GEOLOGINEN TUTKIMUSLAITOS

BULLETIN

DE LA

COMMISSION GÉOLOGIQUE

DE FINLANDE

N:o 145

PHYSICAL AND CHEMICAL PEAT INVESTIGATIONS ON THE PINOMÄENSUO BOG, SW. FINLAND

BY

MARTTI SALMI

WITH 12 FIGURES IN TEXT AND ONE TABLE

HELSINKI

1949

GEOLOGINEN TUTKIMUSLAITOS
BULLETIN DE LA COMMISSION GÉOLOGIQUE DE FINLANDE N:o 145

PHYSICAL AND CHEMICAL PEAT INVESTIGATIONS ON THE PINO-MÄENSUO BOG, SW. FINLAND

BY
MARTTI SALMI

WITH 12 FIGURES IN TEXT AND ONE TABLE

HELSINKI
1949

Helsinki 1949. Valtioneuvoston kirjapaino

CONTENTS

PREFACE

It is natural that in our boggy country great attention has been paid to bog investigations from many points of view. The elucidation of those physical-chemical properties, which are characteristic of the whole peat strata and, in the first place, are connected with the technical uses of peat, has hitherto been almost entirely neglected. In connection with the inventory investigations of peat resources under taken by the department for sedimentary deposits of the Geological Survey the writer has during several years had opportunities of entering into some of these questions.

In these investigations it is interesting to examine properties of the peat strata of a certain bog. For such purpose the Pinomäensuo bog (Ulvonsuo) at Pöytyä was chosen as an object of research. This bog is a distinct highmoor. In research attention has been paid to peat kinds, age relations of peat, humification, reaction, ash content, heat value, and bitumen quantity, and also to their mutual relations.

The samples for this investigation were taken according to my instructions by Forester V. E. Valovirta, and the physical-chemical analyses were made at the laboratory for sedimentary deposits of the Geological Survey under the direction of Mr. A. V. P. Toivonen, M.A. To these, as well as to the persons who have taken part in the treatment of the material, and to the translator, Mrs. A-L. Okko, M.A., I beg to express my special thanks.

THE BOG AND ITS DEVELOPMENT

The Pinomäensuo bog is situated in the parish of Pöytyä, SW Finland, about 4.5 km.NE of Aura railway station and south of the railway.

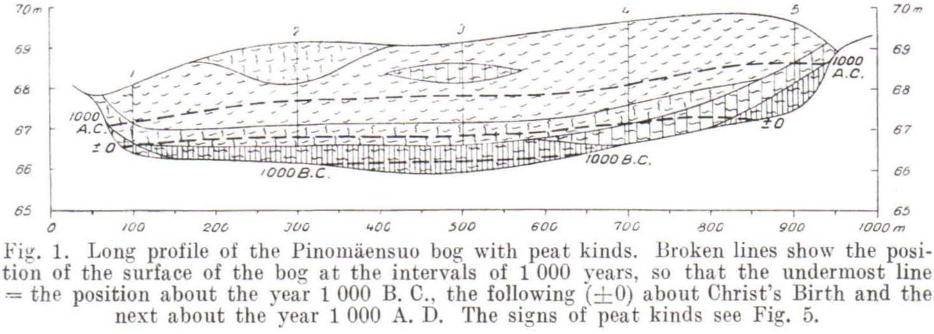

Fig. 1. Long profile of the Pinomäensuo bog with peat kinds. Broken lines show the position of the surface of the bog at the intervals of 1 000 years, so that the undermost line = the position about the year 1 000 B. C., the following (±0) about Christ's Birth and the next about the year 1 000 A. D. The signs of peat kinds see Fig. 5.

The area of the bog comprises about 60 hectares. It measures in the WE direction about 2 km. and its greatest breadth is over 1 km.

The Pinomäensuo bog is a highmoor of convex surface (Fig. 1). Its altitude ranges from 68 to 70 m. above sea-level. The flanks of the bog are covered with dwarf shrub vegetation with pines. The middle part is formed by a treeless *Sphagnum* white moor, rich in *Sphagnum fuscum* hummocks. Here and there in the middle part of the bog there are small depressions in which, in addition to *Sphagnum* species that stand much moisture, *Carex limosa* is growing in eparse quantity.

The bog chiefly gets moisture necessary for its present development and for the growth of its peat though rains from the atmosphere, as do the highmoors in general. In the first stages of its development the bog was situated in a basin, the bottom of which is formed of fine sand and clay. Into this basin nutritious waters have drained from the surroundings. From the stratigraphy of the peat strata, which will later be dealt with in detail, it is evident that the bog was then to be considered as a watery *Carex* white moor. Therefore peats found at the bottom of the bog are entirely *Carex*-predominant or at least contain *Carex*-remains. These change through *Eriophorum vaginatum-Sphagnum* peat (ErS-peat) into more or less pure *Sphagnum* peat (S-peat). The last-mentioned peat kind forms the greatest part of the whole peat strata, being at its thickest in the middle part of the bog. On the basis of its stratigraphy the Pinomäensuo bog is a normal highmoor.

Pollen analytically it has been ascertained that paludification in the basin of the Pinomäensuo bog started during the last stages of the Littorina period, a little before spruce began to attain its maximum. The position of the bog surface is marked in Fig. 1 with broken lines at intervals of 1 000 years, so that the undermost line indicates the surface of the bog about 1 000 B. C., the following line at the time of Christ's Birth, the next about 1 000 A. D. or a thousand years ago, the highest limit of the figure naturally showing the present surface. Thus it is proved that during the earliest stages of the development, until the year 1 000 B. C., SC-peat was being formed in the Pinomäensuo bog, the surface of which was nearly horizontal. The boggy area was then fairly insignificant. During the following thousand years the area of the bog increased manifold and during the end of that period the peat kinds became S-predominant. In the marginal parts of the bog CS- and SC-peats were being formed, in the middle part ErS-peat. During the last 2 000 years, the growth of S-peat continues in the first place, although on the flanks of the bog the formation of CS- and ErS-peats takes place, these peats also being met with at places on the surface of the middle part, depending upon the influence of nutritious waters draining from the surroundings.

INVESTIGATION MATERIAL AND METHODS

In order to carry on the investigation from the points of view presented in the preface, five sample series were taken from the peat strata of the Pinomäensuo bog, all from the same line, crossing the bog from NW to SE. The sample series were taken at distances of 200 m., only the first and the last boring point being situated at the distance of 50 m. from the border of the bog. There are 27 samples in all, and their number varies at different boring points, depending upon the thickness of the peat strata and upon the changes of peat kinds and degrees of humification, as shown in Fig. 1.

In the field investigations L. v. Post's peat formula has been used, according to which peat kind, degree of humification (H_{1-10}), water content (B_{1-4}), amount of *Eriophorum vaginatum* fibres (F_{0-3}), amount of rhizomes (R_{0-3}) and that of wood remains (V_{0-3}), have been determined from each sample.

After the samples had come to the laboratory, their reaction was at once determined in fresh condition by means of the Danish Autonometer Type 21 from peat porridge made thinner by distilled water.

The air-dried samples were later ground into powder, from which the determinations of the amounts of ash, heat value, and bitumen were made. Using the same powder the peat kinds were checked microscopically. In my opinion, the most trustworthy determination of a peat kind is to be obtained in this manner, nor is it to be feared that occasional occurrences of certain plant remains, *e. g.* fibres of *Eriophorum vaginatum*, can dominate too much, as may be the case when handling small samples. All plant remains, found in each sample through microscopic analysis, have been taken into consideration, and marked in Table 1 according to the peat formula. The denominations of peat kinds are restricted to express one or two plant substances. The latter letter thus denotes the main mass of peat and the former its secondary substance. Other more insignificant plant matters become clear either from the peat formula elsewhere or from the notes made after it. A more exact analysis is not held to be necessary, because one has to be satisfied with such accuracy as a trained investigator is able to attain in field work.

The ash content has been determined in the usual way as ignition residue, by burning about 5 g. of peat.

The calorimetric heat values have been determined by burning 1.2 g. of peat powder (pressed into a tablet) in a combustion bomb of 300 c. c. under pressure of 20 atmospheres. Before burning, peat powder has been dried at 105°C. The influence of nitrogen and sulphur upon the effective heat value of peats has not been taken into consideration. The heat values = kcal/kg, abbreviated cal.

Table 1. Physical-chemical results of analyses of peat samples

Number of sample	Peat kind	Peat formula	Depth of sample m	pH	Ash %	Heat value kcal/kg				Bitumens from dried matter	
						Hs′	Hs	Hi	Hi^{30}	%	Ash-free %
	Boring point 1										
1	S—t	$H_1B_3F_0R_0V_0$	0.2—0.4	3.20	0.61	4 483	4 456	4 145	2 726	4.14	4.17
2	S—t	$H_3B_3F_0R_{0-1}$ (Er) V_0 C, N	0.6—1.0	3.86	2.04	4 783	4 685	4 371	2 884	4.81	4.91
3	ErS—t	$H_5B_3F_{0-1}R_2$ (Er) V_0 C, L	1.1—1.4	3.90	2.19	5 244	5 129	4 804	3 187	7.03	7.19
4	CS—t	$H_8B_3F_{0-1}R_1$ (C) V_0 Eq, L	1.5—1.7	4.40	10.03	5 840	5 254	4 934	3 278	10.45	11.62
	Average $H_{4 \cdot 3}$			3.84	3.72	5 088	4 881	4 564	3 019	6.61	6.97
	Boring point 2										
5	ErS—t	$H_6B_3F_0R_{1-2}$ (Er, C) V_0	0.1—0.2	3.68	1.37	5 180	5 109	4 767	3 161	7.54	7.64
6	ErS—t	$H_5B_3F_1R_1$ (Er) V_0 C	0.3—0.5	3.59	1.45	4 975	4 903	4 595	3 041	6.63	6.73
7	ErS—t	$H_4B_4F_0R_1$ (Er) V_0	0.6—1.0	3.80	1.22	4 871	4 812	4 500	2 975	6.37	6.45
8	S—t	$H_3B_4F_{0-1}R_0V_0$	1.1—1.5	3.72	0.99	4 787	4 740	4 442	2 934	4.56	4.61
9	S—t	$H_3B_4F_0R_0V_0$ Er, L	1.6—2.0	3.89	1.18	4 768	4 712	4 406	2 909	5.02	5.08
10	ErS—t	$HB_{43}F_1R_1$ (Er) V_0	2.1—2.4	4.28	1.42	5 363	5 287	4 929	3 275	5.75	5.83
11	SC—t	$H_8B_3F_{0-1}R_2$ (C) V_0 Br, Phr	2.6—3.0	4.43	2.63	5 872	5 718	5 374	3 586	10.81	11.10
	Average $H_{4 \cdot 9}$			3.91	1.47	5 117	5 040	4 716	3 126	6.67	6.78
	Boring point 3										
12	S—t	$H_1B_3F_0R_0V_0$ BrC	0.1—0.2	3.71	1.75	4 896	4 804	4 492	2 969	6.21	6.32
13	CS—t	$H_7B_3F_{0-1}R_2$ (C, Er) V_0 Sch	0.6—0.8	4.02	3.89	5 332	5 125	4 802	3 186	7.72	8.00
14	S—t	$H_3B_3F_0R_0V_0$ L	1.1—1.5	3.71	0.81	4 799	4 760	4 447	2 937	5.81	5.86
15	S—t	$H_3B_3F_0R_0V_0$ Br	1.6—2.0	3.80	0.84	4 829	4 788	4 484	2 963	5.51	5.56
16	ErS—t	$H_4B_3F_1R_0V_0$ Polyp	2.1—2.5	3.73	1.07	4 858	4 806	4 516	2 986	5.41	5.47
17	SC—t	$H_7B_3F_0R_1$ (C) V_0 Er, L	2.8—3.2	4.59	2.94	5 782	5 612	5 280	3 521	9.40	9.68
	Average $H_{4 \cdot 2}$			3.93	1.88	5 083	4 983	4 670	3 094	6.68	6.82
	Boring point 4										
18	S—t	$H_3B_3F_{0-1}R_{0-1}$ (Er) V_0 L	0.1—0.5	3.70	1.39	4 954	4 885	4 520	2 986	6.47	6.56
19	S—t	$H_2B_3F_{0-1}R_{0-1}$ (Er) V_0 C	0.6—1.0	3.75	0.98	4 871	4 823	4 515	2 985	5.78	5.84
20	S—t	$H_2B_3F_{0-1}R_{0-1}$ (Er) V_0	1.1—1.5	3.85	1.11	4 825	4 771	4 479	2 960	4.98	5.03
21	S—t	$H_3B_3F_{0-1}R_{0-1}$ (Er) V_0	1.6—2.0	4.11	1.42	4 833	4 764	4 465	2 950	5.52	5.60
22	ErS—t	$H_4B_3F_{0-1}R_1$ (Er) V_0	2.1—2.5	4.35	1.78	4 938	4 850	4 541	3 003	6.26	6.37
23	CS—t	$H_7B_3F_{0-1}$ (C) V_{0-1} Phr	2.6—3.0	5.21	7.26	5 720	5 305	4 987	3 315	8.23	8.87
	Average $H_{3 \cdot 6}$			4.15	2.32	5 024	4 900	4 585	3 033	6.21	6.38
	Boring point 5										
24	S—t	$H_1B_3F_0R_0V_0$	0.1—0.2	3.69	1.38	4 587	4 524	4 218	2 777	5.12	5.19
25	S—t	$H_4B_3F_{0-1}R_0V_0$	0.6—0.8	3.97	1.35	4 705	4 641	4 344	2 865	5.63	5.71
26	CS—t	$H_7B_3F_{0-1}R_1$ (C) V_{0-1}	1.1—1.5	4.46	2.09	5 576	5 459	5 141	3 423	10.45	10.67
27	SC—t	$H_8B_3F_{0-1}R_{1-2}$ (C) V_{0-1} Eq	1.6—1.8	4.55	3.86	5 853	5 627	5 298	3 533	10.20	10.61
	Average H_5			4.17	2.17	5 180	5 063	4 750	3 150	7.85	8.05
	Total $H_{4 \cdot 4}$			4.00	2.19	5 093	4 976	4 659	3 086	6.73	6.91

Br = *Bryales*
C = *Carex*
Eq = *Equisetum*
Er = *Eriophorum vaginatum*
L = *Lignidi*
N = *Nanolignidi*
Phr = *Phragmites*
Polyp = *Polypodiaceae*
S = *Sphagnum*
Sch = *Scheuchzeria*

The bitumen determinations have been made by extracting 5—10 g. of dried peat powder at 105°C in the Soxhlet apparatus and a mixture of benzene and alcohol (1 : 1) has been used as solvent.

PEATS AND THEIR HUMIFICATION

Peat kinds found in the Pinomäensuo bog have already been briefly dealt with above, but as the results of this investigation depend upon them in a decisive manner, their more detailed examination will still be needed. Humification of peats is so closely connected with peat kinds that it will be examined at the same time.

Though only giving a superficial glance at Table 1, it is clear that the slightly decayed S-predominant peats form the chief elements in the succession of strata (see also Figs. 1, 5, and 6). Especially the share of S-peats is very considerable. Moreover, they are in the main part pure, chiefly *Sphagnum fuscum* peats, as is the case in the highmoors generally. In some samples there are to be found as »impurity» sparse fibres and rhizomes of *Eriophorum vaginatum*. At the boring points 1, 4, and 5 the slightly decayed S-peatlayer continues without a break from the surface of the bog to a depth of 1—2 meters. At point 3 it is broken off by the 0.3 m. thick CS-peat layer, where the degree of huminosity is considerably higher than in S-peat situated above and under it. At point 2 there is in the top part of the bog ErS-peat H_{6-4} in a thichness of 1 meter and beneath it S-peat H_3 also in a thickness of 1 meter. S-peat changes through ErS-peat mostly into SC-peat. An exception is found at point 5, where the change takes place through CS-peat, as well as at point 4, where SC-peat in entirely lacking. The last-mentioned peat kinds form the undermost peat strata bordering the mineral ground. Compared to S-peats, they contain considerably more additional matter, among which may be mentioned, in the first place, the general, even though sparse occurrence of wood remains. In S-peats the degree of huminosity is generally low, mostly H_{1-3}. In ErS-peats it is regularly higher, varying from 4 to 6. Among the lastmentioned kinds the boring point 2 is the most interesting, as the degree of huminosity in ErS-peat is on the surface of the bog at its highest and becomes lower downward. It may be mentioned that in the samples in question there occur C-remains, most in the uppermost ones, where they have been ascertained already macroscopically during field work. The degree of huminosity in CS- and SC-peats is, without exception, higher than is the case with other peats found in the bog, varying 7—8. Also at boring point 3, where CS-peat enters as a thin layer between S-peats, its degree of huminosity is 7, apart from the fact that this peat is comparatively young and the difference in age between it and the CS- and SC-peats found at the bottom of the bog is even over 2 000 years.

Comparing peat kinds and their degree of huminosity with each other, attention is called to the fact that in the degrees of huminosity there is a great difference between those of S- and ErS-peats and between those of CS- and SC-peats. At the bottom part of the peat strata, this difference seems to be regularly 3 degrees of huminosity, but in the upper part at the boring point 3 it is still greater.

As is proved by the above, in the Pinomäensuo bog the peat kinds are divided on the basis of their huminosity into different groups, so that S-peats are the least decayed (H_{1-4}), second come ErS-peats (H_{4-6}), with CS- and SC-peats together (H_{7-8}) as the third group. As to the last-mentioned group, it can be ascertained that in CS-peats the degree of huminosity is mostly 7 and in SC-peats 8. Consequently, the degree of huminosity increases with the decreasing amount of peat forming *Sphagnum* remains. This regularity seems to hold good in spite of the age relations of peats, as becomes evident from the above and especially from Table 1, but this will be dealt with later. On the ground of analysed samples the huminosity of the peat strata of the bog is approximately $H_{4.4}$. At the boring points 1—5 the mean values of H are 4.3, 4.9, 4.2, 3.6, and 5.

As is known, also in the bog decomposition of plants takes place chiefly by the aid of micro-organisms. The quality and quantity of microbes vary in the peat strata. Thiessen and Johnsson (1929) have ascertained that in the surficial part of an American wooded peat bog there is an abundance of fungi, bacteria, and the *Actinomycetes*. Near the ground-water table proper fungi are not to be found, but actually both aerobic and anaerobic bacteria, as well as the *Actinomycetes*. Beneath the water table only anarobic bacteria are encountered. In an American white moor Waksman and Stevens (1929) have found from the surface to the depth of 90 cm. aerobic bacteria decomposing cellulose as well as aerobic nitrifying bacteria. Fungi and bacteria decomposing cellulose decrease rapidly downwards and disappear entirely at the depth of 75—90 cm. The *Actinomycetes* are common in the surficial peat of the bog, but disappear rapidly with increasing depth and only a few of them are met with at the depth of 120—150 cm. The highmoors have a bacterial flora of their own, chiefly containing species enduring fairly strong acidity, the activity of which is not hindered by the reaction of pH 4.0, even though on the increase of acidity the activity of microbes is generally retarded.

Waksman has proved that the nitrogen content of peats is of great importance to their decay. Nitrogen is, in the first place, needed by microbes for the decomposition of cellulose, which the remains of plants contain in different forms. Especially in *Sphagnum* mosses there is an abundance of cellulose and hemicellulose. Whereas the *Carex*-species, particularly their rhizomes, which chiefly form peat, contain the above-mentioned substances but sparsely, they contain, on the other hand, more lignine of great resistance than is the case in *Sphagnum* mosses. When peats decay, the lignine content increases, while the amounts of cellulose and hemicellulose decrease.

According to Waksman, the fungi and bacteria need one part of soluble nitrogen for each of 30—50 parts of cellulose decomposed by them. Moreover, it has been ascertained (Waksman and Tenney 1928) that so far peats contain more than 1.7 % of nitrogen, this amount is quite sufficient for the rapid decay of plant remains, but in so far as the nitrogen content does not attain this degree, the decay of plants will be retarded and incomplete.

From the peats of the Finnish bogs nitrogen analyses have been made by several scientists, as Warén (1924), Kotilainen (1928), Lukkala (1929), and Kivinen (1933, 1934). It is proved by all the mentioned studies that *Sphagnum* peats contain on the average less nitrogen than is the case with the other peat kinds. On the whole, its amount increases in peats, while the share of *Sphagnum* mosses becomes smaller. Kivinen has calculated the mean values of the nitrogen content of the different peat kinds according to the investigations carried out in our country, as follows:

	N %
Sphagnum peat	1.2
Carex-Sphagnum peat	1.8
Sphagnum-Carex peat	2.1
Eutr. *Sphagnum-Carex* peat	2.3
Carex peat	2.3
Bryales peat	2.2

According to the investigations on the bog plants by Kivinen (1933), *Sphagnum fuscum* contains less nitrogen, its amount varying 0.51 – 0.90 %. In other *Sphagnum* mosses the quantity of nitrogen is somewhat greater, being greatest in eutrophic species. The information about the low nitrogen content of *S. fuscum* is interesting, because the *Sphagnum* peat layer of the Pinomäensuo bog chiefly consists of such remains. *Eriophorum vaginatum*, which to a considerable degree forms peat in the Pinomäensuo bog, contains, according to Kivinen, 1.1—2.37 % of nitrogen and in different *Carex* species its amount varies 0.85—2.97 %.

When to the above is further added that the organic mass formed by *Sphagnum fuscum* is very acidic — according to Kivinen approximately pH 4.0 — and if one moreover takes into consideration Waksman's statement that hemicellulose in *Sphagnum* mosses is one of the more sparsely decomposing hexosanes, which already is much less susceptible to decay than, are the pentosanes occurring more commonly in other bog plants, the differences in the degrees of huminosity between different peat kinds in the bog in question become comprehensible, especially the slight decay of *Sphagnum* peats.

When observing degrees of decay in peats in Pinomäensuo, attention is drawn to the fact that in the surficial parts of the bog there are found in the same peat kind peats either as well or better decayed than deeper down. Thus, for instance, at the boring point 4 there is in the surface of the bog 0.5 m. of S-peat H_3, but thence downwards until 1.5 m. S-peat H_2 and from there as far as 2 m. again S-peat H_3. The difference of age between the first- and last-mentioned peat layers is, however, 1 000—1 500 years, as becomes clear from Fig. 1. The difference of age between the top and bottom parts of the H_2 layer (situated between the afore-mentioned peats) is approximately 1 000 years.

The difference of age between peat layers is distinct in the above-mentioned profile, but by means of pollen analyses (Fig. 1), also layers situated at different boring points can be compared with one another. Then it becomes evident that at boring points 2 and 3 S-peat H_3 found at the depth of 1.0—2.0 m. is located as to its age relation in either case chiefly between 1 000—2 000 years. The comparison indicates that during the last 2 000 years in the Pinomäensuo bog there has been formed S-peat H_{2-3}, and this peat strata comes down without breaks from the surface to the depth of 2.0 m. At boring points 1 and 5 there is in the surface S-peat H_1.

As regards ErS-peats, boring point 2 is the most interesting. These peats are found in the surface of the bog as a layer 1.0 m. thick, where the degree of decay falls from H_6 to H_4 from the surface downwards. As becomes evident from Fig. 1, the difference in age between the top and bottom limit of this layer is nearly 1 000 years. Deeper at the same boring point ErS-peat is again met with, the age of which is 1 500—2 500 years, being thus considerably older than the peat situated higher. Of approximately the same age with the last-mentioned layer is at boring points 3 and 4 ErS-peat H_4 at the depth of 2.0—2.5 m.

In the Pinomäensuo bog CS- and SC-peats are generally much decayed and situated at the bottom of the bog, being as regards their age relations older than other peat kinds. An exception is, however, CS-peat H_7 at boring point 3 at the depth of 0.6—0.7 m. In spite of its comparatively young age, about 500—800 years, its degree of decay is the same, like, for instance, that of CS-peat, situated at boring point 4, although the age of the latter layer is 2 500—3 000 years. CS-peat H_8 of about the same age is found at point 1. At boring point 5 CS-peat is encountered which corresponds as to humification to the first-mentioned CS-peat, its age being a little higher or 1 000—1 500 years.

The examples of the peat kinds and their degrees of humification indicate that the age relations do not decisively at least, influence humification of peats in the Pinomäensuo bog, or, in so far as humification takes place continuously in the whole peat strata, it is in the older layers so slow and insignificant that it cannot be observed by aid of the methods used for this study and in the compass of the 3 000 years for which the bog in question provides the comparative material. Instead of this, the material in hand indicates very clearly that humification of peat chiefly takes place either just in the surface of the bog, in the source of the formation of peat, or at least in the surficial part, in the first place, in the layer where aerobic microbes are doing their decomposing work in remains of plants. Depending upon circumstances it may extend in the bog somewhat beneath the water table. According to this, the microbes living deeper down in the peat strata take part in the decomposition of remains of plants to a very slight degree. To maintain their vital functions, they possibly avail themselves of substances found in peat mass, but this does not, to any noteworthy degree, influence the decay of plant remains nor can the process be observed in regard to the course of humification. The rapid humification of peat, in the first place, depends upon the composition of its plant material, which forms peat. This is again closely connected with the bog types and further with the multifarious either local or more general factors, which in each case determine the formation of different bog types.

REACTION OF PEATS

Table 1 shows the pH-values of all the analysed samples of the Pinomäensuo bog, pH varying 3.20—5.21. When observing these at the respective boring points, we ascertain that the acidity of peats is slightest at the basal part of the bog, increasing towards the surface, except at points 2 and 3 where insignificant exceptions are found. These indicate that the reaction of peats is closely connected with peat kinds (Kotilainen 1927, Kivinen 1933, 1935). The *Sphagnum* peats are the most acid of all, and in the same proportion as the share of *Sphagnum* remains becomes less in the formation of peat (an exception is made by eutrophic species) and correspondingly the share of higher plants increases, the peats become less acid. In the following table the changing limits and the mean values of the pH-figures will be presented according to the peat kinds in the Pinomäensuo bog. They correspond approximately to the values published earlier in our country.

S-peat	pH	3.20—4.11	average	3.77
ErS-peat	»	3.59—4.35	»	3.90
CS-peat	»	4.02—5.21	»	4.52
SC-peat	»	4.43—4.59	»	4.52

That in the peat strata of the bog in question acidity increase towards the surface is most likely due to the normal development of a highmoor, because, as is generally known, the bog types of the highmoors become the more oligotrophic the more they, on account of the growth of thickness of peat strata, draw upwards from the bottom of the bog.

At the different boring points the average pH-values of the whole peat strata vary very little, *viz.* pH 3.84—4.17. At point 1 the acidity of the peat layer is greatest, decreasing regularly point by point, so that at point 5 it is at its slightest (Table 1).

In the compass of the material in hand, it is possible to examine also the correlation between the degree of humification and the reaction of a peat kind, even though with certain restrictions. This is done best by means of S-peats, of which the material contains most, yet so that the degrees of humification H_{1-4} are to be got from them. The mean values of their pH-figures are according to the degrees of humification, as follows:

S-peat H_1	pH 3.50
S-peat H_2	» 3.80
S-peat H_3	» 3.83
S-peat H_4	» 3.97

As is to be ascertained from the above, the acidity of the S-peats becomes less on the increase of the degree of humification (see also Figs. 6 and 7). This phenomenon does not, however, appear as distinct in other peat kinds. Especially on the basis of the CS- and SC-peats, the reverse would even seem to be the case, which would correspond to the result presented by Kotilainen (1927) as to the correlation between the degree of huminosity and the reaction of peats. The material, however, contains the last-mentioned peats so sparsely and only of two degrees of humification that on their basis a full comprehension cannot be achieved in one respect or another. One can, of course, refer to the paucity of the material as regards the result given by the S-peats. With this aim, I have, however, examined my more extensive peat material, comprising hundreds of samples and it yields the same result already presented above, that the acidity of peats becomes less on the increase of the degree of humification. It is, however, to be remembered that my material has been taken from the whole peat strata of bogs, as is the case with the Pinomäensuo samples, whereas Kotilainen's material is almost exclusively based on surficial peats.

We will further examine the reaction of the Pinomäensuo peats in layers of different age. At boring point 3 there is on the surface S-peat H_3, its pH being 3.70, and at the depth of 1.5—2.0 m. there occurs analogous, but 1 000—1 500 years older peat, the reaction of which is less acidic or 4.11. The profile mentioned shows two more samples of S-peat H_2, situated one upon the other; on comparing the reactions of these samples it is ascertained that the younger peat is more acid than the older. A similar phenomenon is met with in the S-peats also at boring points 2 and 3. In the *Sphagnum* peats held as the objects of comparison, ash content varies so little that it cannot very likely be considered as the cause of the phenomen, although it does influence the reaction of peat, so that on the increase of the ash content the acidity of peats becomes less, as is proved by Kotilainen (1927).

In other peat kinds the development of reaction is of the same kind, but it is only natural that it is not as clearly marked in mixed peats, because in those the amounts of different plant substances vary, as do also the amounts of ash, upon both of which the reaction of peats depends.

In my opinion the above result of the correlation between the reaction and the age relations of the peats is due to the regular development of a highmoor, referred to earlier, but if we only keep within the compass of the peat kinds it seems on the basis of the above that a peat kind of the same degree of humification is the more acid the younger the age of the peat.

ASH CONTENT OF PEATS

In the peat strata of the Pinomäensuo bog the ash content varies in different samples to a comparatively great degree, *viz.* from 0.61 to 10.03 %, calculated from dried matter. Both of these limit values are found at boring point 1. The lowest ash content is in S-peat H_1 in the surficial part of the bog and the highest in the undermost sample of the profile, which consists of CS-peat H_8. Also at other boring points the highest amounts of ash are found in the undermost samples of the strata, except point 3, which forms an exception.

At the investigated points of the peat strata, the amount of ash generally decreases from the bottom upwards, not, however, so evenly and regularly, as above ascertained as regards the increase of the acidity of peats in the same direction. The average ash content of the peat strata in the bog in question is 2.19 %, and according to the peat kinds it is, as follows:

S-peat	ash	1.22 %
ErS-peat	»	1.50 »
CS-peat	»	5.82 »
SC-peat	»	3.14 »

From the above it becomes apparent that — of the peat kinds in Pinomäensuo bog — S-peats contain less and CS-peats most ash matter (cf. also Figs. 5 and 8). I have earlier ascertained a similar ratio in the ash content of the four corresponding peat kinds (Salmi 1947) on the basis of a more extensive material, even though the mean values are throughout higher than they are in the Pinomäensuo bog. It is, however, to be remembered that it is now the question of a highmoor, into which mineral substances, such as secondary ash, are not carried by waters from the surroundings to such a degree as into the bogs of different kinds. Only the marginal parts of a highmoor are better exposed to their influence, which can be seen in this case, too, from the generally greater amounts of ash in samples collected from the basal layer and from the marginal parts than in those from the middle part of the bog, in the first place, from its uppermost peat strata. The average ash content of the analysed samples is at its greatest at boring point 1, being 3.72 %. At points 4 and 5 it is somewhat smaller, *viz.* 2.32 and 2.17 %. The smallest ash content is found in the middle part of the bog at point 2, where it is 1.74 % and the second smallest at point 3, being 1.88 %.

In the Pinomäensuo bog the ash content of peats differs also from the results presented by other Finnish scientists in the first place in regard to their smaller values. The mutual relations of the different peat kinds are, however, so far dissimilar that in CS-peats the amount of ash is generally smaller than it is in SC-peats. The differences are most likely due to the fact that their material has been gathered chiefly from surficial peats and in connection with the investigations made from the agricultural view point. Further, eutrophic bogs have mainly been examined, the ash content of which is known to be high and in which great changes are caused by rich secondary ash matter (Anttinen 1927, Kivinen 1933).

On the basis of the Pinomäensuo material no distinct correlation between the ash content and the degree of humification of peats is to be observed, and this must also be said of the correlation between the ash content and the age relations of peats. It should however, be mentioned that the comparison made between the different kinds of peat refers to the fact that on the increase of the degree of humification there would to some extent occur an increase of ash, most clearly in S- and ErS-peats. Also in some cases the younger peats, representing the same peat kind and the same degree of humification, contain less ash matter than do the older peats. On the other hand, exceptions are to be found so abundantly that, our material being of such an restricted compass, there is no reason to draw final conclusions, especially as we know that a highmoor is in question and that the changes of the ash content generally take place within very wide bounds and that they are very sensitive to the influence of the most multifarious external factors. Instead of this, the acidity of peats, the correlation of which was earlier dealt with in regard to the facts in question, reacts slowly to the changes taking place in the bog, which is due to the fact that the peats are strongly buffered (Brenner 1924).

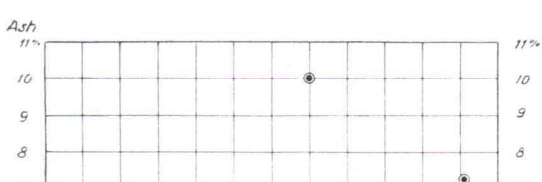

Fig. 2. Correlation between the ash content and the reaction of peats.

The correlation between the reaction and the ash content of peats is fairly distinct. The best conception of it we obtain on the ground of Fig. 2, showing also the peat kinds of the samples. The figure makes it clear that on the decrease of the acidity of peats the ash content becomes greater. This does not seem to hold good absolutely. Especially in CS-peats, but generally also in such samples as contain ash in comparative abundance, the reaction does not change correspondingly to less acidic, as could be expected on the basis of the samples containing less ash matter. To this fact Kotilainen (1927) has also paid attention. He says that secondary ash, which the samples also in this case contain in a considerable measure, does not influence the reaction of peats to any noteworthy degree. An exception is made by lime, the changes of which make themselves easily felt.

HEAT VALUE OF PEATS

The heat values of the peat samples from the Pinomäensuo bog will be presented in Table 1 in four adjacent columns. Hs' = calorimetric heat value of moisture-free and ash-free peat, Hs = calorimetric heat value of moisture-free peat, Hi = effective heat value of moisture-free peat, and Hi^{30} = effective heat value of peat containing 30 % water. The last-mentioned peat corresponds in Finland to a normal fuel peat in regard to its moisture content.

We will first examine the heat values of different samples in the column Hs', where the changes take place between 4 483—5 872 cal. The lowest value is found in the surface sample of boring point 1, which is S-peat H_1, and the highest heat value in the bottom sample of the profile 3, SC-peat H_8. On the basis of the material, it can be established that on the increase of the degree of humification the heat values become higher and the age relations seem to have no effect in this respect (see also Figs. 6 and 9). At boring point 2, where there are from the surface downwards three samples of ErS-peat having successive degrees of humification the difference of one degree in humification indicates about 100 cal, calculated on the ground of the moisture-free and ash-free material. In other profiles samples of the corresponding peat kind and of the corresponding degree of humification are, however, found, with heat values which differ from those mentioned above. Similar differences are met with also in other peat kinds. These may chiefly be due to the composition of plant substances, according to different plant species, and in mixed peats to the correlation of several factors forming peat, but also to additional matters, which certainly for their part also influence the heat values. In the heat values of the plants forming peat, several investigators have namely ascertained even considerable exceptions. For this reason a clear conception of the heat values of peats as well as of the influence of the degree of humification upon such can be obtained only on the basis of an extensive material, when the differences caused by disturbing factors will be smoothed over.

The above may be most easily understood through my earlier investigations (Salmi 1947), comparing over 200 samples and basing on the accurate determinations of the peat kind and the degree of humification. According to these, the S-peats have the lowest heat value, and with a decreasing share of the *Sphagnum* mosses in the formation of peat, when the share of other plants correspondingly increases, the heat value becomes higher. In peats containing wood-remains it is highest, which is of interest also as regards this study, because these peats (L) are found as additional matter in the peats of the Pinomäensuo bog. The heat values of the combustible matter of the four peat kinds dealt with in this study become higher, according to my investigations, in the following order: S-, ErS-, CS-, and SC-peast. The ash content causes such changes in order that ErS- and CS-peat kinds vary to some extent, but considering all the analysed peat kinds, the rise of the calorimetric heat value is approximately 135 cal per one degree of humification.

In order to get a clearer conception of the influence of ash and watre upon the heat value of peats, the heat values of the Pinomäensuo samples on their mean values have been grouped by degrees of humification in Fig. 3. In addition, the peat kinds have been separated from each other by certain marks. Uppermost there runs a line showing the average of the calorimetric heat values of the moisture-free and ash-free samples (Hs′). The calorimetric heat values of the moisture-free peats are so near the former values that presenting both graphically sample by sample would only cause confusion. For this reason Fig. 3 shows of these only the heat values of the moisture-free samples (Hs). The line indicating their mean values runs a little below the first-mentioned average line. The next line downward gives the mean values of the effective heat values of the moisture-free samples (Hi), the undermost line showing that of the effective heat values of the samples containing 30 % water (Hi^{30}). The signs of peat kinds are connected with the last-mentioned.

As shown by the figure, on the increase of the degree of humification the heat values become very distinctly higher. It is, however, to be remembered that the figure is drawn on the basis of ama terial where the lowest degrees of humification are exclusively represented by S-peats, the highest by CS- and SC-peats, and those of medium huminosity by ErS-peats. Above is presented that differences are to be observed, in the heat values of the different peat kinds so that in *Sphagnum* peats they are smaller than in others. For this reason Fig. 3 does not give a right idea about the share of the humification degree in the heat values of the peats generally; thus the rise of the lines showing the mean values is too sharp. Thus, the conceptions presented here apply only to the peats of the Pinomäensuo bog.

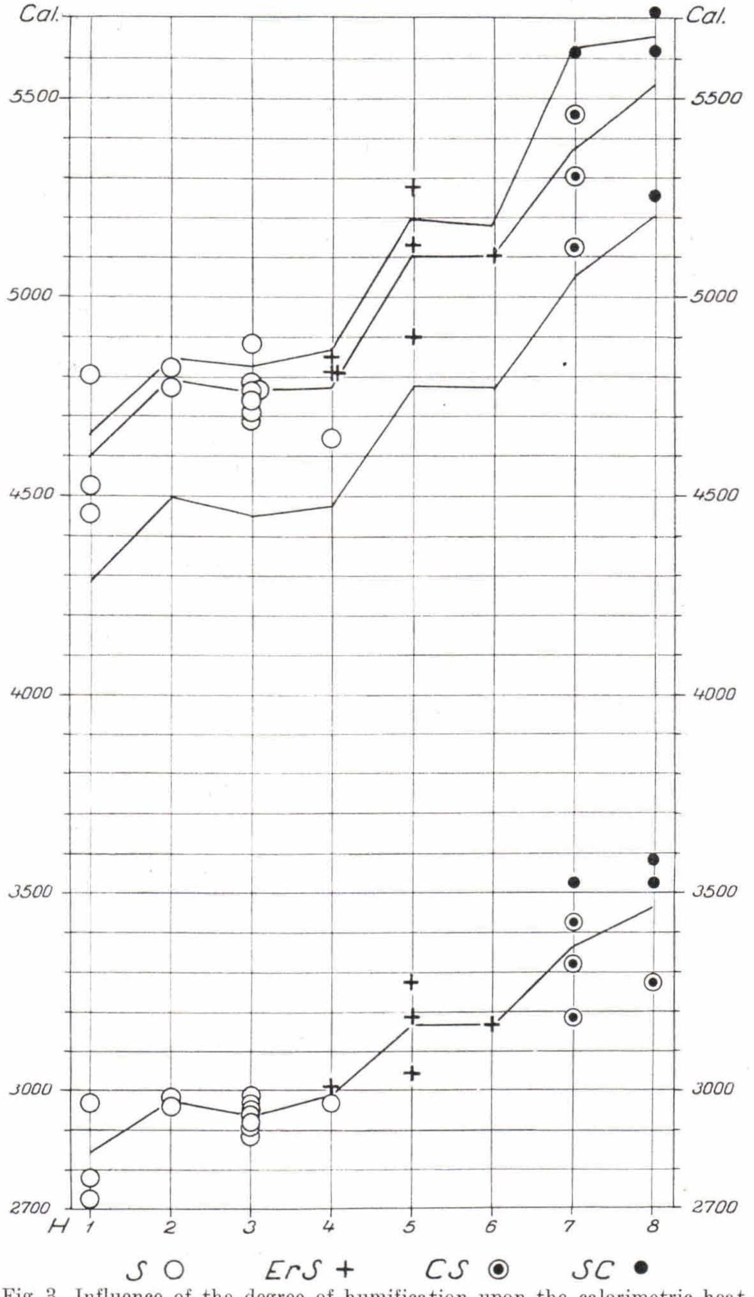

Fig. 3. Influence of the degree of humification upon the calorimetric heat value. The uppermost line shows the average calorimetric heat value of moisture-free and ash-free peats and the line beneath that of moisture-free peats. The signs of peat kinds refer to the last-mentioned. The third line from above indicates the average effective heat value of moisture-free peats, and the undermost that of peats containing 30 % water. Signs of peat kinds are connected with the last-mentioned according to degrees of humification.

It is mentioned above that the difference of the two topmost average lines shows the influence of ash upon the heat values of the moisture-free peats. Moreover, Table 1 makes clear the effect of ash in each sample. Let us illustrate this by two examples. In the topmost sample of profile 1 the ash content of 0.61 % has an effect of 27 cal in the heat values and in the undermost sample of the same profile the ash content of 10.03 % that of 587 cal. In the different samples the heat values decrease by 44—58 cal per 1 % ash and considering all the Pinomäensuo samples approximately 53 cal.

The average heat values of the samples from the different boring points differ very little from one another. Calculated on the ground of the combustible matter the changes take place between 5 024—5 180 cal, and the common value is 5 093 cal. The calorimetric heat values of the moisture-free peats (Hs) are correspondingly 4 881—5 063, on the average 4 976 cal.

The effective heat values of the moisture-free peat samples (Hi) vary between 4 195—5 374 cal and the average values of the different boring points between 4 564—4 716 cal, the common mean value of all the samples being 4 659 cal. In comparison with the corresponding calorimetric values the effective heat values are more than 300 cal smaller.

If we consider peat as a fuel, then of the above-presented factors its quality, in the first place, depends upon the peat kind, the degree of humification, as well as upon the ash content. In addition to these qualities proper to the raw material, among which there can be included others, such coherence, volume weight etc., also the mechanical methods of fuel peat manufacture and the handling during and after production are of importance to the value of peat in use. A very important part is played *i. a.* by the reduction of the abundant amount of water in natural peat to the smallest possible and later by its preservation as such in the product ready for use, because the water content has a decisive effect upon the value of peat as a fuel. As shown in Fig. 3, the amount of 30 % water diminishes the heat values of peats very greatly (the difference of Hi and Hi^{30}). In the different samples of the Pinomäensuo bog, this reduction varies between 1 419—1 788 cal, being 1 573 cal compared to the effective heat values of the moisture-free peats. Thus, to each per cent of water there correspond 52—53 cal.

At the different boring points the average changing limits in the heat values of the peat strata containing 30 % water are between 3 019—3 150 cal, and the mean value of all the samples is 3 086 cal. On the basis of my earlier material (Salmi 1947), I have calculated the corresponding average heat value of the four peat kinds occurring in Pinomäensuo in H_4. In the first place, is the average humification of the peat strata in question, which is $H_{4.4}$, as was mentioned before. The result will be 3 066 cal, corresponding fairly strictly to the value obtained from the Pinomäensuo bog.

According to my analysis, the effective heat value of birch wood containing 30 % water is about 2 950 cal and that of pine and spruce 3 000 – 3 100 cal. The average effective heat value of fuel wood is about 3 000 cal or approximately the same as the average heat value of the Pinomäensuo peat strata, in spite of the fact that its average humification is so low (4.4) that it does not, in this respect, meet the minimum requirements set for a fuel peat bog.

BITUMEN CONTENT OF PEATS

The peat bitumens consist of carbonic, hydrogenous, and oxygenous compounds, which dissolve into organic solvents, such as ether, alcohol, benzene etc. They chiefly comprise waxes, resins, fats, oils, as well as many other substances found in plants. The bitumens are for the most part dispersed in peat, but their accumulations, as resin concretions, may also be encountered.

Investigations on peat bitumens have been carried on since the last century. Among scientists there may be mentioned in this connection Treffner (1881), Zeiler and Wilk (1907), Minssen (1913), Schneider and Schellenberg (1920), Dachnowski (1924), Odén and Lindberg (1926), Waksman and Stevens (1928, 1930), Feustel and Byers (1930), Stadnikoff (1930), and Souci (1930). In Finland peat bitumens have been dealt with by Kivinen (1934), Sundgren and Ekman (1945), and Soveri (1948). Also the writer has made researches into peat bitumens, though the results have not yet been published. On the ground of these results, which are based on over 100 samples and divided among various peat kinds and degrees of humification, I gave a lecture on the bitumen content of peats before the Geological Society of Finland in the year 1947.

From the above-mentioned studies it is evident that the result of extraction depends upon peat and solvent, as well as upon circumstances during extraction.

As solvent has mostly been used ether, benzene, and alcohol, but also a mixture of benzene and alcohol (1 : 1), as was the case in connection with this study, too. The smallest amounts of extract have been got by means of ether and the largest by means of benzene-alcohol. If extraction is made under pressure and at high temperature, the bitumen product considerable increases, compared to the amount obtained by heating in the Soxhlet apparatus and by means of water bath. Schneider and Schellenberg (1920) got from a certain peat kind by aid of the above-mentioned apparatus 6.8 % bitumens, but from the same peat when handled under pressure and at 250°C 27.5 % bitumens; alcohol being used as solvent. According to Stadnikoff (1930), when S-peat was treated with 10 % hydrochloric acid, 26.8 % of benzene-alcohol extract was obtained whereas without the abovementioned treatment the amount of the extract from the same peat was 18.8 %.

Most scientists are of the opinion that the bitumen content of *Sphagnum* peats is smaller than that of *Carex*-peats. A similar result is obtained from recent plants corresponding to these peats. Waksman and Stevens (1928) and Feustel and Byers (1930) have, however, come to a contrary result. My investigations, as presented in the above lecture, indicate that S-peats contain bitumens in a very small degree, yet CS-peats on the average contain still less, which result may have been influenced by the great ash content of the lastmentioned peats. In many C- and SC-peats, as well in peats containing wood remains, even in *Bryales*-mixed peats, there are more bitumens than in S- and CS-peats, but depending upon the mutual relations of plant substances as well as upon changes in the ash content, the amount of bitumen varies greatly in different samples. Thus the percentage of the extract can remain the same as the percentages obtained from the first mentioned peats or even become lower. According to the material presented in my lecture, the highest average of the bitumen content seems to be, present in ErS-peats. The amount of the benzene-alcohol extract varied in my material between 2.54—19.41 %. The former value was obtained from a sample which was S-peat H_1, and the latter from that of ErS-peat H_9. Stadnikoff (1930) states great bitumen amounts from the Russian ErS-peats, the highest of these being 24.4 %, obtained by means of the above-mentioned solvent. With growing humification the amounts of bitumen will increase, while on the increase of the ash content they become less.

In the peat samples of the Pinomäensuo bog the bitumen content varies between 4.14—10.81 %. The smallest result was obtained from S-peat H_1, the greatest from SC-peat H_8. On the basis of this material, the influence of the peat kind upon the bitumen content cannot be cleared up, as there are only few points of comparison in the same degree of humification. Instead, the influence of the degree of humification is better discernible. This is made clear by Fig. 4. It is drawn keeping to the same method as in Fig. 3, so that it shows the relations between the amounts of bitumen and the degrees of humification in the Pinomäensuo peats. The drawing indicates that the amounts of bitumen in ErS- and SC-peats are equal, in each degree of humification, whereas in CS-peats there occur considerable variations. They may mainly be due to the ash content. But also in S-peats, especially in H_1 and H_3, the amounts vary very greatly, approximately within the limits of 2 %. Attention is drawn to S-peats H_1, their average amount of bitumen being only a little less than it is in the two following degrees of humification, which are also S-peats. Yet taking the separate samples into consideration, the amount of bitumen found in S-peat exceeds both in H_2 and in H_3 all the others, except the highest value, which was obtained from a surficial sample.

Some earlier scientists have presented that the bitumen content increases with growing age (Schneider and Schellenberg 1920). To get this question cleared up on the basis of the Pinomäensuo material, we shall first examine Table 1. At boring point 2 there are three successive samples of ErS-peat from the surface downward. We see that the amount of bitumen is greatest in the surficial sample and grows less downwards, but in the same direction also the degree of humification decreases. In the profile there is deeper down ErS-peat, which is considerably older than the corresponding peat situated higher in the peat strata (Fig. 1), but its amount of bitumen is less than in the younger peat. At both points 3 and 4 there is ErS-peat H_4, the peats being approximately of the same age, but distinctly older than corresponding peat found at point 2. In this case, too, the bitumen content of the younger peat is greater than that of the older. The same phenomenon is met with also in CS- and S-peats, being most distinct in the S-peats in H_3, where the youngest sample taken from the surface (point 4) has a greater bitumen content than is the case with the older ones. There are also exceptions, but they are more rare than the cases presented above. Among my analyses are also the bitumen determinations from two recent species of *Sphagnum* made by means of benzene-alcohol. Both of these occur in the Pinomäensuo bog. *Sphagnum fuscum* gave as result 4.86 % and *Sphagnum papillosum* 7.02 %. The amounts are thus of the same degree as are such obtained from S-peats H_3. The Pinomäensuo material indicates that the amount of bitumen got by benzene-alcohol does not increase with growing age in peats of the same degree of humification. On the contrary, in younger, especially in quite young peats, it seems to be greater than is the case in older such.

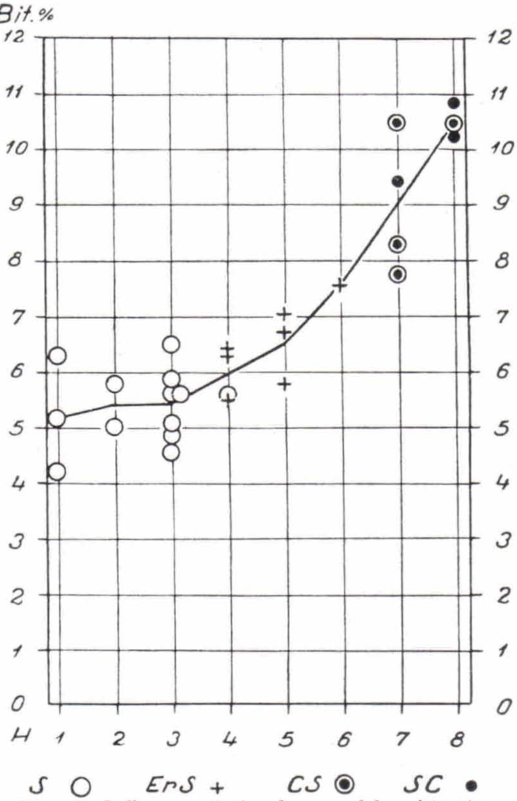

Fig. 4. Influence of the degree of humification of peats upon the bitumen content.

In the following table the average values of the bitumen contents of the Pinomäensuo peat samples are grouped with 0.5 m. differences in depth. Moreover, it shows the average degree of humification at different depths.

Depth m.	0—0.5	0.5—1	1—1.5	1.5—2	2—2.5	2.5—3
Bitumen average %	6.02	6.06	6.37	7.34	5.80	9.48
Humification average	2.8	4	4	5	4.3	7.3

Attention is first drawn to the fact that the amount of bitumen increases with increasing depth, first in a small degree, but then more strongly. An exception is the depth of 2.0—2.5 m., where the bitumen content is smallest. As regards average humification it is remarkable that it is distinctly slightest in the topmost layer and strongest in the undermost, while in the layers situated between them there are no great differences to be found. The most interesting comparison is directed to the depths of 0—0.5 m. and of 2.0—2.5 m. To the former there belong S- and ErS-peats and to the latter only ErS-peats, which, according to my earlier investigations, contain in the same degree of humification on the average more bitumens do than S-peats. Peats situated deeper down, however, contain in this case distinctly less bitumens than do the younger surficial peats, in spite of their average humification being 1.5 degrees higher. In my opinion this phenomenon is in the first place due to chemical factors and is connected with the process of humification and with the activity of micro-organisms.

It is known that the aerial parts of plants contain more substances classed as bitumens, such as waxes, resins, fats etc. than do their subterranean parts which chiefly form peat. As the bog plants die and decay in their habitats, those matters in the aerial parts of plants, which have the greatest power of resistance, like substances belonging to bitumens, remain in their substratum. Being fine-grained, they are able, depending upon circumstances, to sink into a peat strata. A considerable part of peat bitumens have apparently originated from the aerial parts of plants, but partly also from different fungi, algae, and microbes living in a bog.

According to Fuchs (1931), especially the tiny amounts of fat and oil in the cells of the higher plants are largely decomposed already under aerobic circumstances and are enriched into sparsely soluble bitumens under anaerobic circumstances. Waxes and resins are less sensitive to biological changes and become enriched under both aerobic and anaerobic conditions. But in the course of time, under the influence of chemical reactions, they can be polymerized into sparsely soluble substances. Souci (1932) divides bitumens into two groups: »Bitumen A» and »Bitumen B». To the former he counts the bitumens obtained by extracting peat by means of benzene-alcohol under general pressure. Zetzsche (1932) divides them into two more groups: »Extract-Protobitumina» and »Extract-Bitumina». By the former he means bitumens that have not yet been decomposed in a peat strata.

By B-bitumen is meant such resinous and wax-like substances, which can be obtained by extracting peat again under a pressure of 50 atmospheres and in the temperature of 250—280°C, after A-bitumens have been eliminated from peat. Zetzsche divides them again into two further groups: »Polymer-Protobitumina» and »Polymer-Bitumina» or »Stabil-Bitumina». The former consist chiefly of undecomposed sporopollenine, cutine, and of suberine, while the latter are their fossilized derivates. Zetzsche and Kälin (1932) have ascertained that the separation and the quantitative determination best takes place by means of fuming nitric acid and bromine.

When the bitumen results of the Pinomäensuo peat strata are examined from the view points presented above they become very easily comprehensible. It can be thought that particularly in the topmost layer there is still an abundance of easily soluble Extract-Protobitumina, contained in parts of plants which have died and decayed on the surface of the bog. Moreover, those bitumens of the surficial layer of the bog, which are of different origin, are still in an easilysoluble form. In the next two depth groups the influence of Extract-Protobitumina, which are carried by waters from the surface downwards, may still be felt, as their decayed peats are still very permeable to water. Deeper down the bitumens have, however, in the course of time turned sparsely soluble under the influence of different factors. So *e. g.* the age of peat at the depth of 2.0—2.5 m. is approximately 2 500 years; in this peat the unimportant share of the extraction product compared to the surficial layer is most distinctly discernible. Thus in the case of the Pinomäensuo bog during at least 2 000—2 500 years the bitumen content changes to such a degree that, in spite of the difference of the 1.5 degree of humification, it is lower in older peat than in surficial peat. One might indeed expect it to be higher because of the enrichment of bitumens taking place in connection with its humification process as well as considering the peat kind. In reality, the case may be such that in the same degree of humification the same peat kind contains bitumens totalling approximately the same amount, whether the peat be younger or older in age, but in course of time bitumens turn sparsely-soluble and this is the reason why employing the same solvent and the same method a larger amount of bitumen is obtained from younger than from older peats. In so far as the use of peat bitumens is planned for manufacturing purposes, it is necessary to take the above-presented facts into consideration. Although the differences are evidently not very great, they may even be of decisive importance for the final yield, as the bitumen content is generally comparatively small. Besides, it is to be remembered that the different peat kinds contain different bitumens.

At the different boring points the average bitumen content of the peat strata varies to a very small degree, being at the points 1—5, as follows: 6.61 (6.97), 6.67 (6.78), 6.68 (6.82), 6.21 (6.38), and 7.85 per cent (8.05 per cent). The figures refer to the percentages from driedmatter; the values

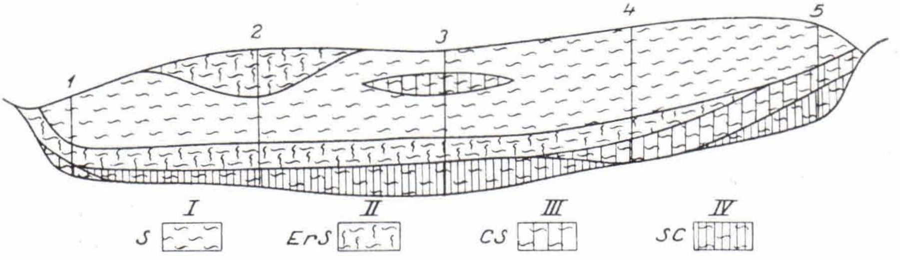

Fig. 5

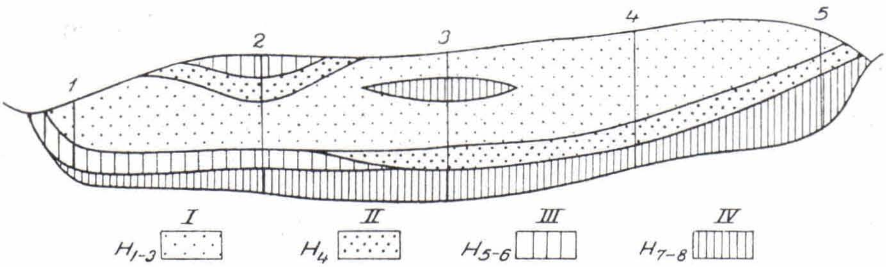

Fig. 6

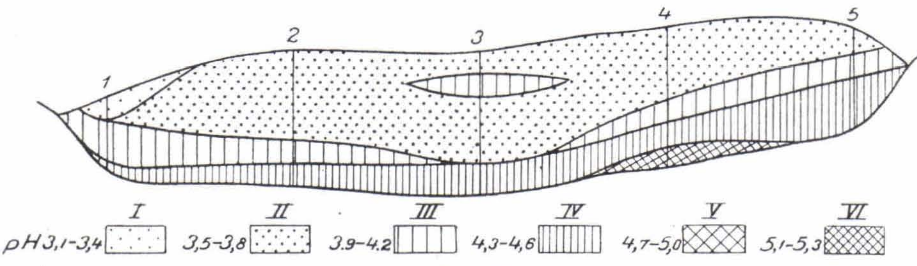

Fig. 7

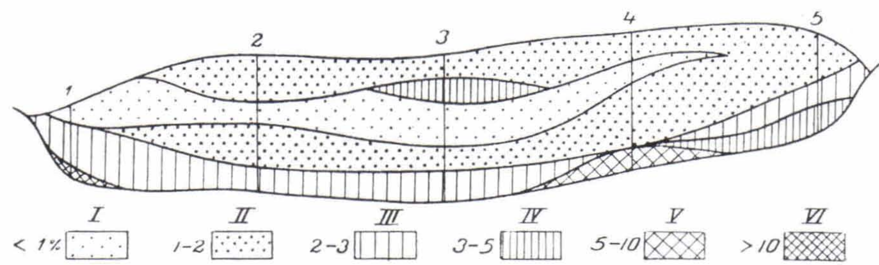

Fig. 8

Fig. 5. Peat kinds. — Fig. 6. Humification of peats. — Fig. 7. Reaction of peats. — Fig. 8. Ash content of peats.

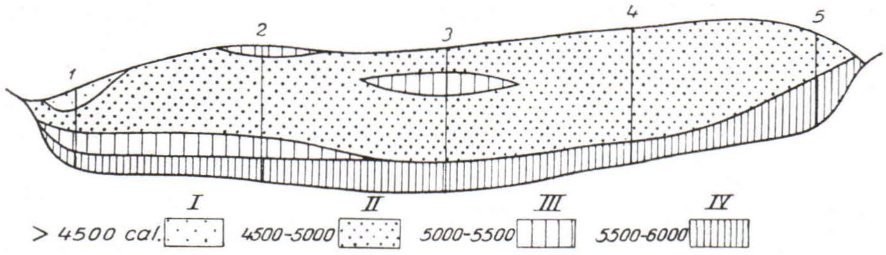

Fig. 9

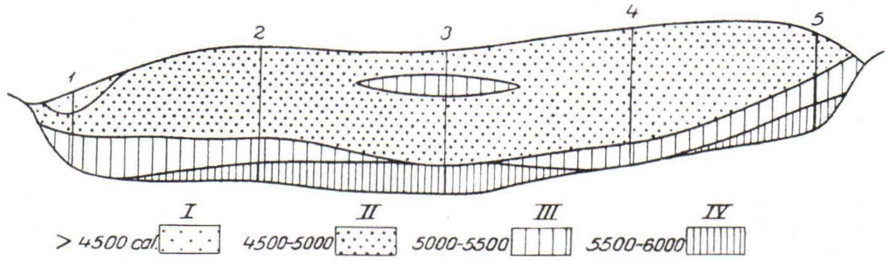

Fig. 10

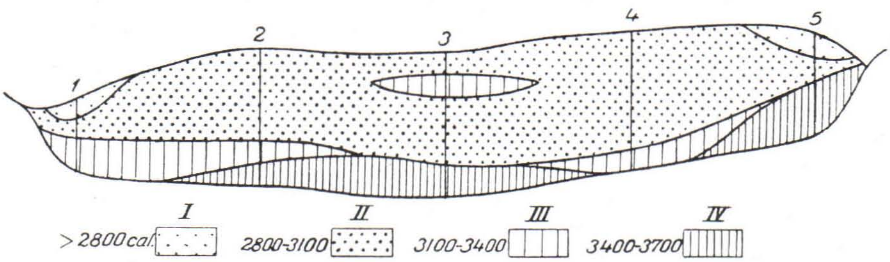

Fig. 11

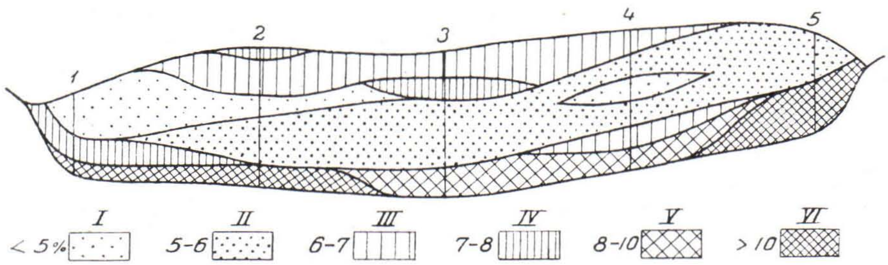

Fig. 12

Fig. 9. Calorimetric heat value of moisture- and ash-free peats. — Fig. 10. Calorimetric heat value of moisture-free peats. — Fig. 11. Effective heat value of peats containing 30 % water. — Fig. 12. Bitumen content of peats.

within brackets have been calculated for ash-free peats. In the whole peat strata the average values are correspondingly 6.73 per cent (6.91 per cent).

SUMMARY

Comparisons have already been made above and have explained the correlations of the different factors in the peat strata of the Pinomäensuo bog. Now we will once more take a look at the profile drawings. Figs. 5—12 show the results of analyses connected with this study, grouped in a certain way.

Fig. 5, being the same as Fig. 1, presents the peat kinds of the bog in question. The figure has been taken in this connection because it could better be compared with the following figures of the same scale.

In Fig. 6 the peats are grouped by the degrees of humification into four different classes, their numbers corresponding to the peat kinds. That H_{1-3} is put in the same class is explained by the fact that these are merely S-peats. Figs. 5 and 6 are very much alike and indicate that at least in the bog in question S-peats decay more slowly than the other peat kinds. The young ErS-peats in the surficial part of boring point 2 form a better decayed part in the *Sphagnum* bed and as a still clearer lens there is discerned young, welldecayed CS-peat at point 3.

Fig. 7, where the reactions of peats are grouped into six classes with differences of 0.3 in the value of pH, also resembles the two former ones and shows the correlation of the facts presented by the figures. The figure indicates that the reaction at the bottom and flanks of the bog is less acidic than is the case in the corresponding peat kinds in its middle part and higher up in the peat strata. This may, in the first place, be due to the influence of the mineral ground. From the bottom upwards it seems to influence only in a thin, about 0.5 m. thick peat strata. This is most clearly seen at boring point 3, at the bottom of which there is a layer of the thickness mentioned, this being of SC-peat of the pH-class IV. Above it there is directly the pH-class II, extending to the surface, except the CS-lens, which belongs to the class III. Proceeding from the middle part of the bog to its flanks, the share of the pH-class II becomes less and the shares of the pH-classes III and IV increase correspondingly. To class III there belong, among others, S-peats at the borders of the bog, which peats are elsewhere more acid. In my opinion, this phenomenon should be explained so that nutritious waters draining from the borders of the bog secondarily dilute the acidity of peats. The influence of this phenomenon is abated towards the middle part of the bog, which in the Pinomäensuo case is clearly discernible, class II there sinking deeper down.

Fig. 8 shows the division of the ash content in the Pinomäensuo peat strata. Were classes I and II connected with each other, the figure would

resemble Fig. 7 to a very great extent. The correlation between the ash content, the reaction, and the peat kind is to be seen clearly in Figs. 5, 7, and 8.

The figure shows also the influence of the ash matters carried by waters draining from the borders of the bog. It appears, however, that the mineral matter, evidently depending upon the grain size and the humification of peat, stops comparatively close to the marginal parts of the bog, as if sinking into the peat strata, nor is its influence felt as far away in the middle part of the bog, as is the case with that of draining waters upon the reaction of peats. It is interesting to ascertain that the lowest ash content is to be found at a short distance from the surficial layer. This may be due to the fact that at the corresponding point fairly pure S-peats are encountered, while S-peats belonging to the ash content class II contain additional matters in greater abundance or else those peats are ErS-peats. At boring point 3 the CS-lens differs greatly from the surrounding peat strata on account of its ash content.

By the heat value, peats are grouped in the manner shown in Figs. 9—11. The figures are very much alike, as is only natural. It is, however, to be noticed that in the first two figures the grouping is made with differences of 500 calories and in Fig. 11 with that of 300 cal. Figs. 9 and 10 show the influence of the ash content upon the heat values. The most distinct differences in figures are formed by the undermost peats, having the greatest ash content. Fig. 11 shows the influence of the 30 % water content upon effective heat values. That the heat value of peats depends also upon the peat kind (Fig. 5) and upon the degree of humification (Fig. 6) is clearly to be seen.

Fig. 12 presents the division of the bitumen content in the Pinomäensuo peat strata. It clearly shows the correlation between the bitumen content, the peat kind, and the degree of humification. The most interesting is the surficial part of the peat strata, to which in the middle part of the bog chiefly belongs class III and to which there belong, also S- and ErS-peats H_{1-5}. This clears up the opinion stated above that in the surficial part bitumens are different as regards their solubility than is the case in older peats. The smallest amounts of bitumen in the bog in question are found beneath the surficial layer, in the profile at left, as well as a separate lens at boring point 4. They are S-peats H_{1-3}. The rest of the S-peats and part of the ErS-peats belong to class II. Peats at the bottom of the bog are counted as belonging to classes III—VI, depending upon the peat kind and the degree of humification.

The resemblance between Figs. 5—12 is surprising, although that which they present is of very different kinds. For instance, the lens formed by CS-peat at boring point 3 appears in all profile drawings. This similarity of the figures proves that all the facts dealt with in this study have a definite correlation either between one another or between the peat kinds and their humification. The correlation becomes apparent when the results are grouped in a suitable manner.

LITERATURE

Anttinen, O., 1927. Turpeiden ja turvelaaturyhmien tuhka-ainemäärästä. S. Suovilj. yhd. vuosik., 31, 2.

Brenner, W., 1924. Über die Reaktion finnländischen Böden. Agrogeol. julk., 19.

Dachnowski, A. P., The Chemical Examination of Various Peat Materials by Means of Tood Stuff Analyses. Journ. Agr. Res. 29.

Feustel, I., and Byers, H., 1930. The physical and chemical characteristics of certain american peat profiles. U. S. Dept. of Agric., Techn. Bull., 214.

Fuchs, W., 1931. Die Chemie der Kohle. Berlin.

Kivinen, E., 1933. Suokasvien ja niiden kasvualustan ravintoainesuhteista. Acta Agralia Fennica, 27.

—»— 1934. Über die organische Zusammensetzung der Torfarten und einiger Torfkonstituenten, Acta Agralia Fennica, 31.

—»— 1935. Über Elektrolytgehalt und Reaktion der Moorwässer. Agrogeol. julk., 38.

—»— 1948. Suotiede. Porvoo—Helsinki.

Kotilainen, M. J., 1927. Untersuchungen über die Beziehungen zwischen der Pflanzendecke der Moore und der Beschaffenheit, besonders der Reaktion des Torfbodens. Wissensch. Veröff. des Finnischen Moorkulturvereins, 7.

Lukkala, O. J., 1929. Über den Aziditätsgrad der Moore und die Wirkung der Entwässerung auf denselben. Comm. Inst. quaest. forest. Finl., 13.

Minssen, H., 1913. Beiträge zur Kenntnis typischer Torfarten. Landw. Jahrb., 44.

Odén, S., and Lindberg, S., 1926. Einige Torfanalysen im Lichte neuzeitlicher Theorien der Kohlebildung. Brenstoff-Chemie, 7.

Salmi, Martti, 1947. Turpeiden tuhkapitoisuuksista ja lämpöarvoista. Tekn. aikakauslehti, 4.

Schneider, W., and Schellenberg, A., 1920. Über den Bitumengehalt des Torfes. Ges. Abh. z. Kenntnis d. Kohle, 5.

Souci, S. W., 1938. Die Chemie des Moores. Stuttgart.

Soveri, U., 1948. Eräiden turvelajiemme kemiallisesta kokoomuksesta ja sen vaikutuksesta niiden polttoarvoon. Maataloustieteellinen Aikakauskirja, 3.

Stadnikoff, G., 1930. Neuere Torfchemie. Dresden und Leipzig.

Sundgren, A. and Ekman, E., 1945. Turve ja turpeenjalostus. Tekn. aikakauslehti, 9.

Thiessen, R. and Johnsson, R. C., 1929. An analysis of a peat profile. Journ. of Ind. a. Eng. Chem. Anal. Ed., 1.

Treffner, E., 1881. Beiträge zur Chemie der Laubmoose. Pharmac. Zeitschr. für Russland.

Tuorila, P., 1928. Wirkung der Kalziumkarbonat und Schwefelsäurezugaben Torfarten. Wissensch. Veröff. des Finnischen Moorkulturvereins, 8.

Waksman, S. A. and Stevens, K., 1928. Chemical composition of various peat profiles. Soil. Sci., 26.

WAKSMAN, S. A. 1929. The role of microorganisms in peat formation and decomposition. Ibidem, 29.

—»— 1930. A critical study of the methods for determining the nature and abundance of soil organic matter. Ibidem, 30.

WAKSMAN, S. and TENNEY, F. G., 1928. The influence of nature of plant upon the rapidity of its decomposition. Ibidem, 26.

WARÉN, H., 1924. Untersuchungen über die botanische Entwicklung der chemischen Zusammensetzung des Torfes. Wissensch. Veröff. des Finnischen Moorkulturvereins, 5.

ZEILER, V. and WILK, L., 1907. Über den Einfluss der Pflanzenkonstituenten auf die physikalischen und chemischen Eigenschaften des Torfes. Zeitschrift für Moorkultur und Torfverwertung, 5.

ZETZSCHE, F. and KÄLIN, O., 1932. Eine Methode zur Isolierung des Polymerbitumens (Sporenmembranen, Kutikulen usw.) aus Kohlen. Braunkohle, 31.

ZETZSCHE, F., 1932. Fossile Pflanzenstoffe. Handbuch der Pflanzenanalyse von G. Klein, Bd. 3, Wien.

Bulletin de la Commission géologique de Finlande.

N:o 1. Ramsay, Wilhelm und Nyholm, E. T. Cancrinitsyenit und einige verwandte Gesteine aus Kuolajärvi. S. 1—12. 4 Fig. 1895 .... 60: —

*N:o 2. Sederholm, J. J. Ueber einen metamorphosirten praecambrischen Quarzporphyr von Karvia in der Provinz Åbo. S. 1—16. 12 fig. 1895 .... —

N:o 3. Ramsay, Wilhelm, jemte Bihang 1 af Hackman, Victor och 2 af Sederholm, J. J. Till frågan om det senglaciala hafvets utbredning i Södra Finland. S. 1—44. 1 karta. Résumé en français: La transgression de l'ancienne mer glaciaire sur la Finlande méridionale. 1896 .... 100: —

*N:o 4. Frosterus, Benj. Ueber einen neuen Kugelgranit von Kangasniemi in Finland. S. 1—38. 11 Fig. 2 Taf. 1896 .... —

*N:o 5. Berghell, Hugo. Bidrag till kännedomen om Södra Finlands kvartära nivåförändringar. S. 1—64. 16 fig. 1 plansch. 1 karta. Deutsches Referat: Beiträge zur Kenntniss der quartären Niveauschwankungen Süd-Finlands. 1896 .... —

*N:o 6. Sederholm, J. J. Über eine archäische Sedimentformation im südwestlichen Finland und ihre Bedeutung für die Erklärung der Entstehungsweise des Grundgebirges. S. 1—254. 97 Fig. 5 Taf. 2 Karten. 1897 .... —

*N:o 7. Ailio, Julius. Über Strandbildungen des Litorinameeres auf der Insel Mantsinsaari. S. 1—43. 8 Fig. 1898 .... —

*N:o 8. Andersson, Gunnar. Studier öfver Finlands torfmossar och fossila kvartärflora. S. 1—210. 21 fig. 4 tafl. Deutsches Referat: Studien über die Torfmoore und die fossile Quartärflora Finlands. 1898 .... —

N:o 9. Sederholm, J. J. Esquisse hypsométrique de la Finlande. P. 1—17. 1 carte. 1899 .... 100: —

N:o 10. Sederholm, J. J. Les dépôts quaternaires en Finlande. P. 1—28. 2 fig. 1 carte. 1899 .... 100: —

*N:o 11. Hackman, Victor. Neue Mitteilungen über das Ijolithmassiv in Kuusamo. S. 1—45. 7 Fig. 1 Taf. 2 Karten. 1899 .... —

*N:o 12. Ramsay, Wilhelm und Borgström, L. H. Der Meteorit von Bjurböle bei Borgå. S. 1—28. 20 Fig. 1902 .... —

*N:o 13. Frosterus, Benj. Bergbyggnaden i sydöstra Finland. S. 1—168. 18 fig. 8 tafl. 1 karta. Deutsches Referat: Der Gesteinsaufbau des südöstlichen Finland. 1902 .... —

*N:o 14. Borgström, Leon. H. Die Meteoriten von Hvittis und Marjalahti. S. 1—80. 8 Taf. 1903 .... —

N:o 15. Hackman, Victor. Die chemische Beschaffenheit von Eruptivgesteinen Finlands und der Halbinsel Kola im Lichte des neuen amerikanischen Systemes. S. 1—143. 3 Tab. 1905 .... 120: —

*N:o 16. Sundell, I. G. On the Cancrinite-Syenite from Kuolajärvi and a Related Dike Rock. P. 1—20. 1 plate. 1905 .... —

N:o 17. Fircks, Curt. On the Occurrence of Gold in Finnish Lapland. P. 1—35. Frontispiece. 15 fig. 1 map. 1906 .... 80: —

N:o 18. Tanner, V. Studier öfver kvartärsystemet i Fennoskandias nordliga delar. I. Till frågan om Ost-Finmarkens glaciation och nivåförändringar. S. 1—165. 23 fig. 6 tafl. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fenno-Scandia. I. Sur la glaciation et les changements de niveau du Finmark oriental. 1906 .... 200: —

---

*) Loppuunmyyty.
Out of print.

*N:o 19. Trüstedt, Otto. Die Erzlagerstätten von Pitkäranta am Ladoga-See. S. 1—333. 80 Fig. 19 Taf. 1 Karte. 1907 .... —

N:o 20. Tanner, V. Zur geologischen Geschichte des Kilpisjärvi-Sees in Lappland. S. 1—23. 3 Fig. 2 Taf. 1 Karte. 1907 .... 60: —

N:o 21. Tanner, V. Studier öfver kvartärsystemet i Fennoskandias nordliga delar. II. Nya bidrag till frågan om Finmarkens glaciation och nivåförändringar. S. 1—127. 10 fig. 6 tafl. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fenno-Scandia. II. Nouvelles recherches sur la glaciation et les changements de niveau du Finmark. 1907 .... 200: —

N:o 22. Borgström, L. H. Granitporphyr von Östersundom. S. 1—20. 3 Fig. 1 Taf. 1907 .... 60: —

*N:o 23. Sederholm, J. J. Om granit och gneis, deras uppkomst, uppträdande och utbredning inom urberget i Fennoskandia. S. 1—110. 11 fig. 8 tafl. 1 planteckn. 1 karta. English Summary of the Contents: On Granite and Gneiss, their Origin, Relations and Occurrence in the Pre-Cambrian Complex of Fenno-Scandia. 1907 .... —

*N:o 24. Sederholm, J. J. Les roches préquaternaires de la Fennoscandia. P. 1—39. 20 fig. 1 carte. 1910 .... —

N:o 25. Tanner, V. Über eine Gangformation von fossilienführendem Sandstein auf der Halbinsel Långbergsöda-Öjen im Kirchspiel Saltvik, Åland-Inseln. S. 1—13. 5 Fig. 2 Taf. 1911 .... 60: —

*N:o 26. Mäkinen, Eero. Bestimmung der Alkalien in Silikaten durch Aufschliessen mittelst Chlorkalzium. S. 1—8. 1911 .... —

N:o 27. Sederholm, J. J. Esquisse hypsométrique de la Finlande. P. 1—21. 5 fig. 1 carte. 1911 .... 80: —

*N:o 28. Sederholm, J. J. Les roches préquaternaires de la Finlande. P. 1—27. 1 carte. 1911 .... —

N:o 29. Sederholm, J. J. Les dépôts quaternaires de la Finlande. P. 1—23. 5 fig. 1 carte. 1911 .... 80: —

*N:o 30. Sederholm, J. J. Sur la géologie quaternaire et la géomorphologie de la Fennoscandia. P. 1—66. 13 fig. 6 cartes. 1911 ...... —

N:o 31. Hausen, H. Undersökning af porfyrblock från sydvästra Finlands glaciala aflagringar. S. 1—34. 9 fig. Deutsches Referat. 1912 .. 80: —

N:o 32. Hausen, H. Studier öfver de sydfinska ledblockens spridning i Ryssland, jämte en öfversikt af is-recessionens förlopp i Ostbaltikum. Preliminärt meddelande med tvenne kartor. S. 1—32. Deutsches Referat. 1912 .... 80: —

N:o 33. Wilkman, W. W. Kvartära nivåförändringar i östra Finland. S. 1—40. 9 fig. Deutsches Referat. 1912 .... 100: —

N:o 34. Borgström, L. H. Der Meteorit von St. Michel. S. 1—49. 1 Fig. 3 Taf. 1912 .... 100: —

N:o 35. Mäkinen, Eero. Die Granitpegmatite von Tammela in Finnland und ihre Minerale. S. 1—101. 23 Fig. 1913 .... 120: —

N:o 36. Eskola, Pentti. On Phenomena of Solution in Finnish Limestones and on Sandstone filling Cavities. P. 1—50. 15 fig. 1913 100: —

N:o 37. Sederholm, J. J. Weitere Mitteilungen über Bruchspalten mit besonderer Beziehung zur Geomorphologie von Fennoskandia. S. 1—66. 27 Fig. 1 Taf. 1913 .... 140: —

N:o 38. Tanner, V. Studier öfver kvartärsystemet i Fennoskandias nordliga delar. III. Om landisens rörelser och afsmältning i finska Lappland och angränsande trakter. S. 1—815. 139 fig. 16 tafl. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fennoscandia. III. Sur la progression et le cours de la récession du glacier continental dans la Laponie finlandaise et les régions environnantes. 1915 .... 600: —

N:o 39. Hackman, Victor. Der gemischte Gang von Tuutijärvi im nördlichen Finnland. S. 1—41. 9 Fig. 1914 .... 80: —

*N:o 40. Eskola, Pentti. On the Petrology of the Orijärvi region in Southwestern Finland. P. 1—277. 55 fig. 6 plates. 2 maps. 1914 —

N:o 41. Borgström, L. H. Die Skapolithlagerstätte von Laurinkari. S. 1—30. 7 Fig. 1913 .... 60: —

N:o 42. Hackman, Victor. Über Camptonitgänge im mittleren Finnland. S. 1—18. 3 Fig. 1914 .... 60: —

*) Loppuunmyyty.
Out of print.

N:o 43. Wilkman, W. W. Kaleviska bottenbildningar vid Mölönjärvi. S. 1—36. 11 fig. Résumé en français. 1915 .... 80: —

N:o 44. Eskola, Pentti. Om sambandet mellan kemisk och mineralogisk sammansättning hos Orijärvitraktens metamorfa bergarter. S. 1—145. 5 fig. English Summary of the Contents. 1915 .... 120: —

N:o 45. Ailio, Julius. Die geographische Entwicklung des Ladogasees in postglazialer Zeit und ihre Beziehung zur steinzeitlichen Besiedelung. S. 1—158. 51 Abbild. 2 Karten. 1915 .... 200: —

N:o 46. Laitakari, Aarne. Le gisement de calcaire cristallin de Kirmonniemi à Korpo en Finlande. P. 1—39. 14 fig. 1916 .... 80: —

N:o 47. Mäkinen, Eero. Översikt av de prekambriska bildningarna i mellersta Österbotten i Finland. S. 1—152. 25 fig. 1 karta. English Summary of the Contents. 1916 .... 200: —

N:o 48. Sederholm, J. J. On Synantetic Minerals and Related Phenomena (Reaction Rims, Corona Minerals, Kelyphite, Myrmekite, &c.). P. 1—148. 14 fig. in the text and 48 fig. on 8 plates. 1916 .... 240: —

N:o 49. Wilkman, W. W. Om en prekalevisk kvartsitformation i norra delen af Kuopio socken. S. 1—18. 7 fig. Résumé en français. 1916 .... 60: —

N:o 50. Sauramo, Matti. Geochronologische Studien über die spätglaziale Zeit in Südfinnland. S. 1—44. 5 Abbild. 4 Taf. 1918 .. 120: —

N:o 51. Laitakari, Aarne. Einige Albitepidotgesteine von Südfinnland. S. 1—13. 5 Abbild. 1918 .... 60: —

N:o 52. Brenner, Th. Über Theralit und Ijolit von Umptek auf der Halbinsel Kola. S. 1—30. 4 Fig. 1920 .... 60: —

N:o 53. Hackman, Victor. Einige kritische Bemerkungen zu Iddings' Classifikation der Eruptivgesteine. S. 1—21. 1920 .... 60: —

N:o 54. Laitakari, Aarne. Über die Petrographie und Mineralogie der Kalksteinlagerstätten von Parainen (Pargas). S. 1—113. 40 Abbild. 3 Taf. 1921 .... 120: —

N:o 55. Eskola, Pentti. On Volcanic Necks in Lake Jänisjärvi in Eastern Finland. P. 1—13. 1 fig. 1921 .... 60: —

N:o 56. Metzger, Adolf A. Th. Beiträge zur Paläontologie des nordbaltischen Silurs im Ålandsgebiet. S. 1—8. 3 Abbild. 1922 .... 60: —

*N:o 57. Väyrynen, Heikki. Petrologische Untersuchungen der granitodioritischen Gesteine Süd-Ostbothniens. S. 1—78. 20 Fig. 1 Karte. 1923 .... —

*N:o 58. Sederholm, J. J. On Migmatites and Associated Pre-Cambrian Rocks of Southwestern Finland. Part I. The Pellinge Region. P. 1—153. 64 fig. 8 plates. 1 map. 1923 .... —

N:o 59. Berghell, Hugo und Hackman, Victor. Über den Quartzit von Kallinkangas, seine Wellenfurchen und Trockenrisse. Nach hinterlassenen Aufzeichnungen von Hugo Berghell zusammengestellt und ergänzt von Victor Hackman. S. 1—19. 19 Fig. 1923 .... 60: —

N:o 60. Sauramo, Matti. Studies on the Quaternary Varve Sediments in Southern Finland. P. 1—164. 22 fig. in the text. 12 fig., 1 map and 2 diagrams on 10 plates. 1923 .... 200: —

N:o 61. Hackman, Victor. Der Pyroxen-Granodiorit von Kakskerta bei Åbo und seine Modifikationen. S. 1—23. 2 Fig. 1 Karte. 1923 .... 60: —

N:o 62. Wilkman, W. W. Tohmajärvi-konglomeratet och dess förhållande till kaleviska skifferformationen. S. 1—43. 15 fig. 1 karta. Deutsches Referat. 1923 .... 80: —

N:o 63. Hackman, Victor. Über einen Quartzsyenitporhyr von Saariselkä im finnischen Lappland. S. 1—10. 2 Fig. 1923 .... 60: —

N:o 64. Metzger, Adolf A. Th. Die jatulischen Bildungen von Suojärvi in Ostfinnland. S. 1—86. 38 Abbild. 1 Taf. 1 Karte. 1924 120: —

N:o 65. Saxén, Martti. Über die Petrologie des Otravaaragebietes im östlichen Finnland. S. 1—63. 13 Abbild. 5 Fig. auf 1 Taf. 2 Karten. 1923 .... 120: —

N:o 66. Ramsay, Wilhelm. On Relations between Crustal Movements and Variations of Sea-Level during the Late Quaternary Time, especially in Fennoscandia. P. 1—39. 10 fig. 1924 .... 80: —

N:o 67. Sauramo, Matti. Tracing of Glacial Boulders and its Application in Prospecting. P. 1—37. 12 fig. 1924 .... 80: —

N:o 68. Tanner, V. Jordskredet i Jaarila. S. 1—18. 2 fig. 10 bild. Résumé en français. 1924 .... 60: —

---

*) Loppuunmyyty.
Out of print.

N:o 69. A u e r, V ä i n ö. Die postglaziale Geschichte des Vanajavesisees. S. 1—132. 10 Fig. 10 Taf. 11 Beil. 1924 .... 200:—

N:o 70. S e d e r h o l m, J. J. The Average Composition of the Earth's Crust in Finland. P. 1—20. 1925 .... 80:—

N:o 71. W i l k m a n, W. W. Om diabasgångar i mellersta Finland. S. 1—35. 8 fig. 1 karta. Deutsches Referat. 1924 .... 80:—

N:o 72. H a c k m a n, V i c t o r. Das Gebiet der Alkaligesteine von Kuolajärvi in Nordfinnland. S. 1—62. 6 Fig. 1 Taf. 1925 .... 120:—

N:o 73. L a i t a k a r i, A a r n e. Über das jotnische Gebiet von Satakunta. S. 1—43. 14 Abbild. 1 Karte. 1925 .... 120:—

N:o 74. M e t z g e r, A d o l f A. Th. Die Kalksteinlagerstätten von Ruskeala in Ostfinnland. S. 1—24. 9 Abbild. 2 Karten. 1925 .... 80:—

N:o 75. F r o s t e r u s, B e n j. Ueber die kambrischen Sedimente der karelischen Landenge. S. 1—52. 1 Fig. 1925 .... 120:—

N:o 76. H a u s e n, H. Über die präquartäre Geologie des Petsamo-Gebietes am Eismeere. S. 1—100. 13 Fig. 2 Taf. 1926 .... 120:—

N:o 77. S e d e r h o l m, J. J. On Migmatites and Associated Pre-Cambrian Rocks of Southwestern Finland. Part II. The Region around the Barösundsfjärd W. of Helsingfors and Neighbouring Areas. P. 1—143. 57 fig. in the text and 44 fig. on 9 plates. 1 map. 1926 .. 240:—

N:o 78. V ä y r y n e n, H e i k k i. Geologische und petrographische Untersuchungen im Kainuugebiete. S. 1—127. 37 Fig. 2 Taf. 2 Karten. 1928 .... 160:—

N:o 79. H a c k m a n, V i c t o r. Studien über den Gesteinsaufbau der Kittilä-Lappmark. S. 1—105. 23 Fig. 2 Taf. 2 Karten. 1927 .... 160:—

N:o 80. S a u r a m o, M a t t i. Über die spätglazialen Niveauverschiebungen in Nordkarelien, Finnland. S. 1—41. 8 Fig. im Text. 11 Fig., 1 Karte und 1 Profildiagr. auf 7 Taf. 1928 .... 60:—

N:o 81. S a u r a m o, M a t t i and A u e r, V ä i n ö. On the Development of Lake Höytiäinen in Carelia and its Ancient Flora. P. 1—42. 20 fig. 4 plates. 1928 .... 60:—

N:o 82. L o k k a, L a u r i. Über Wiikit. S. 1—68. 12 Abbild. 1928 ...... 120:—

N:o 83. S e d e r h o l m, J. J. On Orbicular Granite, Spotted and Nodular Granites etc. and on the Rapakivi Texture. P. 1—105. 19 fig. in the text and 50 fig. on 16 plates. 1928 .... 200:—

N:o 84. S a u r a m o, M a t t i. Über das Verhältnis der Ose zum höchsten Strand. S. 1—17. 1928 .... 40:—

N:o 85. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, I. P. 1—88. 1 stéréogramme. 1929 .... 160:—

N:o 86. S a u r a m o, M a t t i. The Quaternary Geology of Finland. P. 1—110. 39 fig. in the text and 42 fig. on 25 plates. 1 map. 1929 .... 240:—

N:o 87. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, II. P. 1—175. 48 fig. 8 planches. 1929 ...... 280:—

N:o 88. T a n n e r, V. 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. S. 1—589. 84 fig. 4 tavl. 1 karta. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fennoscandie. IV. Sur les changements de niveau et les traits fondamentaux du développement géographique de la Finlande aux confins de l'océan Arctique après l'époque glaciaire et sur l'homotaxie du quaternaire marin en Fennoscandie. 1930 .... 600:—

N:o 89. W e g m a n, C. E. und K r a n k, E. H. Beiträge zur Kenntnis der Svecofenniden in Finnland. I. Übersicht über die Geologie des Felsgrundes im Küstengebiete zwischen Helsingfors und Onas. II. Petrologische Übersicht des Küstengebietes E von Helsingfors. S. 1—107. 4 Fig. 16 Taf. mit 32 Fig. 1 Übersichtskarte. 1931 ...... 160:—

N:o 90. H a u s e n, H. Geologie des Soanlahti-Gebietes im südlichen Karelien. Ein Beitrag zur Kenntnis der Stratigraphie und tektonischen Verhältnisse der Jatulformation. S. 1—105. 23 Fig. im Text und 12 Fig. auf 4 Taf. 1930 .... 200:—

N:o 91. Sederholm, J. J. Pre-Quaternary Rocks of Finland. Explanatory Notes to accompany a General Geological Map of Finland. P. 1—47. 40 fig. 1 map. 1930 .... 120: —
N:o 92. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, III. P. 1—140. 29 fig. 3 planches. 1930 ...... 200: —
N:o 93. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, IV. P. 1—68. 12 fig. 6 planches. 1931 ...... 160: —
N:o 94. Brenner, Thord. Mineraljordarternas fysikaliska egenskaper. S. 1—159. 22 fig. Deutsches Referat. 1931 .... 280: —
N:o 95. Sederholm, J. J. On the Sub-Bothnian Unconformity and on Archæan Rocks formed by Secular Weathering. P. 1—81. 62 fig. 1 map. 1931 .... 200: —
N:o 96. Mikkola, Erkki. On the Physiography and Late-Glacial Deposits in Northern Lapland. P. 1—88. 25 fig. 5 plates. 1932 .... 200: —
N:o 97. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, V. P. 1—77. 15 fig. 1932 .... 160: —
N:o 98. Sederholm, J. J. On the Geology of Fennoscandia. P. 1—30. 1 map. 1 table. 1932 .... 120: —
N:o 99. Tanner, V. The Problems of the Eskers. The Esker-like Gravel Ridge of Čahpatoaiv, Lapland. P. 1—13. 2 plates. 1 map. 1932 .. 60: —
N:o 100. Sederholm, J. J. Über die Bodenkonfiguration des Päijänne-Sees. S. 1—23. 3 Fig. 1 Karte. 1932 .... 200: —
N:o 101. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, VI. P. 1—118. 17 fig. 5 planches. 1933 .... 200: —
N:o 102. Wegmann, C. E., Kranck, E. H. et Sederholm, J. J. Compte rendu de la Réunion internationale pour l'étude du Précambrien et des vieilles chaînes de montagnes. P. 1—46. 1933 .... 120: —
N:o 103. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, VII. P. 1—48. 2 fig. 1933 .... 100: —
N:o 104. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, VIII. P. 1—156. 33 fig. 7 planches. 1934 .... 220: —
N:o 105. Lokka, Lauri. Neuere chemische Analysen von finnischen Gesteinen. S. 1—64. 1934 .... 120: —
N:o 106. Hackman, Victor. Das Rapakiwirandgebiet der Gegend von Lappeenranta (Willmanstrand). S. 1—82. 15 Fig. 2 Taf. 1 Analysentab. 1 Karte. 1934 .... 140: —
N:o 107. Sederholm, J. J. † On Migmatites and Associated Pre-Cambrian Rocks of Southwestern Finland. Part III. The Åland Islands. P. 1—68. 43 fig. 2 maps. 1934 .... 160: —
N:o 108. Laitakari, Aarne. Geologische Bibliographie Finnlands 1555—1933. S. 1—224. 1934 .... 200: —
N:o 109. Väyrynen, Heikki. Über die Mineralparagenesis der Kieserze in den Gebieten von Outokumpu und Polvijärvi. S. 1—24. 7 Fig. 1 Karte. 1935 .... 80: —
N:o 110. Saksela, Martti. Über den geologischen Bau Süd-Ostbothniens. S. 1—35. 11 Fig. 1 Titelbild. 1 Taf. 1 Karte. 1935 .... 100: —
N:o 111. Lokka, Lauri. Über den Chemismus der Minerale (Orthit, Biotit u. a.) eines Feldspatbruches in Kangasala, SW-Finnland. S. 1—39. 2 Abbild. 1 Taf. 1935 .... 100: —
N:o 112. Hackman, Victor. J. J. Sederholm. Biographic Notes and Bibliography. P. 1—29. With a vignette. 1935 .... 80: —
N:o 113. Sahama (Sahlstein), Th. G. Die Regelung von Quarz und Glimmer in den Gesteinen der finnisch-lappländischen Granulitformation. S. 1—110. 5 Fig. 80 Diagr. 3 Taf. 1936 .... 160: —
N:o 114. Haapala, Paavo. On Serpentine Rocks in Northern Karelia. P. 1—83. 21 fig. 2 maps. 1936 .... 120: —
N:o 115. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, IX. P. 1—505. 83 fig. 20 planches. 1936 .... 400: —

N:o 116. Väyrynen, Heikki. Petrologie des Nickelerzfeldes Kaulatunturi—Kammikivitunturi in Petsamo. S. 1—198. 71 Abbild. 36 Tab. 1 Karte. 1938 .... 200: —

N:o 117. Kilpi, Sampo. Das Sotkamo-Gebiet in spätglazialer Zeit. S. 1—118. 36 Abbild. 3 Beil. 1937 .... 200: —

N:o 118. Brander, Gunnar. Ein Interglazialfund bei Rouhiala in Südostfinnland. S. 1—76. 7 Fig. im Texte u. 7 Fig. auf 2 Taf. 1937 160: —

N:o 119. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, X. P. 1—170. 30 fig. 4 planches. 1937 ...... 200: —

N:o 120. Hyyppä, Esa. Post-Glacial Changes of Shore-Line in South Finland. P. 1—225. 57 fig. 21 tab. 2 append. 1937 .... 200: —

N:o 121. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XI. P. 1—166. 47 fig. 8 tab. 2 cartes. 1938 200: —

N:o 122. Hietanen, Anna. On the Petrology of Finnish Quartzites. P. 1—118. 20 fig. 8 plates. 3 maps. 1938 .... 200: —

N:o 123. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XII. P. 1—107. 20 fig. 3 planches. 1938 .... 200: —

N:o 124. Väyrynen, Heikki. On the Geology and Tectonics of the Outokumpu Ore Field and Region. P. 1—91. 11 fig. 2 maps. 1939 .... 200: —

N:o 125. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XIII. P. 1—119. 45 fig. 1 planche. 1939 .. 120: —

N:o 126. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XIV. P. 1—140. 60 fig. 4 planches. 1941 .... 150: —

N:o 127. Mölder, Karl. Studien über die Ökologie und Geologie der Bodendiatomeen in der Pojo-Bucht. P. 1—204. 7 Abbild. 1 Karte. 14 Diagr. 14 Tab. 1943 .... 200: —

N:o 128. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XV. P. 1—183. 43 fig. 2 planches. 1943 .. 200: —

N:o 129. Lokka, Lauri. Beiträge zur Kenntnis des Chemismus der finnischen Minerale Glimmer, Pyroxene, Granate, Epidote u. a. Silikatminerale sowie melnikowitähnliches Produkt und Shungit. S. 1—72. 48 Tab. 1943 .... 150: —

N:o 130. Hietanen, Anna. Über das Grundgebirge des Kalantigebietes im südwestlichen Finnland. S. 1—105. 55 Fig. 8 Tafeln. 1 Karte. 1943 .... 250: —

N:o 131. Okko, V. Moränenuntersuchungen im westlichen Nordfinnland. S. 1—46. 12 Abb. 4 Tab. 1944 .... 90: —

N:o 132. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XVI. P. 1—196. 41 diagr. 9 tabl. 3 cartes. 3 fig. 1944 .... 200: —

N:o 133. Rankama, Kalervo. On the Geochemistry of Tantalum. P. 1—78. 1 fig. 8 tabl. 1944 .... 150: —

N:o 134. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XVII. P. 1—91. 59 fig. 1 carte. 1944 ...... 150: —

N:o 135. Sahama, Th. G. Spurenelemente der Gesteine im südlichen Finnisch-Lappland. S. 1—86. 12 Fig. 29 Tab. 1945 .... 150: —

N:o 136. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XVIII. P. I—XXXVIII; 1—67. 3 diagr. 11 tabl. 2 cartes. 11 fig. 2 planches. 1945 .... 200: —

N:o 137. Rankama, Kalervo. On the Geochemical Differentiation in the Earth's Crust. P. 1—39. 18 tables. 1946 .... 100: —

N:o 138. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XIX. P. 1—120. 7 diagr. 13 tabl. 9 fig. 1 planche. 1946 .... 100: —

N:o 139. Brenner, Thord. Om mineraljordarternas hållfasthetsegenskaper. S. 1—77. 11 fig. Summary in English. 1946 .... 120: —

N:o 140. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XX. P. 1—302. 37 tabl. 103 fig. 7 planches. 2 cartes. 1947 .... 300: —

N:o 141. Simonen, Ahti. On the Petrochemistry of the Infracrustal Rocks in the Svecofennidic Territory of Southwestern Finland. P. 1—18. 7 tabl. 5 fig. 1948 .... 25: —

N:o 142. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XXI. P. 1—129. 45 fig. 1 planche. 4 tabl. 3 cartes 1948 200: —

N:o 143. Simonen, Ahti. On the Petrology of the Aulanko Area in Southwestern Finland. P. 1—66. 25 fig. 6 tabl. 1 map. 1948 .... 100: —

N:o 144. Suomen Geologisen Seuran julkaisuja — Meddelanden från Geologiska Sällskapet i Finland — Comptes Rendus de la Société géologique de Finlande, XXII. P. 1—165. 70 fig. 3 planches. 4 cartes. 1949. 200: —

N:o 145. Salmi, Martti. Physical and Chemical Peat Investigations on the Pinomäensuo Bog, SW. Finland. P. 1—31. 12 fig. 1 table. 1949 50: —