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Nitrate reduction in the subsoil

II. General description of boring profiles, and chemical investigations on the profile cores

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Summary

This paper deals with the procurement of undisturbed sample material from subsoil profiles taken up by 3 borings to a depth of about 20 meter. The profiles are described in general and storage of the profile samples is mentioned.

The chemical characteristics of the profiles have been investigated, especially the relationship between the nitrate and the ferrous iron content. Based on the chemical analyses, a relative evaluation of the nitrate reducing ability of the profiles is given.

Introduction

As a result of an earlier paper (Pedersen and Lind, 1976a) concerning the general problems of ground water quality in relation to the use of nitrogen fertilizer, it was considered how to solve some of the problems in practice. It was important first to prove the hypothesis that the content of ferrous iron in the subsoil act as an effective protection against nitrate pollution of the ground water.

We have concluded that the only way to elucidate the leaching of nitrate through a soil profile is to bore up this profile as intact as possible. Comprehensive analyses of the soil samples from such a bore profile may give a picture of the nitrate movement through the profile, its penetration depth at the time of boring, and they may also indicate the risks that nitrate, without hindrance, can be leached and possibly reach the ground water.

Lund, Adriano and Pratt (1974) have studied the nitrate concentrations in 8 meter deep soil cores in relation to soil profile characteristics.

They found that the nitrate content varied greatly within the first meter below the surface while changes below 1 meter were more gradual. They correlated the average nitrate content with the sand, coarse silt, fine silt and the clay fraction, further with the cation exchange capacity and with the field moisture.

Their conclusions were that the nitrate concentrations found in deep soil cores depended on characteristics of the soil profiles. In particular did the textural discontinuities influence nitrate concentrations through their effect on nitrification, denitrification and drainage volume. Therefore, profile characteristics have to be considered when selecting soils receiving large amounts of nitrogen whether through fertilization or through waste disposal.

A real complete survey of the leaching of nitrate within considerable areas requires a great number of deep, closely situated borings. Furthermore, the borings must be repeated at regular intervals during a number of years.

Selection of the boring sites

It was however predetermined that only 3 borings to a depth of about 20 meter were possible. Consequently, these 3 borings should be placed in 3 areas widely different regarding to soil chemical and soil physical properties. Furthermore, the characteristics of each area should be typical for a major part of the agricultural areas in Denmark.

The indications for the selection of the boring sites were as follows:

A typical agricultural area, which has been well fertilized with nitrogen during a number of years.

If the area has been drained, informations about the nitrate content of the drain water should be available.

Informations about the quality of the ground water, especially in respect to the nitrate content.

Extensive informations about the geological properties of the soil underground within a major area around the boring site.

At least one site on a clay soil area, and one on a sandy soil area.

At least one boring without nitrate in the ground water, and preferably one boring with nitrate in or near the ground water.

The selection of the 3 boring sites has required comprehensive preliminary investigations, first of all in the Well Record Department of the Geological Survey of Denmark. By means of this Department, it has been possible to get an outline of the geological characteristics within a given area to the depth of ordinary well borings. The Well Record Department contains a visual description of the soil, its texture and/or structure and possibly its colour, which may give an impression of the oxidation conditions of various soil depths. Reddish colours may indicate oxidized or weathered soil layers, and bluish and greyish colours often indicate reduced or unweathered soil layers.

Additional investigations in the field mainly comprising the collecting and analysing of samples from drainwater and ground water

borings, supplemented with informations from local waterworks resulted in a series of test borings to a depth of about 2 meter in order to ensure a reasonable high nitrate level in the top layers of the soil.

On the basis of the investigations described, the boring sites were placed as shown on the map in Figure 3 in the paper of *Pedersen and Lind* (1976a).

The boring technique

The borings were performed by the Danish Geotechnical Institute. The technique was briefly as follows: A casing was driven into the soil to protect the final boring. Subsequently the boring and sampling tube with a diameter of 7 cm was pressed into the soil inside the casing down to a suitable depth, usually from 15 cm to 45 cm for each sampling. The sampling tube was taken up and sealed at once. If there were any risks of water penetrating into the boring from the sides and the bottom, the casing was filled up with a 5 pct. bentonite suspension. The bentonite suspension is practically water-proof. This boring technique was used at Bramminge and Skælskør.

Core sections from one day's work were immediately transported to the laboratory and as soon as possible analysed for the most unstable chemical compounds: ammonium nitrogen, nitrate nitrogen, nitrite nitrogen and ferrous iron. The methods of analyses are described later in this paper.

Storage of the boring samples

Completely intact storing of these fresh soil samples is obviously not possible. Solely the uptake from the natural deposit alter the pressure of carbon dioxide at once. It has furthermore been necessary to transfer the samples into other containers from the boring tubes.

In the literatures some investigations on pretreatment and storage of soil samples are found, especially with regard to inorganic nitrogen analyses (*Nelson and Bremner*, 1972; *Gasser*, 1958; *Selmer-Olsen et al.*, 1971; *Storrier*, 1966).

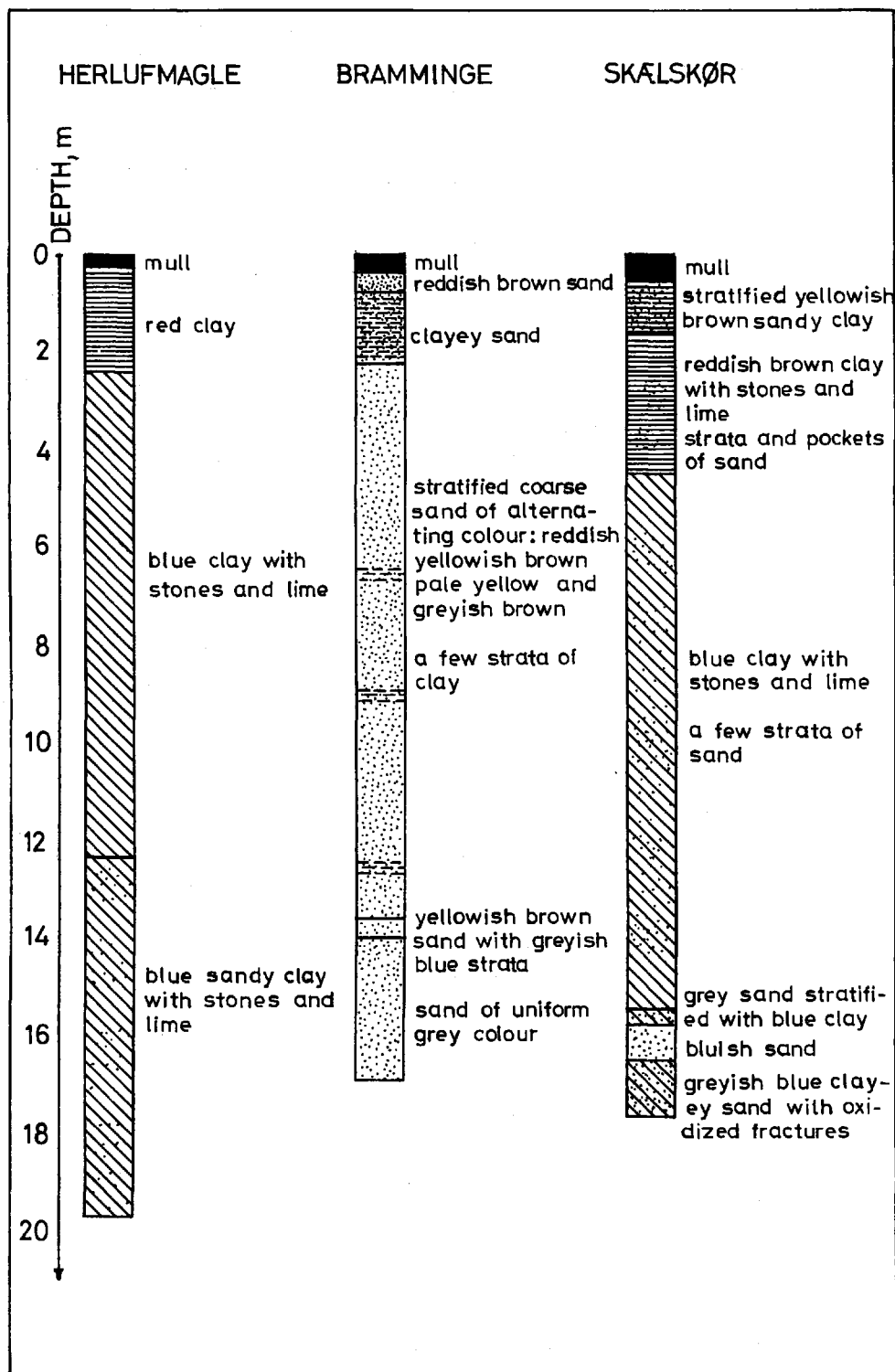


Fig. 1. Soil profiles from Herlufmagle (Sjælland), Bramminge (Jylland) and Skælskør (Sjælland).

These investigations mainly showed that storing of fresh soils in an air-tight container in a deep-freezer was the best chemical preservation method, and storing at low temperatures (0-5°C) the second-best. Since it was most important to avoid an oxidation of the soil (for the sake of the ferrous iron content) and to keep the soil physically intact, we have chosen the following storing method:

When the soil samples were pressed out of the boring tubes, they were directly transferred to polyethylene containers equipped with silicone greased lids. The atmosphere in the containers was replaced with argon until an oxygen content of 1 per cent or less is obtained. The containers were then stored at 5°C. The replacing with argon is repeated at regular intervals.

Descriptions of the borings

A visual description of the boring profiles is given in Figure 1.

In the description as well as in the following figures, the expression »oxidation limit« is used about the transition zone between oxidized and reduced soil layers, especially referring to the soil content of iron. The oxidation condition in the profiles appears in the colours of the soil: Reddish or brown colours indicate oxidized or weathered soil layers, and bluish or greyish colours indicate reduced or unweathered soil layers.

In the following sections, a short survey of general informations about the boring profiles is given. A more detailed chemical and physical description will be given later in this and in a following paper (Pedersen and Lind, 1975b).

1. Herlufmagle

This boring was carried out in an area of homogeneous clay with a high content of lime. Analyses of the drain water during 3 years have shown high levels of nitrate (aver. 25 mg/liter, Hansen and Pedersen, 1975). Analyses of drinking water from borings near the site showed no nitrate content.

The oxidation limit is situated in a depth of about 2.5 meter. Below this limit, the profile consists of plain blue clay with lime and stones.

It was not possible to estimate a ground water level in this profile, since no water penetrated into the boring. The reason for this is special physical conditions, which are described in details by Lind & Pedersen (1976b). The artesian ground water level in the borings near the site was situated in a depth of about 3 meter.

2. Bramminge

The Bramminge profile consists of inhomogeneous, predominantly sandy soil. This area is not drained. Among 4-5 borings from local water works within a radius of 4-500 meter, water from a single one contained traces of nitrate, while the others were free of nitrate.

The Bramminge profile consists of stratified sandy soil with very thin layers of silt and clay. The colour of the soil is changing very often, but below the oxidation limit in a depth of 13.5 meter the colour is plain grey.

The free ground water level was found in a depth of about 5 meter.

3. Skælskør

The Skælskør area is build up by an inhomogeneous, predominantly clayey soil. The area is not drained.

The profile is speckled and contains layers and pockets of sand. Below the oxidation limit in a depth of 4.5 meter there are pockets and crackles filled with oxidized material.

The artesian ground water level was found in a depth of about 3.5 meter.

The photos in Figures 2, 3 and 4 give an impression of characteristic sites down through the profiles:

Figure 2. Herlufmagle, uppermost a sample taken from above the oxidation limit (reddish brown colour), and lowest a sample taken from below the oxidation limit (bluish grey colour). Both samples furthermore contain a considerable number of small lime and some stones.

Figure 3. Bramminge. a: A sample from the upper layer with mixed reddish and greyish colours, depending on the oxidation condition of the soil. b: A sample from the middle of the profile showing the typical stratifications found in the major part of this profile. c: The sample, in which the oxidation limit was found as a relatively sharp limit in contrast to that of the two other profiles. d: Shows a cross section of a sample from the upper layers with strongly mixed colours.

Figure 4. Skælskør. a: A sample from the upper layer clearly showing the inhomogeneity of the profile above the oxidation limit. b: A sample from the middle of the profile below the oxidation limit; it is more uniformly grey-brown than is a., but still speckled with fine zones of more reddish sand. c: Shows the bottom of the profile consisting of plain greyish clayey sand.

Chemical analyses of the profile samples

Methods

$\text{NH}_4^+\text{-N}$ and $\text{NO}_3^-\text{-N}$: Extraction with 1 M KCl in 0.2 N HCl, distillation of NH_4^+ as NH_3 , reduction of NO_3^- with Devardas alloy, and repeated distillation of NH_3 .

$\text{NO}_2^-\text{-N}$: Modified Griess-Ilosvays method. After Barnes (1951).

Fe^{++} : The method used is founded partly on literature (Jackson (1958); Ignatieff (1941); Sørensen et al. 1971)), and partly on our own method studies; consequently the analytic methods is referred in details:

Reagents: 3 % AlCl_3 solution

0.5 % 1,10-phenanthroline solution in 96 % ethanol.

Colourizing reagent: 10 ml of the 0.5 % 1,10-phenanthroline solution is diluted to 250 ml with distilled water.

Standard solution: 0.0355 g $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ and 4 ml 5 % hydroxylamine hydrochloride are dissolved in 3 % AlCl_3 solution to 1 liter. This solution contains 10 ppm Fe^{++} . The required concentrations of Fe^{++} are prepared from this solution by dilution with 3 % AlCl_3 solution.

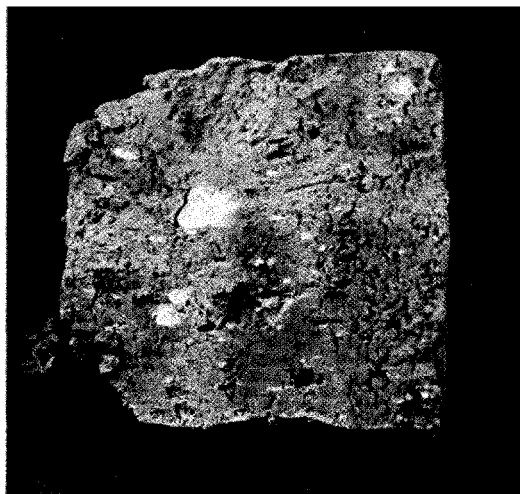
Extraction and measuring: 25 g fresh soil is shaken with 50 ml 3 % AlCl_3 solution in a shaking apparatus for 5 minutes and filtered with suction at once (only one sample is shaken at a time). As quickly as possible, 2 ml of the filtrate is taken out, 2 ml colourizing reagent is added, and the solution is allowed to react for 10 minutes. Then it is measured on a spectrophotometer at a wavelength of 250 nm. A blind sample of 3 % AlCl_3 without soil is also shaken and prepared as the filtrates.

Determinations of tot-N , Mn^{++} , CaCO_3 and humus, org. C were performed according to the methods in »Fælles arbejdsmetoder for jordbundsanalyser (1972)«. Concerning the humus analysis, it should be noticed that the measured amount is not corrected in the usual manner (Bondorff, 1946).

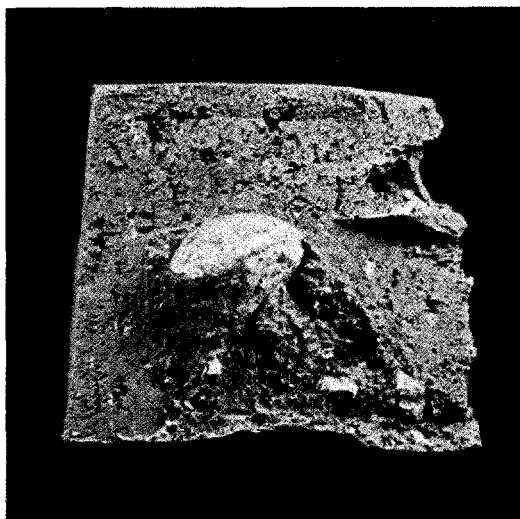
The described analysis of ferrous iron requires a more detailed explanation. Theoretically, any fraction of ferrous iron in the soil, ranging from total amount to the most easily soluble fraction, can be estimated by different empirical methods using extracting solutions of various types and concentrations. An easily soluble fraction of ferrous iron has been selected, partly because the reduction experiments in the laboratory are rather short lasting seen in relation to the time available in the nature (Lind & Pedersen, 1976). Moreover it is difficult to select an empirical method, when the conditions for the mobilization of the slighter soluble ferrous iron fractions are unknown.

A further complication in the ferrous iron analysis is that the ferrous iron is very sensitive to oxidation, especially during the extraction period, resulting in insoluble ferric compounds. However, an attempt with extraction in an inactive atmosphere inside a glove box did not give better results. Consequently, we have selected the short extraction period and a rapid filtering method.

The results of analyses for $\text{NO}_3^-\text{-N}$, $\text{NH}_4^+\text{-N}$ and Fe^{++} are shown in Figures 5, 6 and 7. The other chemical analyses are shown in Tables 1, 2 and 3.

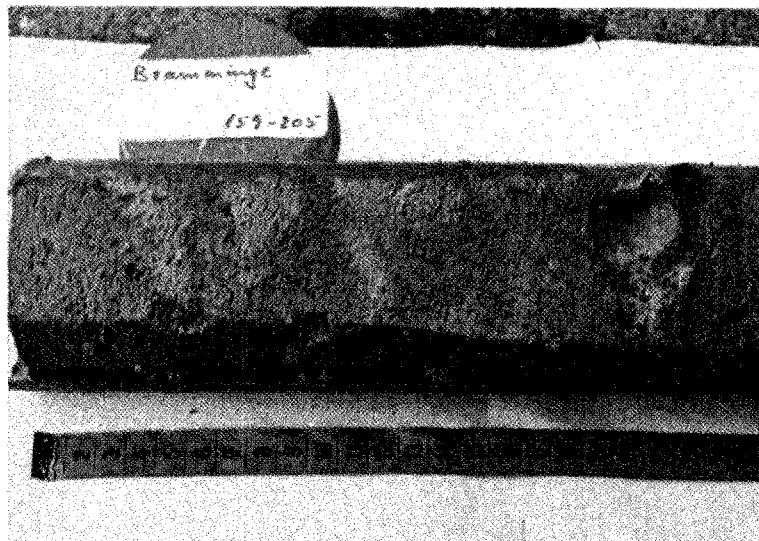


a

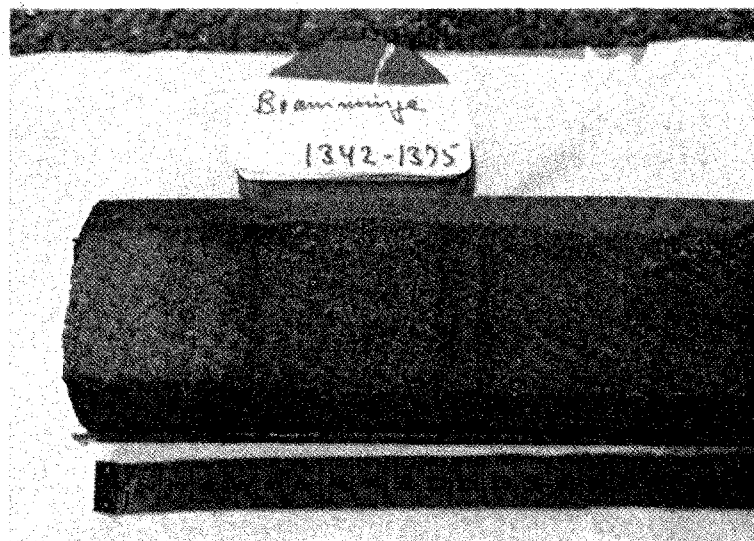


b

Fig. 2. Profile samples from Herlufmagle.
a. depth about 2.5 m.
b. depth about 12 m.



a



b

Fig. 3. Profile samples from Bramminge.
a. aver. depth 1.8 m.
b. aver. depth 9.6 m.

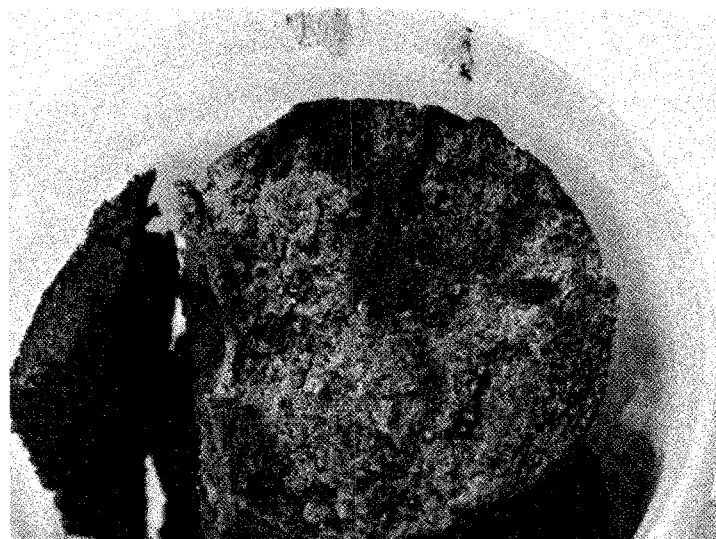
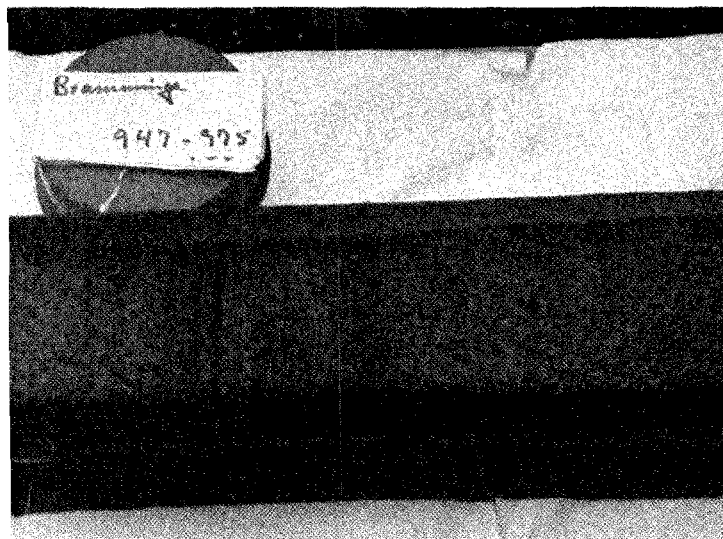
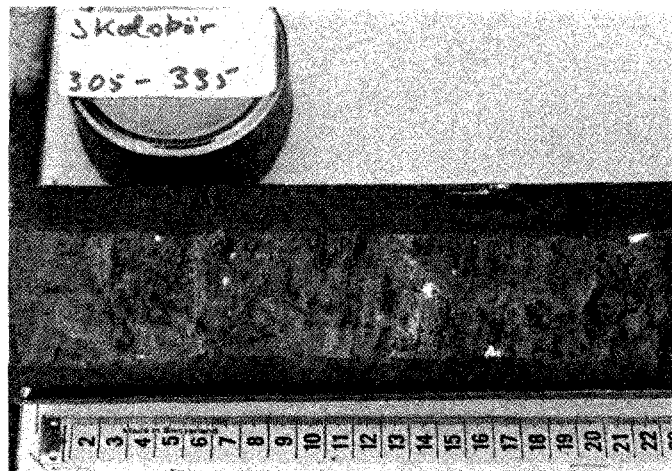
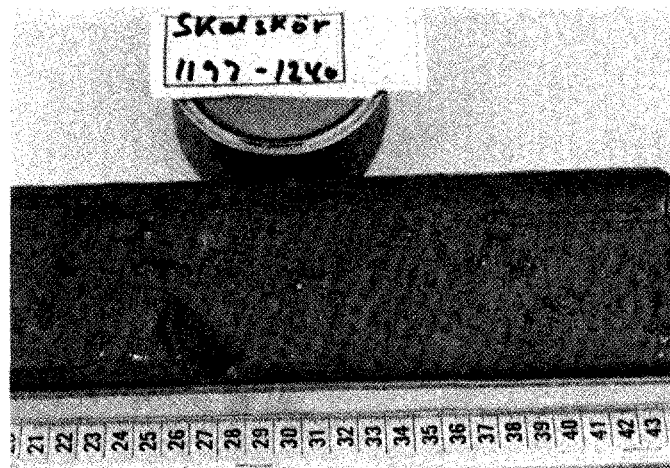


Fig. 3. Profile samples from Bramminge.
c. aver. depth. 13.6 m.
d. aver. depth 1.8 m (cross section of a).



a



b



c

Fig. 4. Profile samples from Skælskør.

a. aver. depth 3.2 m

b. aver. depth 11.2 m

c. aver. depth 16.1 m

HERLUFMAGLE

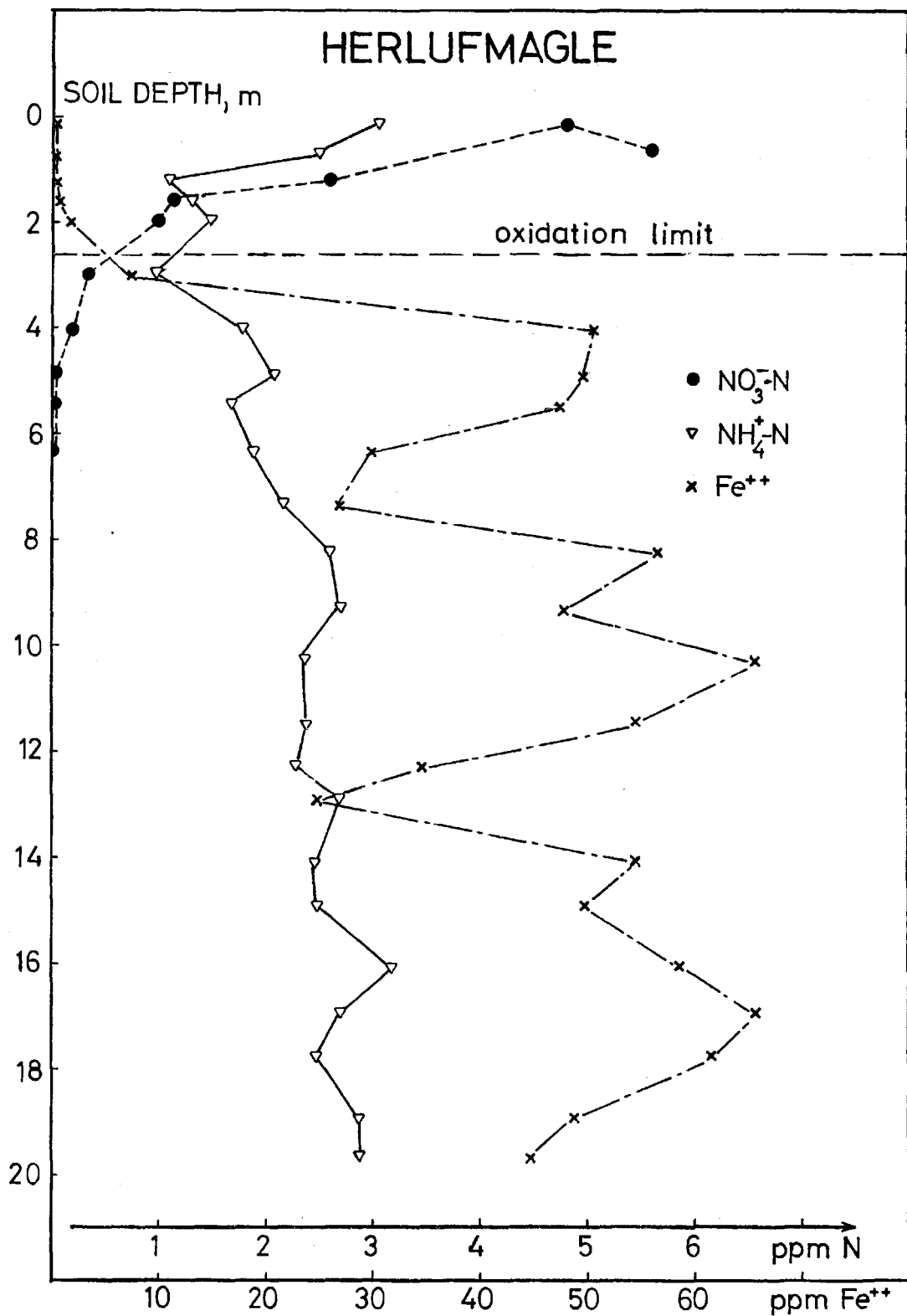


Fig. 5. The Herlufmagle profile. The variation of $\text{NO}_3^- \text{-N}$, $\text{NH}_4^+ \text{-N}$, and Fe^{++} content with the depth.

Table 1. The Herlufmagle profile. The pH value, and the contents of CaCO_3 , tot-N , $\text{NO}_2^- \text{-N}$, and Mn^{++}

No.	Aver. depth. m	pH (H_2O)	CaCO_3 %	org. C %	tot-N %	$\text{NO}_2^- \text{-N}$ ppm	Mn^{++} ppm
1	0.2	6.8	0.1	1.2	0.140	0.025	10.4
2	0.7	7.7	0.1	0.5	0.071	0.029	2.3
3	1.2	7.9	0.1	0.04	0.014	0	0.2
4	1.6	8.4	18.2	0.04	0.012	0.025	0.4
6	2.0	8.5	32.0	0.1	0.010	0.025	0.4
Oxidation limit							
9	3.0	8.6	29.2	0.2	0.012	0	4.8
12	4.1	8.8	36.3	0.2	0.010	0	4.3
15	4.9	8.8	43.2	0.2	0.010	0	2.2
17	5.5	8.8	43.4	0.2	0.010	0	3.1
19	6.4	8.8	40.7	0.2	0.010	0	3.1
23	7.3	8.8	36.1	0.2	0.011	0	4.6
27	8.2	8.8	31.9	0.2	0.014	0	3.4
30	9.3	8.7	30.9	0.2	0.014	0	3.7
34	10.2	8.7	40.3	0.1	0.010	0	4.9
37	11.4	8.7	39.0	0.1	0.009	0	3.1
41	12.3	8.7	41.1	0.1	0.010	0	3.9
43	12.9	8.8	42.3	0.2	0.011	0	4.0
44	14.1	8.8	29.5	0.2	0.012	0	4.0
47	14.9	8.9	28.0	0.2	0.012	0	3.3
51	16.1	8.9	28.7	0.3	0.012	0	3.9
53	16.9	8.7	30.4	0.3	0.012	0	3.5
55	17.7	8.8	27.8	0.3	0.012	0	4.1
56	18.9	8.8	27.6	0.3	0.012	0	4.0
59	19.7	8.8	28.3	0.2	0.012	0	4.3

BRAMMINGE

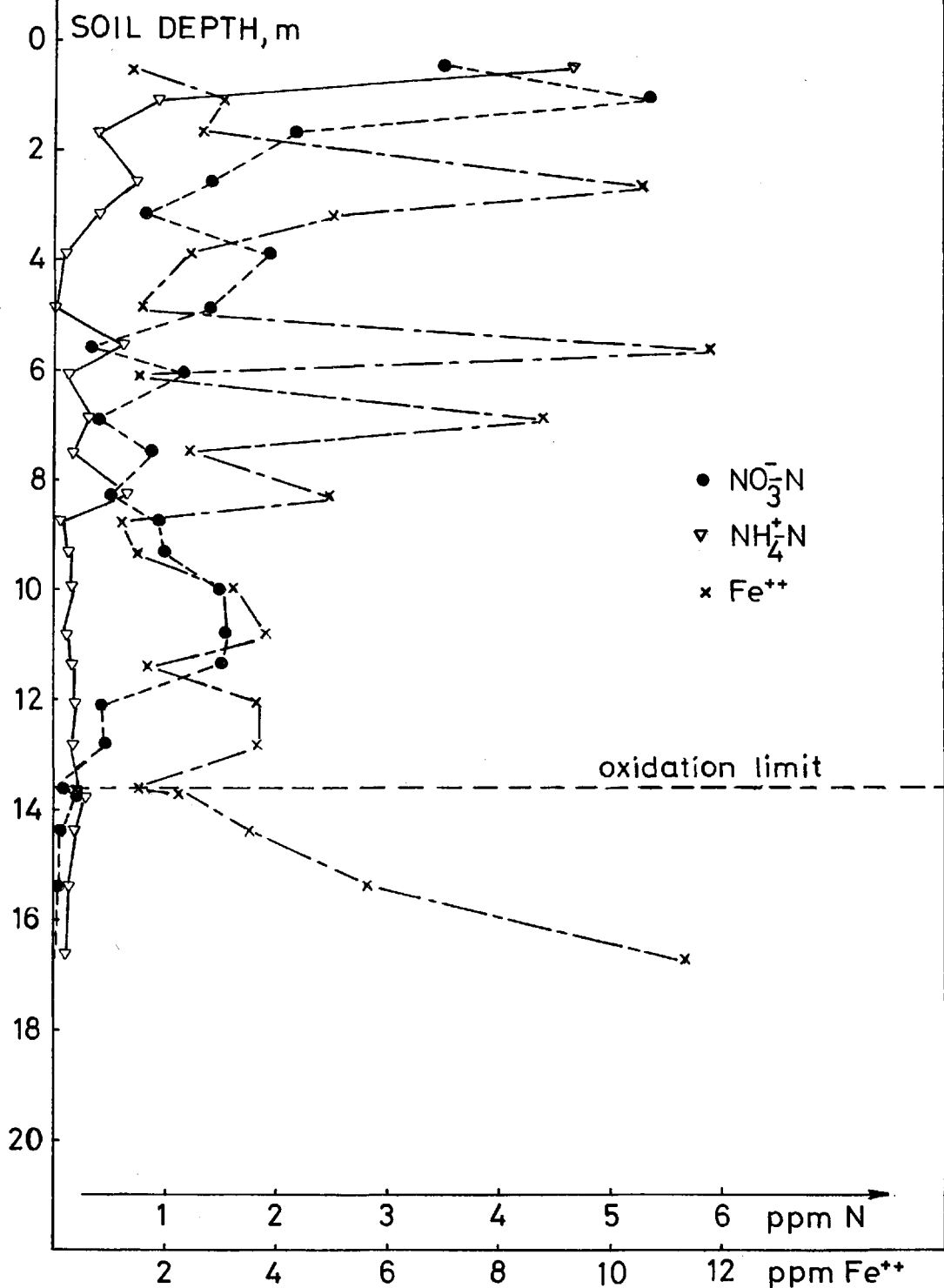


Fig. 6. The Bramminge profile. The variation of $\text{NO}_3^- \text{N}$, $\text{NH}_4^+ \text{N}$, and Fe^{++} content with the depth.

Table 2. The Bramminge profile. The pH value, and the contents of CaCO_3 , org. C, tot-N, NO_2^- -N, and Mn^{++}

No.	Aver. depth, m	pH (H_2O)	CaCO_3 %	org. C %	tot-N %	NO_2^- -N ppm	Mn^{++} ppm
3	0.4	6.1		2.9	0.031	0.061	0.2
7	1.1	4.5			0.010	0.042	0.3
11	1.8	4.7		0.7	0.008	0.038	0.3
15	2.6	5.0			0.005	0.069	0.4
18	3.1	5.2	0.04	0.5	0.001	0.042	0.4
23	3.9	4.9			0.002	0	0.3
28	4.8	5.2	0.06	0.2	<0.001	0.043	0.2
32	5.5	6.8			0.001	0	4.9
35	6.1	5.2	0.06	0.3	<0.001	0.068	2.7
39	6.9	5.5			<0.001	0.039	0.4
41	7.5	6.1		0.3	<0.001	0.063	0.4
44	8.2	6.0			<0.001	0.062	0.3
47	8.8	5.6		0.3	<0.001	0.043	0.2
49	9.3	6.4			<0.001	0.035	0.3
52	9.9	7.3	0.06	0.3	<0.001	0.067	0.2
56	10.8	7.3			<0.001	0.090	0.2
59	11.3	6.1		0.3	<0.001	0.051	0.3
62	12.1	7.4			<0.001	0.051	0.3
65	12.8	7.2			<0.001	0.018	0.2
68	13.2	8.2			<0.001		0
Oxidation limit							
69	13.5	6.7		0.3	0.001	0.040	0.3
70	13.7	7.6	0.08		<0.001	0.013	0.3
73	14.4	7.4			0.001	0.018	0.2
77	15.4	8.1	0.12		<0.001	0	0.2
81	16.7	7.1			<0.001	0	0.2

SKÆLSKØR

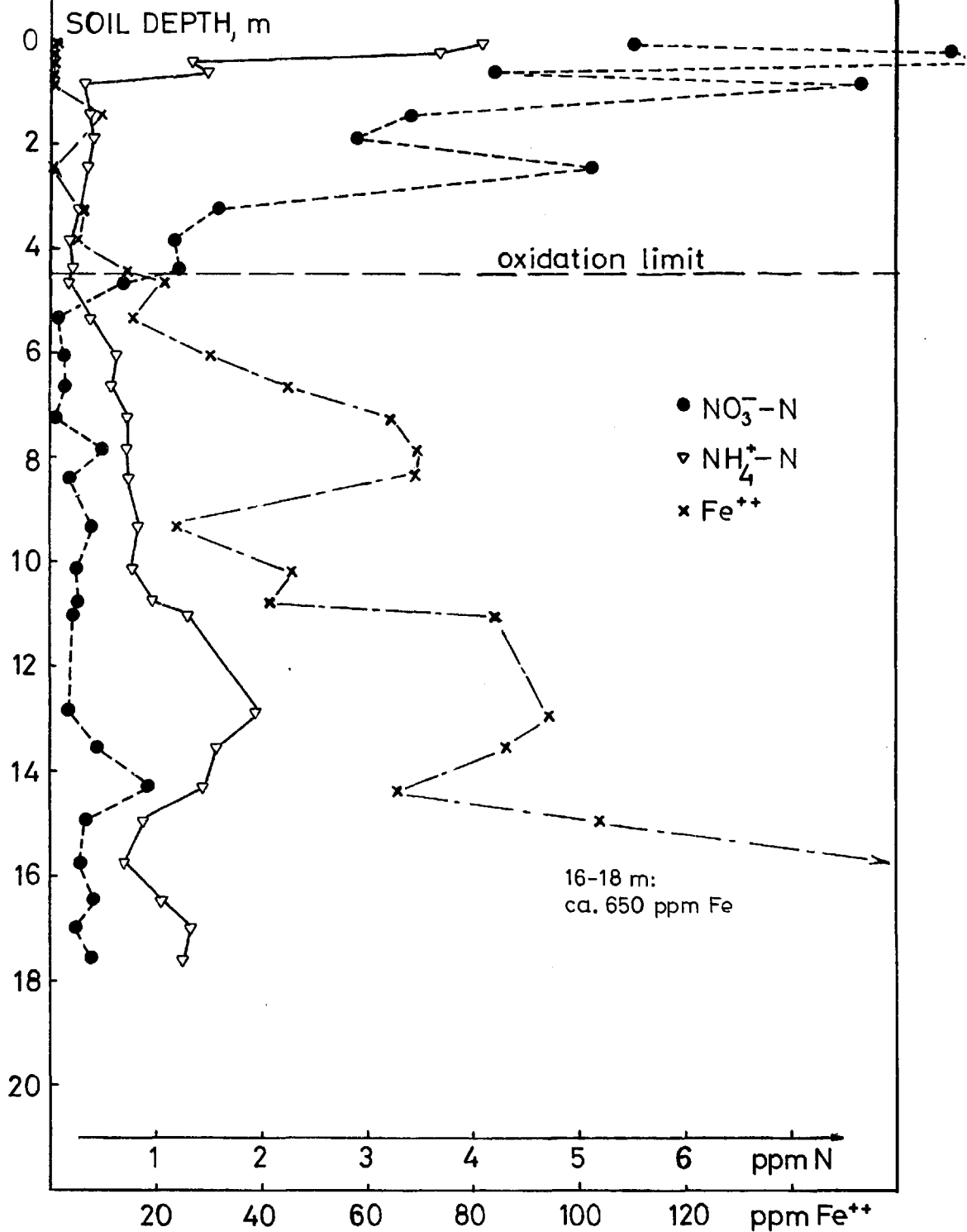


Fig. 7. The Skælskør profile. The variation of $\text{NO}_3^- - \text{N}$, $\text{NH}_4^+ - \text{N}$, and Fe^{++} content with the depth.

Table 3. The Skælskør profile. The pH value, and the contents of CaCO_3 , org. C, tot-N, NO_2^- -N, and Mn^{++}

No.	Aver. depth. m	pH (H_2O)	CaCO_3 %	org. C %	tot-N %	NO_2^- -N ppm	Mn^{++} ppm
1	0.1	7.0	2.1	1.2	0.163	0.085	2.0
3	0.5	6.9	0.6	0.3	0.042	0.154	1.9
6	0.9	7.8	3.1	0.2	0.024	0	0.2
9	1.4	8.2	16.6	0.1	0.019	0	0.4
12	1.9	8.2	14.2	0.2	0.018	0	0.7
15	2.4	8.0	0.2	0.2	0.031	0	0.4
18	3.3	8.5	18.4	0.1	0.010	0	0.2
22	3.9	8.6	15.1	0.1	0.010	0.022	1.1
25	4.4	8.6	20.3	0.2	0.012	0.009	2.1
Oxidation limit							
27	4.7	8.5	19.1	0.3	0.013	0	2.3
30	5.3	8.5	20.6	0.3	0.013	0	4.9
34	6.1	8.5	20.7	0.3	0.013	0	4.8
37	6.7	8.4	20.9	0.2	0.014	0.035	5.1
40	7.2	8.5	20.9	0.2	0.013	0	5.2
43	7.9	8.4	23.4	0.2	0.013	0.048	5.0
46	8.4	8.4	22.1	0.2	0.013	0.035	4.8
48	9.3	8.4	21.8	0.2	0.013	0	2.9
52	10.1	8.4	21.5	0.2	0.013	0.047	2.8
55	10.8	8.4	23.1	0.2	0.013	0.047	3.3
59	11.0	8.3	16.5	0.2	0.017	0.052	4.3
62	12.9	8.3	16.2	0.2	0.017	0.047	2.9
65	13.6	8.3	20.8	0.2	0.014	0.048	2.9
68	14.3	8.3	20.6	0.2	0.014	0	3.2
70	15.0	8.2	26.3	0.4	0.016	0.047	3.2
73	15.7	8.6	17.7	0.1	0.013	0.049	2.4
76	16.4	8.5	20.5	0.2	0.010	0.047	2.3
78	17.0	8.2	27.4	—	0.010	0.048	1.8
80	17.6	8.4	17.2	0.1	—	0.036	1.6

Discussion of the results of chemical analyses

Before discussing the results of the chemical analyses, it must be emphasized that all analyses have been performed with wet, unmixed soil samples, which might give rather fluctuating results. All results are, however, given on the basis of dry soil.

It should be noticed, that in Figure 6 the ferrous iron content is stated with another unit than in Figures 5 and 7.

Nitrate and ferrous iron contents

In the Herlufmagle profile (Figure 5), the nitrate content of the soil disappears 1-2 meter below the oxidation limit, while the ferrous iron content simultaneously increases strongly. This relationship between nitrate and ferrous iron is in fact what theoretically would be expected in a homogeneous soil (Pedersen & Lind, 1976a).

In the Bramminge profile (Figure 6), the ferrous iron content is fluctuating at a low level, and there is a low nitrate content throughout the profile to the oxidation limit. Below this limit, the nitrate disappears, while the ferrous iron content slowly increases. This differing picture of nitrate-ferrous iron relationship must be caused by the stratification and coarse texture of this soil profile.

In the Skælskør profile (Figure 7), the ferrous iron content follow the same pattern as in the Herlufmagle profile: A very small amount above the oxidation limit and below this a marked increase to a very high level, higher than at the corresponding depths of the Herlufmagle profile. The nitrate content decreases at the oxidation limit, but a small amount remains right through the profile. This is surprising in view of the very high level of ferrous iron, but this can be explained by the inhomogeneity of the profile (Pedersen & Lind, 1976b).

Nitrite content

The nitrite content varies considerably in the three profiles. In Herlufmagle, there is nitrite only above the oxidation limit. In Bramminge, nitrite is found in nearly all samples throughout the profile, and in the Skælskør profile it

is found in about half of the samples, mostly in the lower half of the profile. The described distribution must be an indication of where reduction processes are going on in the profiles, since nitrite is an intermediate in the reduction process (Lind and Pedersen, 1976). However, the nitrite content in the upper layers (the root zone) may originate from the nitrification process occurring in aerobic soil layers.

Ammonium content

An evaluation of the ammonium content of the three profiles gives: In all three profiles the ammonium content is decreasing during the first meter below the surface. In the Herlufmagle profile the ammonium content is at a constant level of 2-3 ppm N down through the remaining part of the profile. In the Bramminge profile the content is very low in the remaining part of the profile, from 0 til 0.5 ppm N. In the Skælskør profile the content is constantly 0.5-1.5 ppm N. When these data are compared, it seems as if the ammonium found throughout the profiles, especially in the clayey soil profiles, is a part of the cation exchange system in soil.

Other chemical analyses

In respect to the other chemical analyses, the Herlufmagle and the Skælskør profiles are very similar: A high content of calcium carbonate – highest in the Herlufmagle profile – and a high manganese content below the oxidation limit. The Bramminge profile contains substantially no calcium carbonate, only a little divalent manganese and only one tenth of the total nitrogen content found in the two other profiles.

Conclusion

It appears from the results of the chemical analyses and from the discussion, that the three profiles are quite different in chemical and physical aspects.

On the basis of the relationship between nitrate and ferrous iron content in the profiles, the ferrous iron content is considered as being the most important factor influencing the ni-

trate reduction. Consequently, a chemical evaluation of the three profiles involves that the Herlufmagle and the Skælskør profiles by far offer the best conditions for a chemical reduction of nitrate leaching from the root zone, and Bramminge should only have very little possibility for reducing nitrate caused by the low ferrous iron content in the main part of the profile.

However, the ability for the profiles to protect the ground water against nitrate pollution cannot be evaluated just by means of the chemical conditions without a physical description of the profiles. A combination of these two descriptions should elucidate how the soil water is moving down through a profile, and hence, if the nitrate moving with the soil water has the possibility to react with the ferrous iron in the profile. A detailed description of the physical conditions will be put forward in a following paper (Pedersen and Lind, 1976b).

Sammendrag

For at løse nogle af problemerne omkring udvaskning og reduktion af nitrat i jordlagene under rodzonen er 3 undergrundsprofiler boret op til ca. 20 meters dybde. Der gives en generel beskrivelse af profilerne, og de intakte prøver fra borerne er blevet underkastet kemiske analyser, specielt med henblik på sammenhængen mellem indhold af nitrat og ferro-jern.

De 3 profiler kan kort beskrives således:

1. *Herlufmagle* (Sydsjælland) er en meget homogen lerjordsprofil med et højt indhold af kalk. Profilen består af rødder til ca. 3,5 meters dybde, derunder er der ensfarvet blåler. Nitratindholdet falder kraftigt de første par meter, ved 4,5 meters dybde forsvinder det helt, mens indholdet af letopløseligt ferro-jern samtidig stiger kraftigt fra ca. 2 ppm til gennemsnitligt 50 ppm.

2. *Bramminge* (Sydvestjylland) er i hovedsagen en sandjordsprofil, men den er stærkt lagdelt og indeholder bl.a. tynde lag med ler og silt. Jordlagene er oxiderede (brune, røde og gule farver) indtil 13,5 meters dybde, derunder består profilen af ensfarvet, gråt sand. Der er små mæng-

der nitrat i profilen ned til 13,5 meters dybde (1-2 ppm N) og indholdet af ferro-jern svinger mellem 2 og 10 ppm ned til denne dybde. Herunder stiger det svagt, mens nitrattet helt forsvinder.

3. *Skælskør* (Sydsjælland) er i hovedsagen en lerjordsprofil, men meget inhomogen, idet den er gennemskåret af revner og sprækker, der er fyldt med grovere materiale. Der er rødder til 4,5 meters dybde, derunder består profilen af blåler, men i de omtalte sprækker og revner er materialet oxideret. Der er et lavt indhold af ferro-jern indtil ca. 4,5 meters dybde, derefter stiger det kraftigt til 50-100 ppm og helt op til ca. 600 ppm i bunden af profilen. Nitratindholdet falder i ca. 4,5 meters dybde fra ca. 5-6 ppm til ca. 0,5 ppm. Denne nitratmængde findes derefter ned gennem resten af profilen.

En kemisk vurdering af de 3 profiler viser, at Herlufmagle og Skælskør yder de bedste muligheder for en kemisk reduktion af nitrat, der udvaskes fra rodzonen, mens Bramminge på grund af det ringe indhold af ferro-jern kun har ringe mulighed for at reducere nitrat.

En jordprofils evne til at beskytte grundvandet mod forurening med nitrat kan imidlertid ikke vurderes alene ved dens kemiske egenskaber uden en fysisk beskrivelse af profilen. En kombination af disse to beskrivelser kan belyse, hvorledes jordvandet bevæger sig ned gennem en profil, og dermed om nedsivende nitrat har mulighed for at reagere med jordprofilens indhold af ferro-jern og blive omdannet til luftarter.

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