probably below —178 m (Åhus: 100) in the central parts of these basins. The deepest levels in the southern basin are probably fairly near the ridge of Linderöd while the Archean surface falls relatively slowly from the ridge of Nävlinge to the south towards the river Vramsån.

In the northern basin some ridges of Archean rocks are indicated. Their orientation is parallel with the usual NW—SE fault direction. In some of the ridges the highest parts penetrate the Cretaceous and form the hills Fjälkinge backe, Lilles backe, Kjugekull and Branthällen near the village of Bromölla.

The kaolin deposits form a more or less continuous layer on the Archean surface.

The kaolin thickness varies but sometimes amounts to several tens of metres (in the bore-holes Österslöv: 107 and Vittskövle: 51 b the thickness exceeds 40 m).

Cretaceous deposits

Pl. III, which has been worked out on the basis of materials from the bore-holes shows the distribution of the continuous Cretaceous deposits. The boundary is fairly well known except in the valley of Vramsån northwest of the village of Tollarp, where Cretaceous deposits probably cover parts of the economic map of Linderöd.

Only the principal features are known about the Cretaceous in the Kristianstad plain, especially concerning the lower parts.

Lundegren's work from 1934 is mainly based on investigations in quarries and shallow sections occurring on the periphery of the area. From the central part there is only one thorough investigation, namely Hessland's (1950) work from the bore-hole at Åhus.

The bore-hole samples collected in connection with the present investigation are an important addition to the material. However the paleontological and petrographic treatment is still far from complete.

Investigations of microfossils have been carried out by Fritz Brotzen, chief geologist, on samples from some of the bore-holes in the southern part of the plain. All samples turned out to belong to the Lower Campanian. With the aid of different species of the foraminifer genus Bolivinita, it was possible to divide Lower Campanian into an upper part (Lower Campanian 1) and a lower part (Lower Campanian 2). The boundary between these two subdivisions could be followed from bore-hole to bore-hole (cf. Pl. II). Hence, the investigations made so far prove that the upper part of the Cretaceous in the southern part of the Kristianstad plain belongs to the Lower Campanian, which has a thickness of at least 100 m. As mentioned above it is probable that the entire thickness amounts to about 200 m and the lower half is quite unknown except for Hessland's investigation at Åhus.

The rapid facies variations of the Cretaceous in horizontal sections make it difficult to connect continuous layers even in adjacent bore-holes (cf. for instance Kristianstad: 14 a and 14 b located 20—30 m apart). It seems obvious that connections must be mainly made on a paleontological basis.

Attempts to estimate the distribution of limestone, calcareous sandstone etc. are fraught with considerable difficulty even if each economic map is dealt with individually. The bore-holes are sometimes concentrated in certain areas. Furthermore the depths of the bore-holes vary greatly within different parts of the map.

The table below is an attempt to reproduce numerically the distribution of different Cretaceous rocks within the economic maps of the Kristianstad plain. As a basis I have used all bore-holes with samples from the Cretaceous. The different kinds of Cretaceous rocks are expressed as percentages of the average thickness of Cretaceous.

Table 1. DISTRIBUTION OF VARIOUS CRETACEOUS ROCKS IN BORE-HOLES

Economic map	Number of bore-holes in the Cretaceous	Bored average depth in the Cretaceous in metres	Cretaceous facies in percent					
			Limestone	Sandy limestone	Calcareous sandstone	Sandstone	Glauconitic sandstone	Conglomerate
Hässleholm	1	21			71			29
Vinslöv	5	17		29	47	12	6	6
Österslöv	2	16		12	38	50		
Ivö	3	28		11	68	21		
Önnestad	3	45		67	22	9	2	
Kristianstad	22	63	1	54	35	1	9	
Fjälkinge	6	39	14	55	22	9		
Årup	6	63		47	22	17	13	1
Tollarp	4	19.5			82	15		3
Ugerup	8	39	1	37	41	21		
Landön	1	75		100				
Åhus	13	42		38	50	12		
Maltesholm	3	88	4	42	50	3		1
Yngsjö	2	10		100				
Vittskövle	4	46		56	37	7		
Maglehem	3	29		62	38			

With reservation for errors of different kinds the table may still reflect some general features concerning the upper part of the Cretaceous:

a) LIMESTONE (90—100 % carbonate) is quite secondary and occurs preferably in the central part of the Cretaceous area.

b) SANDY LIMESTONE followed by calcareous sandstone dominate in those parts of the Cretaceous penetrated.

c) SANDSTONE and especially conglomerate are most common in peripheral parts of the Cretaceous area.

Tertiary diatoms in the Kristianstad plain

by Urve Miller

62 clay samples from 18 bore-holes have been examined for their content of diatoms and silicoflagellates. (Table 2).

Table 2. SAMPLES EXAMINED FOR THEIR CONTENT OF DIATOMS AND SILICOFLAGELLATES

Economic map	Boring	Sample	Depth in meters below surface	Occurrence of diatoms and silicoflagellates
Åhus	10	2197	6—9	
”	11 a	13091	8	* * *
”	11 b	2215	20	* *
		2216	30	* * *
		2217	40	*
”	15	2239	11—20	
		2240	20—37	
		2241	38	
”	20 b	4247	4—18	
		4248	18—20	
”	106	12919	7—15	* *
		12920	15—18	* * *
”	111	12098	5—6	
		12099	6—7	
		12100	7—7	
”	112	12084	4—5	
		12085	5—6	
		12086	6—7	
”	113	12939	4—5	
		12940	5—6	
		12941	6—7	
”	114	12090	4—5	
		12093	7—8	
Maglehem	17	3557	17—35	*
		3558	40	
		3559	45	
”	23	4941	20—25	
”	38	12977	16—27	
”	43	5302	15—45	
Vittskövle	8	2000	20—30	*
		2001	35	
		2002	40	
		2003	45	
”	17	3579	35—45	
		3580	45—55	
Yngsjö	4	2016	20—29	
”	21 b	26 samples	16.5—45.6	(*)

* * * = common * * = rather common * = rare (*) = only one diatom fragment noted

In the samples from the bore-holes Åhus: 15, 20 b, 111, 112, 113, 114, Maglehem 23, 38, 43, Vittskövle 17 and Yngsjö 4, in all 22 samples, no diatoms or silicoflagellates have been observed. The only microfossils noted are some fragments of spongie spicules.

From the bore-hole Yngsjö 21 b 26 samples have been examined between 16.5—45.6 m below surface. The only diatom observed is a fragment of *Aulacodiscus crux* Grunow v. *glacialis* Grunow at 19.1 m. Fragments of spongie spicules occur in most of the samples, but never frequently.

8 samples from the remaining 5 bore-holes contain diatoms and silicoflagellates. In all cases they are of Tertiary origin, resembling the Eocene diatom and silicoflagellate floras described by Astrid Cleve-Euler. (Cleve-Euler & Hessland 1948).

Pl. VIII shows the distribution of the Tertiary diatoms and silicoflagellates in the sediments of the Kristianstad plain. The microfloras in samples Åhus 11 a: 13091 and Åhus 11 b: 2216 correspond closely to the Tertiary clay samples examined by A. Cleve-Euler (cf. Pl. IX).

Quantitative analyses made on the samples with highest diatom frequencies, (Åhus 11 a: 13091, Åhus 11 b: 2216 and Åhus 106, 12920) show that composition of the floras is almost the same in all the three samples analysed. The main components of diatoms and silicoflagellates and their %-values are given in table 3.

Table 3. THE MAIN COMPONENTS OF THE MICROFLORAS AND THEIR %-VALUES

Bore-hole: Sample: Depth:	Åhus 11 a 13091 8 m	11 b 2216 30 m	106 12920 15—18 m
Diatoms:			
Melosira (Paralia) sulcata v. *biseriata* f. *minor*	29.0	31.0	39.5
„ „ „ „ „ f. *major*	10.5	11.0	7.0
Hemiaulus (februatus v.?) *maximus* f. *minor*	4.0	6.0	6.5
„ „ „ „ f. *major*	2.5	3.0	4.0
Stephanopyxis turris v. *arctica* f.*inermis* et *spinosa*	6.0	6.0	8.0
„ „ v. *cylindrus* f.*inermis* et *paucispina*	4.5	4.5	4.5
Sceptroneis gemmata v. *jutlandica*	3.5	3.0	2.0
Silicoflagellates:			
Ebria antiqua et v.*simplex*	21.0	18.5	16.0
	81.0	83.0	87.5
Remaining species	19.0	17.0	12.5
	100.0	100.0	100.0
No. of valves counted	130.0	144.0	200.0

The Tertiary diatom and silicoflagellate floras analysed can be characterized by:
1) the large amount of fragments and frayed valves,
2) the similarity in the composition.

These qualities are characteristic for reworked material.

The sub-Quaternary surface and the Quaternary deposits (Pl. III, VI, VII)

The geomorphology of the Kristianstad area is discussed for instance by Lundegren 1934 and Brotzen (1962) in "Description to accompany the map of the pre-Quaternary rocks of Sweden". It is apparent that the Cretaceous area is bordered by a denudation border in the north while faults along the ridges of Nävlinge and Linderöd form the border in the southwest. Because the Cretaceous strata are inclined close to the faults it seems probable that block movements have occurred after the Cretaceous and that the ridges of Nävlinge and Linderöd have got there present morphology during the Tertiary.

The present relief of the bedrock is primarily a result of erosion during the Tertiary and the Pleistocene. Among notable features the following are to be mentioned:

1) The Archean topography can be traced through the Cretaceous cover in the northern part of the plain. The Cretaceous rocks reach a high level in connection with the ridges of Archean rocks at the hills of Fjälkinge backe, Kjugekull etc.

2) Large depressions on the plain such as the basin of lake Hammarsjön owe their occurrence to corresponding depressions on the surface of the Cretaceous.

Capes and bays along the present shore-line often correspond with ridges and depressions respectively on the surface of the Cretaceous (for instance the cape at Åhus and the bays north and south of the village).

3) Among elements formed mainly during the Tertiary the sub-Quaternary canyon of the small river Vramsån may be mentioned. The canyon is supposed to have been formed by erosion of a Tertiary river, whose eroding activity was favoured by poorly consolidated Cretaceous rocks. It is probable that glacial and glacifluvial erosion during the Pleistocene contributed to the formation of the present narrow valley. The direction of the canyon is east—west, that is, more or less perpendicular to the latest movements of the ice cap, but it is known that Scania was earlier crossed by ice streams from the east or south-east, the so-called Baltic ice streams. Deposits from these ice streams are characterized by a rather high content of gray and red orthoceratite limestone from the Baltic. The canyon of Vramsån is now filled up by glacial deposits, and orthoceratite limestone is rather common in the bottom layers from the bore-hole Tollarp: 6 (cf. Table 4).

Another valley in the Cretaceous, parallel to the canyon along Vramsån, extends from the village of Degeberga eastwards. Within the Cretaceous area the valley is completely filled by Quaternary deposits but it appears as a distinct glen from Degeberga towards the southwest up on to Archean rocks of the Linderöd ridge.

A comparison between the topographic map and Pl. III shows the thickness variations of the Quaternary deposits on the Kristianstad plain. Some features may be mentioned:

1) The soil thickness in the valley between Hässleholm and Kristianstad seldom exceeds 20 m.

2) The soil thickness in the Kristianstad district varies between 7 and 35 m.

3) Soil thicknesses of more than 40 m occur in the vicinity of Tollarp, along a zone from Rinkaby to Gualöv and in several places inside the triangle Åhus—Vittskövle—Olseröd—Åhus. The largest known soil thickness is 82 m and has been reported from a bore-hole at Yngsjö starch-factory, just south of the outlet of the river Helgeån (bore-hole without samples).

On the Kristianstad plain the ice erosion has smoothed the Archean rocks. However on the whole the Archean rock surface seems to have been only weakly affected by glacial erosion.

It is probable that glacial erosion of the Cretaceous deposits was important in some cases, especially where the deposits consisted of poorly consolidated sandstones and calcareous sandstones. Examples of glacial erosion are the two basins of lake Ivösjön, the floor of the eastern basin lying more than 40 m below sea level (Persson 1932).

The loosening of slabs of Cretaceous and transport by glacial action as in the Cretaceous area of southwestern Scania has not occurred on the Kristianstad plain. The reason is among other things the proportionately coarse-grained and unconsolidated character of the Cretaceous deposits on the Kristianstad plain.

Because there is no modern soil map covering the plain, the deglaciation is not fully known. Briefly, however, the evolution is as follows: About 13 000 years ago deglaciation had proceeded so far that the area south of the Kristianstad plain was free from ice. During the next thousand years melting freed the whole of Scania of ice (Antevs 1915, Lundqvist 1961). During the deglaciation from the south to the north a continually increasing Baltic Ice lake formed, bounded by land in the south and west and by the melting ice cap in the north and east. The Baltic Ice lake extended over the plain and reached, in its southern part, about 40 m and in its northern part about 55 mm above the present sea level. Due to several factors, soon afterwards the plain rose above the sea and the shore was moved far beyond the present one. In a bore-hole at Yngsjö (Yngsjö: 21 b) a thin peat-layer was found at a depth of 9 m (5 m below the present sea level). The peat was dated by the radiocarbon method to 9 540 ± 120 years. A pollen investigation, made by E. Mohrén, showed that the arboreal vegetation almost entirely consisted of pines and birches. Soon after the last-mentioned time the sea invaded the plain and reached 8—10 m above the present sea level. A regression followed and has been going on to the present day.

The Plates II, VI and VII give a general sketch of the Quaternary deposits of the Kristianstad plain. The soil classification in the sections has been discussed above. The sections, Pl. VII, show schematic vertical cuts in the plain and have been prepared by interpolation between the best known well sections.

In the preparation of Pl. VI the following material and investigation methods have been used:

1) THE GEOLOGICAL MAPS OVER THE PLAIN. The maps have mainly been used where new data have been incomplete (for instance in the valley between Hässleholm and Kristianstad). The geological maps are largely incorrect and old fashioned, especially the map "Kristianstad" (compare for instance the extension of glacifluvial material on this map and on Pl. VI).

2. SAMPLES AND JOURNALS from the well drillings.

3. AIR-PHOTO INTERPRETATION of the morphology, of particular importance for an appraisement of the glacifluvial deposits.

4. FIELD INVESTIGATIONS. These have been performed partly by the author but mainly by C. Åberg, fil. lic., whose investigations have been most important for the preparation of Pl. VI.

The soil classification on the map is somewhat different from the classification used in standard geological mapping. The nature of the material made it necessary to put silt, sand and gravel together in one group and to simplify the rest of the classification. Another difference from the standard geological maps is that Pl. VI generally indicates the soils at a depth of 1—2 m and the regular maps at 0.3—0.5 m. A consequence is that thin sand or peat layers have not been marked. However, from a hydrogeological viewpoint it is more important to mark, for example, a clay-layer at a depth of 1—2 m than superposed sand or silt. Hence, silt, sand, gravel and peat deposits are underrepresented on the map. In order to give a three-dimensional picture in some degree, I have also marked out bore-holes with the sequences: clay, sand or sand, clay, sand.

In regions with thick Quaternary deposits these often have a complex composition. Below the youngest till there often exist older strata. These layers may consist of till or sediment. As fossil-bearing deposits have not been found among them it is not possible to date them, or to state their extension.

In order to illustrate the petrographic composition of the Quaternary deposits the following investigation has been made on samples (fraction 2—4 mm) from the southern part of the plain:

Table 4. ROCK-FRAGMENT DISTRIBUTION IN SOIL SAMPLES

Bore-hole	Depth m	Number of grains counted	%					Facies
			Archean + Cretac.	Orthoc. limest.	Cambro-Silurian shale	Cambr. sandstone	Others	
Tollarp: 6	9—15	472	97.8	1.0	—	0.2	1.0	Till
„	21—35	391	96.4	1.8	—	0.5	1.3	„
„	47—49	371	91.9	5.4	0.3	0.8	1.6	Sedim.
Tollarp: 9	10	497	94.0	3.6	—	—	2.4	Till
„	30	376	96.2	1.4	—	—	2.4	Sedim.
„	45	363	97.8	0.8	—	—	1.4	Till
Vittskövle: 8	40	182	74.2	5.5	15.9	—	4.4	„
„	50	222	87.7	8.6	1.4	0.9	1.4	Sedim.
Vittskövle: 17	3—20	467	90.0	8.6	—	0.6	0.8	Till
„	20—35	213	83.6	7.5	—	3.3	5.6	Sedim.
„	45—55	284	98.9	0.7	—	—	0.4	Till
Maglehem: 23	5—10	287	98.6	0.4	1.0	—	—	Sedim.
„	30—35	396	97.9	1.6	—	—	0.5	„
Maglehem: 38	7—12	132	97.0	—	—	1.5	1.5	„
„	33—39	152	87.5	2.0	1.3	7.9	1.3	„
„	58—60	48	91.6	6.3	—	2.1	—	„
Maglehem: 43	9—15	161	99.4	0.6	—	—	—	„
„	52—54	347	85.0	11.8	0.9	0.9	1.4	„
„	58—60	329	84.5	11.4	0.9	1.2	2.0	„
Åhus: 11 b	8	571	96.7	2.4	—	—	0.9	Till

The purpose of the counts was, among other things to investigate if the content of orthoceratite limestone had any tendency to change towards depth. It appears from the table that the percentage of this limestone in the lower parts of the Quaternary is sometimes larger, sometimes smaller than in the upper parts. These conditions indicate that the lower parts are heterogeneous and deposited at different times. In some samples Cambro-Silurian shale and Cambrian sandstone appear and are probably derived from layers in the Baltic constituting an extension of the Cambro-Silurian belt which crosses Scania diagonally. Their occurrence on the southern part of the plain indicates a transport by easterly and southeasterly ice streams.

With reference to the appearance of the different soils on the plain, the following conditions can be mentioned:

1. The *till* is usually found close to the rock surface, especially in areas with a thin soil cover. As mentioned above older Quaternary strata sometimes exist under the till in areas with a greater thickness of soil.

In some parts of the plain till is completely missing, as for example, along the 2—4 km broad coast-fringe from Åhus southwards (cf. section V). The absence of till probably depends on the fact that the ice was afloat and its recession was mainly caused by calving.

Furthermore till is often missing below the thickest parts of the glacifluvial deposits.

The grain-size of the till has not been examined regionally. As mentioned before the particle distribution of the bore-hole samples is not representative. The grain-size of a few till samples from open cuts is shown on (Fig. 1). On the whole the four curves are consistent and represent clayey, silty, sandy till. Most of the till on the Kristianstad plain is of this type or quite similar types. Laboratory measurements show the permeability in sample nr 1 to be 0.01 cm/h. The carbonate content of the till is usually high, especially close to the Cretaceous bedrock. Except for the weathered upper part of the till an average of 20—30 % can be estimated.

In smaller areas of the plain the till is more fine-grained and consists of boulder-clay. This is the case for example in the bore-holes Tollarp: 6 and Åhus: 11. The sequence in the latter bore-hole was, according to the log: 0—8 m: sand, 8—42 m: clay, greenish-gray, 42 m + = limestone. Investigations by Hessland and Cleve-Euler of some samples of the clay, showed a high frequency of Tertiary diatoms. The clay was therefore considered to be of Eocene age (Cleve-Euler & Hessland 1948). As there were stratigraphical reasons to believe that the clay could be of Quaternary age an attempt was made in 1963 to get more material from the clay but boring was stopped by boulders and stones after penetrating the clay for only 1 metre (Åhus: 11 b). However, it was established that at least the upper part of the clay consists of boulder-clay. The rock fragments in the boulder-clay belong almost entirely to the Archean and the Cretaceous (cf. table 4). The clay content and the diatoms must derive from an adjacent occurrence of Tertiary clay (cf. chapt. VI). This may possibly be found in the bottom layers of the clay in the bore-hole. Boulder-clay of the same nature and origin has also been found in bore-hole Åhus: 106 and is indicated in other bore-hole journals from the Åhus district.

The *glacifluvial deposits* are concentrated in fields and wave-washed eskers. Usually the deposits rest on till but the thickest parts often extend down to the rock surface.

The glacifluvial material mainly consists of stones, gravel, sand and fine sand. Silt is of secondary importance and forms only thin layers.

Owing to their relatively high permeability the glacifluvial deposits are of particular hydrological interest. Their occurrence is shown on Pl. VI but while the principal features are correct several uncertainties exist. Thus, eskers at Vinslöv and Tollarp have mainly been taken from the geological maps "Hässleholm" and "Linderöd" respectively. The esker at Hanaskog and southwards is well covered by pits and can also be traced in bore-holes under the clay west of Kristianstad. It is possible that this esker is connected with the esker south of Kristianstad (the Åsumtorp esker) and also with the glacifluvial field west of Vittskövle. The vertical structure of this field is incompletely known. It is possible that the field is a complex formation and that till layers occur at the bottom of it. The horizontal extension may be larger than appears from the map. Connections are possible to the northwest with the small esker at Maltesholm and also to the east with the coarse-grained sediments which occur close to the bedrock in the southern part of section V.

Also the Åsumtorp esker may extend further northwards as indicated by bore-holes with sand under the clay cover. Further to the northeast a narrow esker extends from the area north of Fjälkestad towards lake Råbelövsjön. The esker northwest of Fjälkinge seems to belong to the same esker system even if the direction has been somewhat displaced due to the character of the terrain.

The possible connection between the three most easterly eskers (on the economic maps of Österslöv, Fjälkinge, Årup and Åhus) has not been cleared up. The establishment of the boundaries of the eskers is difficult, partly because they are often covered by drift-sand, partly because their original shape has been modified by the action of sea waves. The direction of the eskers (mainly northeast—southwest) is remarkable and may indicate the influence of Baltic ice in the bay Hanöbukten during their formation.

Although the coarse sediments are concentrated in the eskers they cover large areas elsewhere also (orange on Pl. VI). It has not been possible to make a detailed subdivision and consequently the coarse sediments include soils such as coarse silt and gravel with different properties. As regards origin and mode of formation these coarse sediments form a heterogeneous group. Most were probably deposited by wave-washing and breaking down of glacifluvial deposits and till areas. An important supply of sediments came from the transport of material by sea currents along the coast, which was gradually moved to the east. A third type of coarse sediment is drift-sand. The coarse sediments (except for the glacifluvial material) are younger than the till and the glacial clay and largely rest on the latter deposits. The greatest thicknesses of coarse sediment (more than 20 metres) are found along the coast-belt from Åhus southwards.

The notation *clay* on Pl. VI includes sedimentary clays of different ages, mainly glacial clay. The other clays are postglacial and often contain a high content of organic matter, for instance, the mud-clays in the neighbourhood of Kristianstad.

The glacial clays cover the main part of those areas which lie below 15 m above sea level. Especially in the southern part of the plain the clay is covered by younger and coarser sediments. Only exceptionally does the glacial clay lie more than 30 m above sea level. The largest clay thicknesses (30 m or more) are found along the coast from Åhus and southwards. A bore-hole made with metal foil sampler at Yngsjö (Yngsjö: 21 b) gave a good glimpse into the structure of the clay. As the glacial clay is relatively uniform in the southern part of the plain, some laboratory investigations of the clay may be of interest. The sequence is: 0—16.5 m: sand (a thin peat layer at 9 m) 16.5—39 m: glacial clay (laminated between 19.2 and 19.5 m and from 36.65 m to at least 37.83 m) 39—42 m: probably coarse silt and fine sand (according to a sample at 42.0 m). 42 m +: sandy limestone (sample from 45.6 m). 9 samples, collected between 18.25 and 37.15 m were investigated. The salinity of the pore water (counted as NaCl) amounts to 20—70 mg/l, indicating that the clay was deposited in fresh water. The carbonate content ranges from 14 to 16 %, the clay content from 70 to 80 %. Microfossils were not found, except fragments at 19.1 m (cf. Table 2). Determinations of the minerals were made on some of the samples as well as on the boulder-clay found in bore-hole Åhus: 11. The results are given in table 5.

Table 5. MINERALS IN DIFFERENT CLAYS

	Mont-mo-rillo-nite	Chlo-rite	Mica	Kaolin	Amphi-bole	Quartz	Feld-spar
Yngsjö, winter varve	—	* *	*	*	—	*	*
„ , summer varve	—	(*)	*	* *	—	* *	* *
Åhus: 11, boulder-clay	* *	(*)	*	*	*	*	—

Hence, montmorillonite occurs in the Åhus sample but is missing in the Yngsjö samples. The winter and summer varves in the Yngsjö clay differ inasmuch as chlorite dominates in the winter varves and kaolin, quartz and feldspar in the summer varves.

Geohydrological aspects of the Kristianstad plain (Pl. V)

As stated above the Cretaceous rests on Archean rocks which form a shallow basin bordered by faults towards the southwest. The Archean basin, on the whole, slopes slightly from northwest to southeast.

The Archean rocks are only of little importance for the water supply of the plain, ground water only being found in fissures in the rocks. The latter are certainly common in the Archean of the Kristianstad plain but are sealed by kaolin in the upper parts so that the water flow is relatively small. The Archean rocks are also covered by the younger, more water-bearing Cretaceous and Quaternary.

The Cretaceous deposits consist of sediments of varying particle sizes, carbonate content and porosity. Theoretically it is possible to make an estimate of the water-bearing capacity of the rocks by using the well sections (Pl. II) and information about the capacity of the wells. However in the present case, the well sections are seldom detailed enough and the information concerning the water flow at different levels incomplete or missing. Consequently, we have no precise figures for the water flow in different types of rocks. Only relative comparisons between different layers can be made.

1. LIMESTONES AND SANDY LIMESTONES

These rocks are usually well consolidated. At first glance the rock samples seem to be relatively dense and impermeable as regards water. To get an idea of the porosity, permeability etc., we made some laboratory investigations on rock samples (Figs. 2—4) from different parts of the limestone quarries in Balsvik, Hanaskog, Ignaberga, Maltesholm, Ringeleslätt and Ullstorp (locations, see Pl. I). The investigation results are presented in Table 6.

Table 6. PROPERTIES OF CRETACEOUS ROCKS

1	2	3	4	5	6	7	8	9	10	11
Sample	Carb. cont. %	Spec. gravity	Unit weight		Porosity computed		H_2O volume percent by			Permeability cm/h
			sat.	dry	sat. sample	dry sample	pF0	pF2	pF2.7	
Balsvik 1	89	2.72	1.99	1.58	42	42	42.3	37.2	22.9	0.38
„ 2	96	2.71	2.01	1.62	41	40	39.2	34.9	19.9	
Hanaskog 1	90	2.65	2.07	1.72	35	35	36.4	33.5	18.8	0.04
„ 2	90	2.62	2.05	1.70	35	35	35.1	33.5	16.9	
„ 3	90	2.61	2.03	1.67	36	36	33.9	29.9	14.5	0.08
Ignaberga 1	90	2.70	2.05	1.68	38	38	37.1	18.9	7.8	1.64
„ 2	89	2.66	2.20	1.92	28	28	30.8	19.7	8.0	0.54
„ 3	83	2.66	2.18	1.89	29	29	28.1	23.4	9.6	0.30
Maltesholm 1	83	2.68	2.00	1.59	40	41	42.4	30.7	9.9	3.26
„ 2	93	2.69	2.09	1.73	36	36	34.6	12.7	6.9	
„ 3	90	2.68	2.02	1.62	39	40	36.7	30.4	13.2	0.84
Ringeleslätt 1	89	2.61	2.13	1.82	30	30	30.8	15.4	6.5	2.66
„ 2	97	2.67	2.12	1.79	33	33	22.0	10.2	7.1	2.32
Ullstorp 1	87	2.65	2.17	1.88	29	29	31.0	13.7	7.3	3.07
„ 2	95	2.64	2.11	1.77	32	33	33.3	20.4	8.8	3.01

The carbonate contents are all high showing that the samples consist of limestone and sandy limestone.

The specific gravity has been determined by using glass pycnometer and varnolen, and by using Beckman's air pycnometer. The results were very compatible. The specific gravities of the samples vary only slightly.

The porosity values have been computed from the specific gravity and the unit weight of the saturated sample on the one hand, and on the dry sample on the other. The porosities vary between 28 and 42 %, and are similar to those for unconsolidated sand and gravel. Approximately the same figures have been given by Hessland (1950) in his investigation of the Åhus bore-hole.

A property that is more interesting from the geohydrological point of view is the effective porosity or the specific yield. Usually the moisture equivalent is determined in the laboratory and then transformed into specific retention. The specific yield is obtained as the difference between porosity and specific retention.

In order to get an approximate idea of these properties for the limestone the moisture content of the samples has been measured at different pF-values (the pF-value = the logarithm of the pressure measured in cm water column which the sample is subjected to). The laboratory investigations have been carried out in the following way in collaboration with the Department of Land improvement and Drainage at KTH: The rock samples (weighing 60—85 g) were saturated with water (pFO) and thereafter drained with a low pressure of 100 cm water column (pF2). The water content measured after draining corresponds to the field capacity at a drainage depth of 100 cm.

The sample was then subjected to a drainage pressure equivalent to 1 000 g for 30 minutes in a centrifuge. The water content after centrifuging is the moisture equivalent and corresponds to the field capacity at a drainage depth of 500 cm (pF2.7).

As the purpose of our investigation has been to get only an approximate idea of the specific yield there is no reason to deal with the methods for determining the moisture equivalent more closely (cf. for instance Johnson, Prill and Morris 1963), nor eventual correction factors for converting the moisture equivalent to specific retention (cf. Stearns 1927, and Piper 1933). In the discussion below it is assumed that the moisture equivalent is equal to the specific retention. This value is then subtracted from the porosity to obtain the specific yield. The porosity has been determined earlier, on the one hand according to columns 6 and 7, on the other according to column 8 from the unit weight of the dry and the saturated sample. The results are in good agreement, except for the sample Ringeleslätt 2. The reason for the different values concerning this sample is not clear.

If the water content at pFO (column 8) is taken as a measure of the porosity and the water content at pF2.7 as a measure of the specific retention, an average value on the specific yield of about 22 % is obtained. Bearing earlier investigations concerning the subject in mind, this figure is probably a maximum value on the specific yield. On the other hand it seems reasonable to consider the water content difference pF0—pF2 as a minimum value. The average value of this difference is about 9 %.

On the assumption that the investigated samples are fairly representative for the quarries one could consequently count upon a specific yield of 10—20 % for the limestone and sandy limestone in the quarries.

The assumption may be extended to the entire volume of Cretaceous deposits on the Kristianstad plain and a calculation of its groundwater recources made.

The area of the Cretaceous is about 700 square kilometres and its averages thickness may be estimated to be about 70 m. If a specific yield of 10 % is assumed, the groundwater resources amount to about 5 billions m^3 and with 20 % specific yield the resources are about 10 billions m^3. A draw down of one meter means a groundwater discharge of 70—140 millons m^3 from the aquifer.

Of course these calculations are surrounded by considerable uncertainty, not only concerning the specific yield but also the assumptions about the area and thickness of the Cretaceous.

In column 11 in Table 6 some investigations on the permeability of the samples are shown. The permeability varies from 0.04 cm/h in "shell fragment limestone" from Hanaskog to 3.26 cm/h in "shell fragment chalk" from Maltesholm. If the permeability of each sample is compared with the corresponding water content difference pF0—pF2, it is obvious that on the whole a high water content difference corresponds to a high permeability. The difference in water content, pF0—pF2, may of course also be an indication of the volume of large pores in the sample which also determines the permeability.

With respect to the permeability it ought to be pointed out that the laboratory investigations to a large extent are specific for specific samples and may not be used to estimate the permeability in the Cretaceous on the whole. Such estimates must, among other things, consider the fissuring of the rocks, which is less important when evaluating storage.

When the determinations in Table 6 are reviewed, especially the pF-values and the permeability, it may be noted, from the geohydrological point of view, that the coarse-grained limestones from Ignaberga, Maltesholm and Ullstorp are comparable with the soil-types medium sand — fine sand while the more fine-grained limestones from Balsvik and Hanaskog in this respect may be compared with fine sand-coarse silt or ordinary Archean till.

If it is assumed that all the limestones and sandy limestones of the Kristianstad plain have similar geohydrological properties it is obvious that the coarse-grained limestones have a specific yield and permeability which admit important groundwater discharge, while the more fine-grained limestones certainly have a relatively high specific yield but low permeability. Consequently highly productive wells are only obtained in parts of the limestone which are fissured or rich in flint.

2. SANDSTONES AND CALCAREOUS SANDSTONES

Investigations on the geohydrological properties of the sandstones and calcareous sandstones have not been made. It seems probable that they usually do not differ considerably from limestones and sandy limestones.

A special variant of calcareous sandstone is the so called Åhus-sandstone, which forms the upper part of the rocks in the area around the village of Åhus. The Åhus-sandstone is characterized by alternating strata of poorly consolidated sand and hard calcareous sandstone and is an important aquifer which, for instance, supplies the village with water.

The most important water-bearing formation in the Cretaceous of the plain is doubtless the glauconitic sandstone, which is often poorly consolidated and appears as glauconitic sand (Fig. 5). The sandstone has been formed near the coast and deposited over practically all the plain on the transgression of the Cretaceous sea. Consequently there is a more or less continuous layer of glauconitic sand and sandstone in the lower part of the Cretaceous. The high water-bearing capacity depends on the coarse grain-size. Furthermore there are also more or less glauconitic layers higher up in the sequence. These are often fine-grained and discontinuous and therefore inferior as aquifers.

The thickness of the lower continuous layer of glauconitic sandstone is incompletely known because the bore-holes are often terminated when the upper part of the sandstone is reached. However the probable average thickness is 5—10 m.

The surface level of the most important water-bearing layers; glauconitic sandstone, calcareous sandstone and sandstone, has been noted on Pl. V. Some contours over the surface of the glauconitic sandstone have also been drawn. In many cases the information is derived from the drillers journal and hence is uncertain. Wells in other kinds of rocks or in Quaternary deposits are not taken into consideration on the map.

The level of the glauconitic sandstone agrees with the main features of the plain and is divided into a northern and a southern basin, the line of separation lying approximately between Vä and Åhus. In each basin the surface of the sandstone slopes from northwest to southeast. The glauconitic sandstone has its greatest importance as a water-bearing formation in the northern basin.

In this basin three zones may be discerned based on the character of the most important water-bearing formation. Wells in calcareous sandstone and sandstone (in the northeastern part especially the so called Holma-sandstone, a coarse equivalent to the kaolin) dominate near the ridge of Nävlinge and along the northern border of the basin. Wells in glauconitic sandstone are most frequent in the central part of the basin. Farther southeast towards the Åhus region the depth to the glauconitic sandstone is greater. In consequence drilling costs are rising and most wells in this area get their water from shallower depths. In the border zone Vä—

Åhus the glauconitic sandstone is found at moderate depths and is the most important water-bearing formation. The vicinity of Åhus is in a way a special case depending on the occurrence of the Åhus-sandstone.

In the southern basin the glauconitic sandstone plays a less important role. This is mostly dependent on the fact that the depth to the sandstone is large in the southeast while in the northwest most wells belong to farms with moderate water consumption and in most cases using wells in Quaternary deposits.

In conclusion it may be pointed out that the geohydrology of the Kristianstad plain is in many respects still unexplored. However, investigations are still going on, and include measurements of the tritium content of the groundwater (Brotzen 1964) for obtaining information about the percolation and flow.

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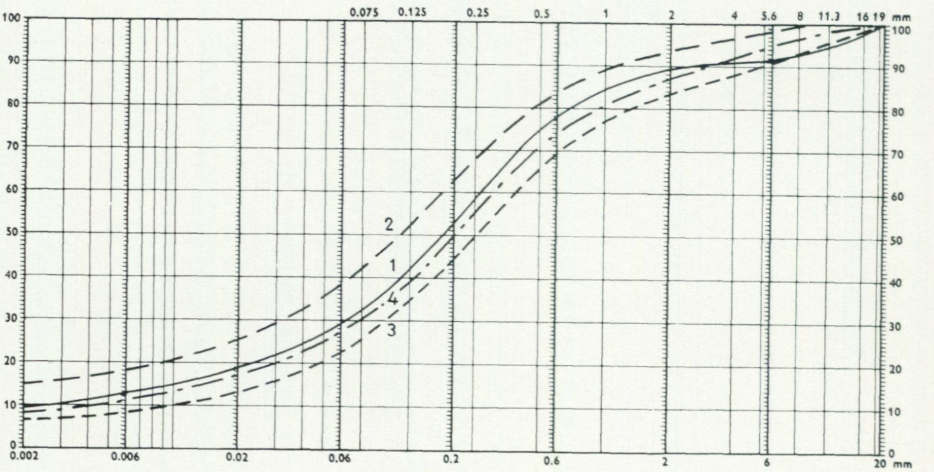
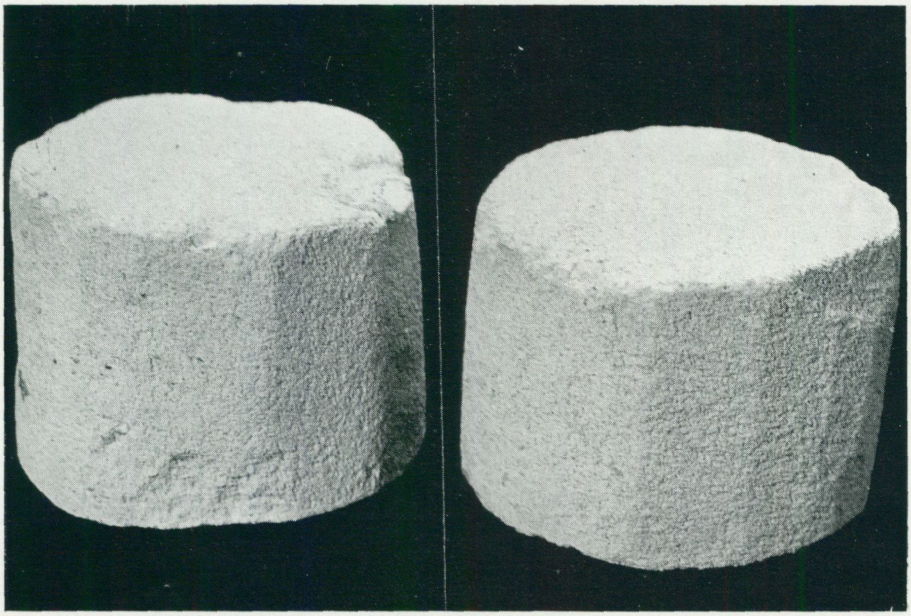


Fig. 1. Till samples from the Kristianstad plain.

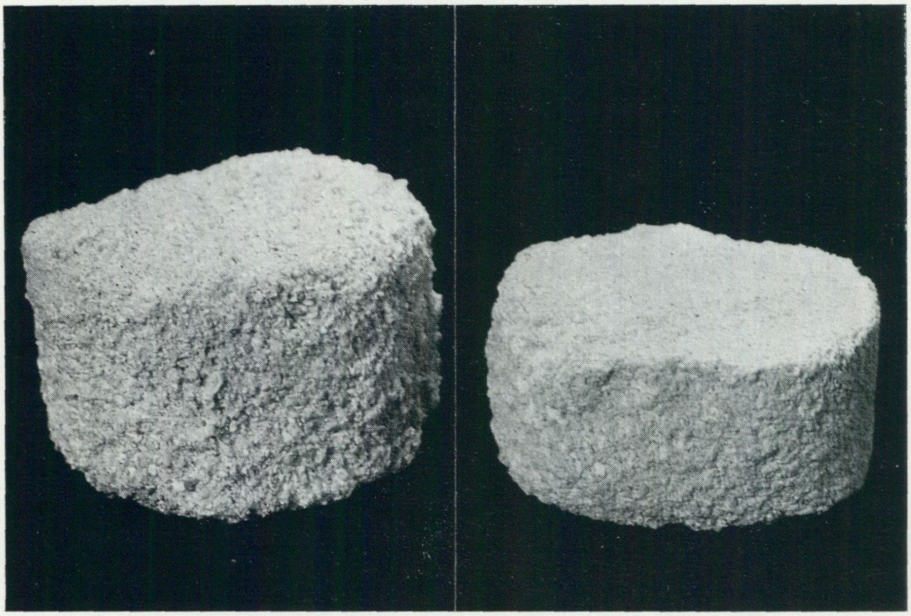
Localities: see Pl. I.

———— : Sample nr 1. Depth 2,5 m.
— — — : „ nr 2. Depth 0,5 m.
- - - - - : „ nr 3. Depth 1,2 m.
— - — - : „ nr 4. Depth 0,5 m.



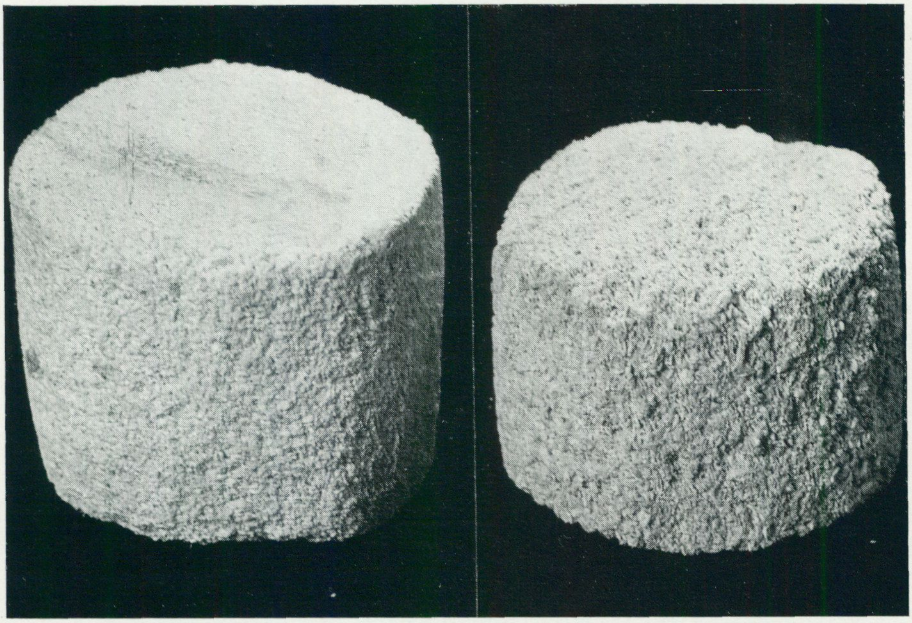
a b

Fig. 2. Limestone samples from the Kristianstad plain. Nat. size.
a: Hanaskog 1
b: Balsvik 1



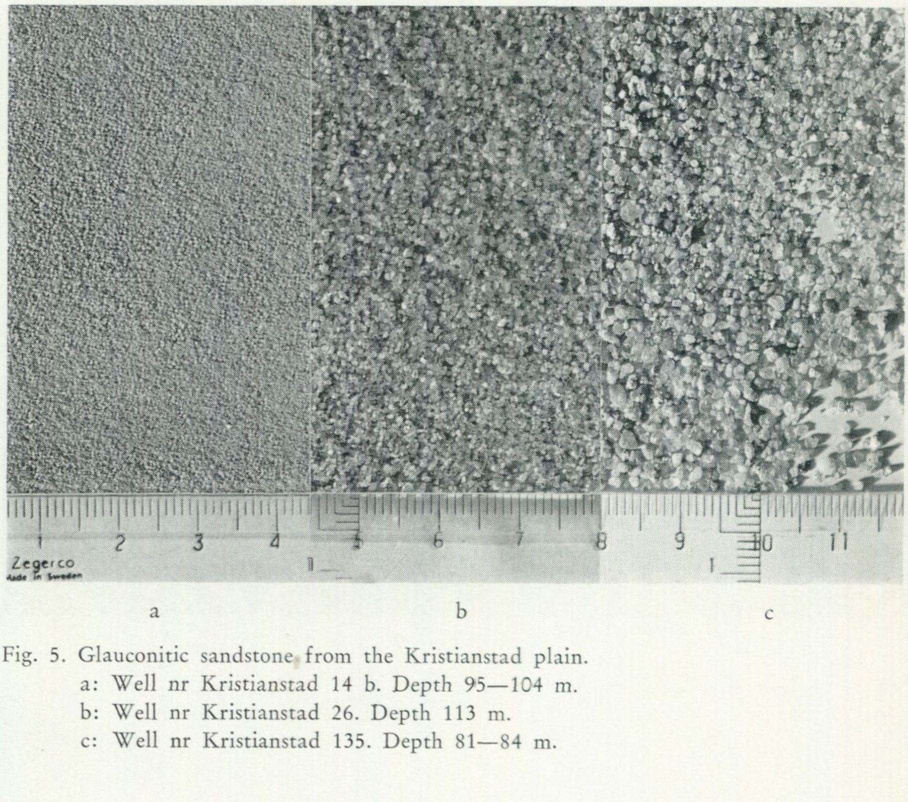
a b

Fig. 3. Limestone samples from the Kristianstad plain. Nat. size.
a: Maltesholm 1
b: Ignaberga 1



a b

Fig. 4. Limestone samples from the Kristianstad plain. Nat. size.
a: Ringeleslätt 1
b: Ullstorp 2



a b c

Fig. 5. Glauconitic sandstone from the Kristianstad plain.
a: Well nr Kristianstad 14 b. Depth 95—104 m.
b: Well nr Kristianstad 26. Depth 113 m.
c: Well nr Kristianstad 135. Depth 81—84 m.

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