Agriculture Canada

Research Branch | Direction générale de la recherche

Technical Bulletin 1987-5E

The characterization of organic soils developed on peat and limnic materials in British Columbia

Canada

The characterization of organic soils developed on peat and limnic materials in British Columbia

M. LÉVESQUE[1], H. DINEL[1], T. LORD[2], and G. LORTIE[3]

1) Land Resource Research Centre, Research Branch, Agriculture Canada, Ottawa, Ontario
2) LRRI, Agriculture Canada, University of British Columbia, Vancouver, B.C.
3) Centre d'Etudes Nordiques, Université Laval, Québec

Technical Bulletin 1987-5E
LRRC Contribution No. 87-06

Research Branch
Agriculture Canada
1987

Copies of this publication are available from
M. Levesque
Land Resource Research Centre
Research Branch, Agriculture Canada
Ottawa, Ontario
K1A 0C6

Produced by Research Program Service

Cat. No. A54-8/1987-5E
ISBN 0-662-15324-3

cover
The dots on the map represent Agriculture Canada research establishments.

CONTENTS

LIST OF TABLES AND FIGURES

SUMMARY

Eight organic soils were sampled from two distinct landscapes and agricultural regions (Interior Plateau and Southwestern Coast) of British Columbia. The two contrasting groups of soils were described, characterized and compared with respect to their physical, chemical, botanical and micromorphological aspects to assess their origin, evolution, and changes under various use and mangement conditions.

The five soils from the Interior Plateau were developed on meadow fens underlain by sedimentary peat. Three of those soils were classified as Limnic Mesisols or Humisols, and two as Humic Mesisols. The three southern soils from the Delta area and Saltspring Island were also Limnic Mesisols or Humisols, but were developed from more acidic peat materials overlying aquatic or sedimentary peats of considerable depth.

Four distinctive peat types were identified in these soils: the grassy sedge peats and the mossy sedge peats associated with the meadow fens of the Interior Plateau, and the woody sedge peats and ericaceous sphagnum peats associated with the peat soils of the Southwestern Coast. Sedimentary peats were commonly found at various depths in the profile of all soils. The proximity of the limnic substratum to the surface was an important factor in fixing the properties and influencing the evolution of the soils. Thus, the Mesisols of the Interior Plateau had thicker organic overlays and subsided less than did the degraded Humisols of the Southwestern Coast which have developed a shallow compact humic layer over the limnic substratum.

The organic soils of the cooler Interior Plateau were generally less decomposed and less acidic than those of the Southwestern Coast. Also, the micromorphology of the former mesic peats was characterized by a discontinuous mass of polymorphic materials made of loosely aggregated fine substances. In contrast, the most decomposed woody sedge peats of the Southwestern Coast were dominated by a large proportion of compact fine substances of monomorphic nature. Dense massive fabrics, monomorphic fine substances and varied diatom populations were common features of the sedimentary peats. Detailed analyses on selected gyttja samples revealed that most diatoms genera found in these materials were developed in freshwaters.

The results of this study indicated that the type of cropping and management practiced on the peat soils of the Southwestern Coast were more conducive to the degradation and decomposition of peat than was the case for the cooler meadow fens of the Interior Plateau. This finding is in support of the notion that grass production is the most benign and natural cultural practice for organic soils.

RÉSUMÉ

Huit sols organiques ont été échantillonnés dans deux régions de la Colombie Britannique, différentes au point de vue agricole et géographique (le plateau intérieur et la région côtière du sud-ouest). Les deux groupes de sols ont été décrits, caractérisés et comparés des points de vue physique, chimique, botanique et micromorphologique afin d'en connaitre la nature, et d'établir leur comportement respectif sous des conditions différentes d'utilisation et de régie.

Les cinq sols du plateau intérieur se sont développés à partir de matériaux minérotrophiques avec des tourbes sédimentaires sous-jacentes. Trois de ces sols étaient des mésisols ou humisols limniques alors que les deux autres étaient des mésisols humiques. Les trois sols de la région du Delta et de Saltspring Island étaient aussi des mésisols ou humisols limniques mais originaient de matériaux plus acides et reposaient sur des tourbes sédimentaires de profondeur considérable.

Quatre types de tourbe distincts ont été identifiés dans ces matériaux tourbeux: les tourbes gramino-caricinées et les tourbes bryalo-caricinées, toutes deux associées aux tourbes minérotrophiques du plateau intérieur, et les tourbes ligno-caricinées et les tourbes à sphaignes éricales associées aux sols tourbeux de la région côtière. Les tourbes sédimentaires sous-jacentes étaient d'occurence commune à différentes profondeurs dans les profils des sols étudiés. La proximité des matériaux limniques de la surface du sol a été un facteur important dans la formation et l'évolution de ces sols. Ainsi, les mésisols du plateau intérieur avaient une couche de surface organique plus épaisse et ils étaient moins affaisés que les humisols dégradés de la région côtière, lesquels montraient une couche de surface mince, compacte et humifiée sur un substratum limnique.

Les sols organiques du plateau intérieur, soumis à des conditions climatiques plus rigoureuses, étaient généralement moins dégradés et moins acides que ceux de la région côtière. Aussi, la micromorphologie de leurs tourbes mésiques était caractérisée par une masse continue de matériaux polymorphiques constitués de substances fines faiblement liées entre elles. Par contre, les tourbes ligno-caricinées plus dégradées de la région côtière montraient une prédominance de substances fines compactes et de nature monomorphique. Les tourbes sédimentaires avaient en commun les traits micromorphologiques suivants: une "fabrique" dense et massive, des substances fines monomorphiques et des assemblages de diatomées de nature variée. L'analyse détaillée de diatomées de quelques matériaux limniques a révélé que la plupart des genres répertoriés se trouvaient normalement dans les milieux d'eau douce.

Les résultats de cette étude ont montré que le type de culture et les pratiques culturales utilisées sur les sols tourbeux de la région côtière ont dégradé ces sols plus intensément que ce ne fut le cas pour ceux du plateau intérieur. Ces résultats sont en accord avec la notion généralement retenue à savoir que les cultures herbagères sont les cultures les plus naturelles et les moins dégradantes à pratiquer sur les sols organiques.

INTRODUCTION

Peat is a common surface material in British Columbia, more so in the northeastern regions where climate and topography are especially favourable for peatland formation. In central and southern regions, organic soils occupy a smaller proportion of the total area but they are generally of more importance to commercial agriculture. This is particularly true in the Lower Fraser Valley and Vancouver Island where intensive cropping is practised which gives rise to problems related to subsidence, wind erosion, fertilization, weed and pest control (Maas 1972). In contrast, the organic soils associated with the fen meadows (or meadow fens when referring to peat landform) in the Interior Plateau are less intensively used but they still represent an important source of forage for the ranching industry. Also, because they are used almost exclusively for native hay and pasture, these soils are not so subject to the problem of subsidence as those used for horticulture which are drained, limed and fertilized. The farming of the meadow fens still encounters some difficulties related to the production of high quality feedstuff with balanced micronutrients levels, and the maintenance of good pasture (McLean and Tisdale 1960; McLean et al. 1963; van Ryswyk and Barrtree 1972; van Ryswyk et al. 1972, 1974; C.I.F.E.C. 1981). Some amendments such as fertilization, liming, minor element additions or drainage are still necessary.

The organic soils of these two landscapes (Interior Plateau and Southwestern Coast) are different and should be used and managed differently. It is important to know the nature of these soils, and to understand their characteristics and behaviour in order to use and manage them properly. Therefore, a number of typical organic soils, developed on peat and limnic materials were selected for study from the Interior Plateau and Southwestern Coast. The two contrasting groups of soils were characterized and compared with respect to their physical, chemical, botanical and micromorphological aspects in an attempt to assess their origin, evolution and changes under various use and management conditions.

MATERIALS AND METHODS

Eight organic soils were selected: five from the Interior Plateau rangelands, and three from the Southwestern Coast (two from Saltspring Island and one from the Lower Fraser Valley). Location and general description of the selected sites are given in Table 1. All eight sites were described and characterized chemically, but micromorphological and macro-fossil analyses were conducted on only five.

The soils were sampled using a modified Macaulay auger. Owing to some difficulties associated with the great variation in stratigraphy, a systematic sampling at every 25 or 50 cm was adopted. Thus, for the five soils from the Interior Plateau, three organic layers of 0-25, 25-50 and 50-100 cm were generally sampled; the top 25 cm layer of the underlying limnic material was also taken. For the three southwestern coastal soils, two layers (usually 0 to 25 and 25 to 50 cm) were samples mainly because of the shallow organic overlays. Kubiena boxes were used to collect undisturbed samples from the surface (10-15 cm) and the sub-surface (50-55 cm) layers.

A general characterization of the samples included rubbed fiber, ash, pH, C.E.C., C, N, P and S; elemental analyses were carried out also for total K, Ca, Mg, Al, Fe, Mn, Cu, Zn, and Sr, (Lévesque et al. 1980; Sheldrick 1984). In order to assess the acidifying capacity of the materials, which is based on the content and oxidation level of sulfur, pH measurement were made at the initial stage of the study and after a 1-year incubation period.

Particle-size fractions were obtained by wet seiving (Dinel and Lévesque 1976), and macrofossil analyses were carried out on these fractions. The quantitative macrofossil evaluation was based on the relative frequency of appearance of the various macrofossils (Dinel et al. 1983). In brief, it was carried out as follows: a suitable sub-sample was spread on a microscopic slide, and all pieces or fragments seen in the field of the stereomicroscope (25X) were recorded; no less than 500 counts were made for each sub-sample; the relative frequency of appearance was reported as percentages. The overall spectrum of macrofossils for a particular peat sample was calculated from a recording of about 2500 macrofossils (500 X 5 fractions).

Thin sections of selected samples (10 sections from 6 selected sites) were prepared using the acetone exchange technique whereby the water of the sample is exchanged with acetone which in turn is replaced by a polyester resin. The impregnation, polymerisation, curing of the sample as well as the mounting of the thin sections were carried out according to conventional methods (Lévesque et al. 1980). The thin sections were examined using a Wild--Leitz Ortholux II microscope at magnification ranging from 25X to 100X. The proportions of eleven micromorphological features, including voids, fine materials, tissue fragments, faunal mesofossils and diatoms were estimated by point counting at 63X magnification. For each thin section, 2000 counts were recorded, that is, 500 counts across the entire thin section area repeated 4 times; this provided a basis for statistical treatments. The terminology and the concepts upon which the micromorphological descriptions were based have been adapted or developed from the work by Bal (1973), Brewer and Pawluk (1975), Babel (1975 and 1978), Dinç et al. (1976) and Fox (1984).

Diatoms from selected gyttja materials from two sites (134M and SCM - see Table 1) were examinated. Diatom valves were cleaned in hot H_2O_2 for 20 minutes, washed in distilled water and then mounted in high refractive resin Naphrax (n_d=1.74). Counts of 250 valves and taxa distribution were carried out on 2 slides using a PhotoZeiss ll at 1250X.

RESULTS

1. General Description

The location, classification and general description of the eight selected organic soils are given in Table 1 and Plate 1. Of the five soils from the Interior Plateau, three were classified as Limnic Mesisols or Humisols, and the two others as Humic Mesisols. They were all developed on meadow fens underlain by sedimentary peat. The thickness of the organic overlay varied, ranging from a shallow 40 cm (134 Mile) to a deep 450 cm (Opax) with a total average depth of 410 cm (including the underlying sedimentary peat). The fen meadows were under improved pasture or hay production and were responding well to NPK fertilization.

The three southern soils from the Delta area and Saltspring Island were also classified as Limnic Mesisols or Humisols. They were developed from more acidic peat materials overlying aquatic or sedimentary peats of considerable depth. The two soils of Saltspring Island had a very compact humic surface layer while the shallow organic layers seemed to float over a deep (>300 cm) sedimentary peat.

2. Peat Properties and Elemental Content

(a) Interior Plateau

The pH values, ash contents and C:N ratios of the soils of the meadow fens reflected good minerotrophic conditions, indicating suitability for biological activities, and in turn, good conditions for plant growth (Table 2). The stage of decomposition shown by the rubbed fiber contents and the pyrophosphate indices (PPi) reflected the mesic to humicnature of these organic soils. The Opax soil was more acidic than the other soils and different in many respects owing to its sub-alpine situation, the greater depth of its organic layers and its limited use by farming.

The nature of the peat materials changed abruptly as the stratigraphy of the deposits passed from the organic overlays to the limnic layers. The contrast is seen mainly as a dramatic increase in the ash content, a decrease in the carbon and nitrogen contents and in the CEC of the underlying sedimentary peat layers.

The elemental content of these soils was generally quite variable. However, a general increase with depth could be noticed for most elements (Table 3). The increase was particularly marked for Ca, Fe and Mn, owing to the nature of the sedimentary layers. In contrast, the P contents decreased with depth; this could be taken as an indication of fertilizer usage on most of these fen meadows. The sulfur content (Table 4) varied from a low 0.24% (Bells Lake) to a high 1.79% (134-Mile), and usually increased with depth. Sulfur content could be an important feature of these soils since they can become more acid when drained, due to the oxidation of subsurface layers rich in S. It was found that the pH values of the soils decreased upon oxdidation (aerated incubation), irrespective of the amounts of S initially present in the samples (Table 4). There were some exceptions, namely the deeper samples (limnic) of the following sites: BL, JL and WL, which decreased in acidity. It seems that the large amounts of Ca associated with the presence of molluscan shells in these samples were responsible.

b) Southwestern Coast

The soils from the Delta and Saltspring Island were more acidic and generally more humified than the soils of the Interior Plateau fen meadows (Table 2). The surface sphagnum layer at the PM site contrasted with the other layers of these soils mostly on account of higher rubbed fiber content, and the lower pH and ash content. A common feature for the 3 soils is the marked increase in K content with depth (Table 3); increases in the other elements were also observed.

The sulfur content varied tremendously, ranging from a low 0.10 percent in the surface sphagnum layer of the PM site to a high 2.286 percent at the

H.K. Farm site (Table 4). The two sites from Saltspring Island showed the highest S contents, which may reflect a marine influence.

3. Botanical composition and peat types

The macrofossil analyses (Table 5) revealed that sedges were, by far, the dominant botanical components of the 5 selected sites followed by the aggregated fine materials. When the sphagnum material was dominant, it was associated with some ericale elements. Selected plant macrofossils used for the identification of the peat types are pictured in Plates 5, 6 and 7. Here is a detailed botanical description of the peat materials at the various sites.

(1) Bells Lake - A sedge-grass vegetation predominated along with a minor component of brown mosses (bryales). No ericales were present. The deeper layers became less sedgy as the bryale elements became more important. The aggregated fine materials consisting of up to 40% of the total material was an important component of the peat. It is noteworthy that roots and rhizomes were found mainly in the coarser fraction along with the branches and stems of mosses, while the tissue debris concentration was associated with the smaller fraction. In fact, the fragments which could be more easily identified were found in the coarser fractions.

Thus, the dominant peat type at the BL site was mossy sedge peat.

(2) 134 Mile - The shallow organic layer overlying sedimentary peat was mainly made of aggregated fine material in which diatomaceous earth was a major component. The small amount of tissue debris was concentrated in the smaller size fractions. There was a significant wood component in this peat material. The organic matrix of this sedimentary peat would be of the woody sedge type.

(3) Watch Lake - Sedges dominated along with a significant contribution from bryale mosses. A higher degree of decomposition of the peat at lower depths was clearly indicated by the decrease in identifiable tissue fragments and by an increase in tissue debris and aggregated fine materials. Indeed, the latter component increased markedly as the fraction size decreased.

(4) Pitt Meadow - The 10-25 cm layer was made almost exclusively of sphagnum material. There was a small contribution from ericales; *Ledum* sp. was the dominant ericale of the peat assemblage. In contrast with the other peat materials, the ericaceous sphagnum peat did not show any significant amounts of aggregated fine materials. The peat sublayer differed greatly from the surface layer in showing a dominant sedge composition with a small wood component. The abrupt change in the stratigraphy of the peat marked a change in the evolution of the peat deposit, passing from a fresh water marshland to an ericaceous sphagnum bog (Styan and Bustin 1983a). Judging from the proportions of the various components of the sublayer, the dominant woody sedge peat was degraded to a large extent.

(5) H.K. Farm - The shallow organic layer overlaid a substratum (25-50 cm) clearly identified as a sedimentary material rich in diatomaceous earth; the sedimentary material still contained some sedgy plant remains which were mainly recent rootlets of *Carex rostrata*. Numerous diatoms could be found in

the surface sedgy materials which were formed under the fresh water period of the marshland.

4. Micromorphological description of the peat materials

The following micromorphological descriptions are of two layers (10-15 cm and 50-55 cm) of the peat profiles; in a few cases, the depth of the sampling zone varied. It was not intended to include a description of the whole profile because the main interest rested on comparisons between surface layers and some layers at relatively shallow depths. For the descriptions, we have adopted concepts and terminologies from several workers, notably Barrat (1968), Bal (1973), Babel (1975), Dinç et al. (1976), Bullock et al. (1978) and Fox (1984).

The descriptions were made at a magnification of 30X for the overall description, and 80X when dealing with the pedological and special features. The essential micromorphological elements which can be used to differentiate and classify the nine peat materials are given in Table 6, while detailed descriptions appear in Appendix I.

a) Interior Plateau

The micromorphology of these soils varies with the degree of decomposition and, to a lesser extent, the type of peat material. With the disintegrated peats, the pleisto-plasmatic arrangement of aggregated tissue fragments becomes a discontinuous mass of polymorphic materials; upon further disintegration, it becomes a dense matrix of monomorphic fine materials. Here, abundant fungal and faunal remains are common. The sedimentary layers have dense and massive matrix of fine materials and usually contain, numerous diatoms and some dark pyrite grains.

b) Southwestern Coast

Aside from the S-matrix of PM_1, which is made of granular units, a diverse and abundant population of diatoms embedded in limnic materials characterizes the micromorphology of these soils. It is noteworthy that numerous diatoms are damaged. The difference between the sedimentary layers of the two groups of soils lies mainly on the bubble-like pores (regular and spherical) found in those of the Southwestern Coast.

5. Quantification of the Micromorphological Features

The proportions of eleven micromorphological features were measured by means of point counting from the thin sections of ten selected peat materials. A list of the features is given in Table 7. They were selected to reflect the most important properties of the peat materials, namely, porosity, density, degree of disintegration and decomposition, water movement, botanical composition, biodegradability, microfaunal and fungal activity (Lévesque and Dinel 1982).

The fine materials ("fine substances" according to Babel, 1975) occupy the largest portions of the thin section areas (Table 8). The sedimentary materials show large proportions of dispersed fine materials while the total areas of combined dispersed and aggregated fine materials varied irrespective of type of peat material, reaching the highest percentages in BL_1 and PM_2.

Not reported here are the coefficients of variation which were significantly lower (<20%) for the predominant features (item no. 1, 3, 4, 6 and 11). By their very nature these can be identified and quantified more easily.

a) Interior Plateau

Total voids ranged from 14.8 (BL_1) to 23.4% (BL_2); these two values happened to be in the surface and subsurface layers, respectively, of the same profile. The proportions of voids generally increased with depth and was greater in the organic peats than in sedimentary peats. The voids found inside the plant structures (Feature 2, Table 7) occupied less than 1.0% of the total area. This feature represents the spheric or rounded pores which were associated with the activity of putrefaction gases, mainly CH^4 and H_2S, and are reported for the 3 southern sedimentary materials. H_2S gas would be more important in brackish and marine sediments where higher amounts of S are found (Lowe and Bustin, 1985).

The sedimentary peats contrasted with the organic peat layers in their important and diversified diatom population, their dispersed fine materials, and their lower proportions of recognizable plant tissues or organs and aggregated fine materials. In addition, a significant proportion of their voids were associated with the bubble-like pores (putrefaction gas activity).

In the case of the deeper peat deposits such as those of sites BL and JL, the porosity and the recognizable plant macrofossils increased generally with depth, whereas both dispersed and aggregated fine materials decreased. This indicates a higher biological degradation at the surface. However, a large proportion of fine materials does not necessarily mean a lower total porosity. Total porosity may be greater, but it may be principally in the form of a large number of small pores.

b) Southwestern Coast

The acidic sphagnum peat, shows the highest proportions of well preserved plant organs or tissues, and the lowest proportions of fine materials. The PM_1 peat materials should have been highly biodegradabile. This is reflected by the population of fungal and faunal remains. This also applies to BL_2 materials. It is noteworthy that a significant number of plant organs still with their original contour were found in the sedimentary peats; however, these plant remains were mostly recent roots filling up the voids.

6. Diatom populations

The SCM and 134M sites were selected as representative of the Interior Plateau and Southwestern Coast respectively.

A total of 73 taxa including 25 diatom genera were found in 3 samples (two from site 134M and one from site SCM, Table 9 and Figures 8 and 9). Most genera developed in freshwaters. The 134M site had basophileous and eutrophic waters while SCM site probably had less favorable conditions with slightly brackish waters.

SCM - The diatom flora observed here is characterized by its lack of diversity, and by the abundance of some taxa such as Fragilaria brevistriata (59%), F. construens var. venter (15%) and F. construens (7%). These species are tychoplanktonic forms living in alkaline, shallow, well-lighted and rather nutrient-poor littoral environments. The Fragilaria spp. assemblage is frequently reported from the basal part of lacustrine cores, and interpreted as a tolerant and pioneer species (eg. Marciniak 1981; Lortie and Richard 1986). The assemblage noted here would have some value as biostratigraphic indicators, although the diatom flora is slightly more diversified, notably with Cymbella inaequalis, than is usually found in similar stratigraphic position. The same tolerant diatom group is also reported as a response to basin isolation from the sea (Kjemperud 1981; Stabell 1985). Very slightly brackish water conditions are possible, although neither halophilous F. virescens var. subsalina nor any marine to typically brackish diatoms have been found.

$134M_1$ - Although the Fragilaria group represents 40% of the total population with the dominant F. brevistriata and F. lapponica, the diatom flora is more diversified with some other important littoral forms, such as Achnanthes minutissima and Cocconeis placentula. The distinctive epiphytic Epithemia, Amphora, Cymbella and Gomphonema total 15% of the population. This assemblage is indicative of a shallow and quiet littoral environment in lakes or ponds with plenty of water plants for anchorage (support), and more basophilous and eutrophic waters than the SCM site. Species like A. pediculus and Mastoglia smithii var. lacustris suggest also water with moderate to high conductivity.

$134M_2$ - The diatom flora is slightly more diversified than that of $134M_1$, mainly because the genera Navicula is better represented. Although the sample was taken 50 cm deeper than $134M_1$, the assemblage is basically similar. Fragilaria construens var. venter is more common while Achnanthes minutissima is less common, but Fragilaria brevistriata, Amphora pediculus and Cocconeis placentula remain the dominant species. The littoral environment was consequently fairly comparable to the $134M_1$ one with possibly some minor differences in pH and trophic conditions. The presence of planktonic Melosira islandica subs. helvetica suggests some shift in deeper waters.

The diatom taxa are recognized as important environmental indicators (van Geel et al, 1983; Pals et al, 1980). The dominant taxa found at the selected sites are listed in Table 10 to show their relationship to pH, habitat and trophism.

DISCUSSION AND CONCLUSIONS

1. General Contrasting Features of the Selected Organic Soils

The eight organic soils selected from the two distinct agricultural regions of B.C. (Interior Plateau and Southwestern Coast) were Mesisols or Humisols, and all had limnic materials at various depths in their profiles. Indeed, the thickness of the organic overlays, that is, the proximity of the limnic substratum to the surface was the key factor which influenced the properties, governed the evolution and dictated the utilisation of the soils. The Mesisols of the Interior Plateau had thicker organic overlays and subsided less than did the degraded Humisols of the Southwestern Coast which have developed a relatively shallow compact humic layer over the limnic substratum.

The organic soils of the cooler Interior Plateau were generally less decomposed and less acidic than those of the Southwestern Coast. The ash content was variable and depended largely on the proximity of the mineral or limnic substratum, the deeper organic overlays having the lower values. The meadow fens of the Interior Plateau were less intensively used and received less fertilization; however, the elemental contents, with the possible exception of K, of these soils did not show any marked differences when compared to the Southwestern Coast soils which were more intensively used.

High S contents were reported for several soils, namely, two soils of the Southwestern Coasts; pyritic grains found in thin section prepared from them confirmed the fact. There is no doubt that the organic S fractions present there, which are potentially oxidizable (Lowe 1986), contributed to the acidification of these soils. Similar large accumulations of organic S in temperate brakish peats of the Lower Fraser Delta have been reported recently (Lowe and Bustin 1985). It is noteworthy that most of these soils registered an increase in acidity upon pre-incubation treatment irrespective of the total S present, indicating that all soils contained some reduced forms of S. Of special interest is the fact that the southwestern Coast soils contained large amounts of S in their compact humic surface layers, where the organic S could be readily oxidized.

Based on the proportions of the dominant botanical components revealed by the macrofossil analyses, four distinctive peat types were identified: the grassy sedge peats and the mossy sedge peats associated with the meadow fens of the Interior Plateau, and the woody sedge peats and ericaceous sphagnum peats associated with the peat soils of the Southwestern Coast. As mentioned earlier, sedimentary peats were commonly found in the profiles of all the soils, irrespective of the regions, and as such, these peat layers could not be used to contrast the various soils. Nonetheless, some differences among the sedimentary peats were noted and will be dealt with in a subsequent section.

The grassy and mossy sedge peats of the Interior Plateau showed a macrofossil assemblage dominated by a sedge component associated with grasses and bryale mosses. These peats were formed under minero- or mesotrophic conditions. Being quite prone to decomposition, these sedge peats decomposed and acquired the following properties: mesic in nature (20-25% RF), a relatively high ash content (10-15%), slightly acidic (5.5-6.5), a low C/N ratio (15-20), a high CEC (>199 meq./100 g), and relatively high base saturation with a Ca content of 2-3%.

From a micromphological point of view, these mesic peats were characterized by a discontinuous mass of polymorphic materials made of loosely aggregated fine substances, and associated with numerous tissue fragments. Grassy sedge peats showed herbaceous roots while mossy sedge peats contained stems and leaves of bryale mosses as accessory components. There was little or no plasmatic material. Some aggregation of the fine substances (20-30% of the total macrofossil contents) was noted, and it increased with depth (in the organic overlays).

In contrast, the most decomposed (high mesic and humic) woody sedge peats of the Southwestern Coast were dominated by a large proportion of compact fine substances embedding fragmented herbaceous plant tissues; intimate mixing through cultivation gave rise to monomorphic materials. Fortunately, a high degree of aggregation was found in these materials; numerous rootlets present in the materials seem to have been instrumental in achieving aggregation and improved porosity.

The ericaceous sphagnum peat, typified by the PM peat found in the Delta area, contrasted with the other peat types. It had a limited amount of aggregated fine substrances and was botanically dominated by sphagnum mosses and some ericales. It was highly fibrous and very acid, and had a high C/N ratio and a low ash content. Its micromorphology was characterized by an s-matrix of particulate materials and granular units with a coniatic internal arrangement. Here, the initial sedge marsh has developed toward an ericaceous sphagnum bog (Styan and Bustin 1983a); so, the conditions of the latter stage did not allow the development of a population of diatoms in this peat material. The recent agricultural utilization of the bog, however, encouraged a diverse and abundant fungal activity; the sclerotia are numerous but highly degraded.

The sedimentary peats we are dealing with here belong to: (1) gyttja, formed in fresh waters under near alkaline conditions of the Interior Plateau, and supporting rich fens; (2) gyttja, deposited in brackish to fresh waters of the lowlands (Fraser delta and Saltspring Island), underlying mesotrophic fens; and finally, (3) gyttja, developed in more acidic conditions, and underlying ericaceous sphagnum peats. It is worth mentioning that gyttja is a term accepted by the International Peat Society; nonetheless, the term carries some confusion (see Appendix II).

Thus, the sedimentary peats found in this study are of various types of gyttja, sharing common features such as a dense massive fabric, monomorphic fine substances embedding some plant debris which often are of algal origin, and the presence of numerous and varied populations of diatoms; black pyrite grains are usually present. The gyttja presumably associated with fresh-brackish waters (sites PM, SCM and HKF) is characterized by the bubble-like pores punctuating the dense matrix.

With respect to agricultural land use, the gyttja would provide good growth media when they are mixed with some organic overlays (Lévesque and Mathur 1985). Problems presented by the acidification of these soils when oxidized could be adequately taken care of by mixing them with the shell-rich layers that are usually present in the profile. At any rate, the preferred use for these soils in British Columbia is pasture or hay; this type of agricultural use is the least damaging to soil (Schothorst 1982); there is very little or no subsidence. Thus, acidification of the gyttja in the sublayers will take place very slowly and will have little effect on the crops.

2. Evolution and changes of peat soils under agricultural management with emphasis on the meadow fens

Humic substances, ash content, bulk density, C.E.C., proportions of fine materials and pyrophosphate index all increase when peat soils decompose through chemical and biological oxidation. These changes normally take place at a limited rate, but they can be accelerated when man uses the soil. This was confirmed here by the higher pyrophosphate index, C.E.C. and fine fraction found in the surface organic layers as compared to the organic sub-layers. The Humisols of the Southwestern Coast were more degraded under intensive utilisation than were the Mesisols of the Interior Plateau which are used for grazing and hay-making. However, as it is difficult to assess the effect of agricultural use, or specific cultural practices, on peats solely by means of conventional chemical and physical measurements, the discussion on peat evolution will be mostly directed to changes shown by micromorphological features.

In the micromorphological features of the Bells Lake profile the higher decomposition of the surface layer compared to the subsurface (BL_1 to BL_2) is indicated by a higher proportion of both fine materials and highly decomposed tissue remains, and a lower proportion of voids in the BL_1 (Table 8 & 11). This can also be said of the Jones Lake and Pitt Meadow sites, although in the latter cases, the presence of diatomaceous earth makes it less obvious. The S-matrix of the surface peat layers is characterized by the predominance of monomorphic fine materials evolved from tissue fragments which are showing pleistoplasmatic internal arrangements. Assuming a prolongation of the degradation process as was the case for the Humisols of the Southwestern Coast, a dense massive matrix of fine plasmic substances will be obtained. Similar results were obtained for cultivated peats under intensive vegetable productions (Lévesque et al. 1982, Parent et al. 1983).

Based on studies of soil microfabrics, Hammond and Collins (1983) reported on peat transformations having resulted from a long period of reclamation and cultivation. They noted that a moulding process had transformed humiskel components of these soils (under permanent pasture) into humicol materials through the intimate mixing of skeleton grains and plasmic materials. Thus, the initial lack of structure and the polymorphic nature of the peat soils were turned into a stable, homogenised, monomorphic mullicol- O-fabric.

In the present study, biological activities, indicated by the presence of fungal and faunal remains, have been observed irrespective of kind of material and depth. Dinç et al. (1976) found that fungal remains decreased with depth but mentioned that more recent fungal activities were responsible for the higher concentrations in the surface layers.

In most British Columbia soils, the fungal remains were usually quite abundant, although they were more so in the subsurface layers. The fungal remains were often found associated with opaque o-plasma, within or around tissue debris. This is often taken as an indication of unfavourable environmental peat evolution (Dinç et al. 1976). Under these conditions, faunal remains are usually found in limited quantities; by contrast, numerous faunal droppings and abundant fungal remains were recorded in the peat materials of both BL_1 and BL_2.

In many cases, fungal spores, including sclerotia, were found with no sign of fungal mycelium or hyphae. This paradox could be associated with certain types of organic materials, organisms or environmental conditions. Thus, the absence of mycelia seems to coincide with very low fungal activities in bare (presumably dry) peats (Latter et al. 1967, Middledorp 1982).

Babel (1975) ascribed the following pedological features to peats not having been yet exposed to secondary decomposition processes initiated by drainage: a relatively high proportion of recognizable plant residues, the presence of fungal hyphae and spores, some humus substances precipitated in and between still-intact structures, and some faunal droppings. These features can be observed in the present peats, in spite of the fact that we are dealing with the peats having been exposed to oxidative and biological decomposition processes following the partial drainage of the surface and subsurface peat layers. So it is probable that, in the peat soils of the British Columbia meadow fens, the "maturing" process would have evolved very slowly; these soils are still far from the moder or mull-like formations observed in organic soils intensively cultivated for vegetable productions. The latter humus types are found in the surface layers of the HKF and SCM profiles.

Thus, unlike most peat soils of the Southwestern Coast, the pedological features of the peat soils from the Interior Plateau are weakly developed. No doubt, this is principally due to the particular type of farming practiced on the meadow fens. This finding is in support of the notion that grass production, either through hay-making or pasture, is the most benign and natural cultural practice for organic soils.

ACKNOWLEDGEMENTS

The authors gratefully thank J. Desjardins (LRRI) for the chemical determinations.

REFERENCES

Babel, U. 1975. Micromorphology of soil organic matter. In Soil components, vol. 1. I.E. Gieseking (ed.). Springer-Verlag, New York, pp.369-473.

Babel, U. 1978. Some aspects of fabric dynamics in a moder profile (investigated by the application of a graphical scheme). In Soil micromorphology. M. Delgado (ed.). Proc. 5th Int. Working Meeting Soil Micromorphology. Spain. 1978.

Bal, L. 1973. Micromorphological analysis of soils; Lower levels in the organization of organic materials. Soil Survey Paper 6. Soil Surv. Inst. Wageningen, The Netherlands.

Barrat, B.C. 1968. A revised classification and nomenclature of microscopic soil materials with particular reference to organic components. Geoderma 2:257-271.

Barry, T.A. 1980. A summary of peat and subsoil surveys of Bord Na Mona mires, industrial cutaway. 1963-69. Proc. 6th Int. Peat Congr., Duluth, U.S.A. 1980. 1-6.

Brewer, R and S. Pawluk. 1975. Investigations of some soils developed in hummocks of the Canadian Sub-Arctic and Southern Arctic regions. 1. Morphology and micromorphology. Can. J. Soil Sci. 55:301-319.

Bullock, P., U. Babel, C. Jeanson and A. Jongerius. 1978. The subgroup on organic matter (A progress report). p.1417-1428. In M. Delgado (ed.). Soil micromorphology. Vol. 2. Proc. 5th Int. Work Meet. Soil Micromorphol., Granada, Spain, 1977.

Central Interior Forage Extension Committee. 1981. Management and improvement of organic Wetlands in the Interior of British Columbia. Ministry of Agr. and Food, British Columbia. Bull. 81-3. 12p.

Cook, L.L., and S.A. Whipple. 1982. The distribution of edaphic diatoms along environmental gradients of a Louisiana salt marsh. J. Phycol. 18:64-71.

Dinç, U., R. Miedema, L. Bal and L.J. Pons. 1976. Morphological and physico-chemical aspects of three soils developed in the Netherlands and their classification. Neth. J. Agric. Sci. 24:247-265.

Dinel, H. and M. Lévesque. 1976. Une technique simple pour l'analyse granulométrique de la tourbe en milieu aqueux. Can. J. Soil Sci. 56:119-120.

Dinel, H., A. Larouche et M. Lévesque. 1983. Evaluation de deux méthodes de quantification des macrofossiles dans les matériaux tourbeux. Naturaliste canadien 110(4): 429-434.

Fox, C.A. 1984. A morphometric system for describing the micromorphology of organic soils and organic layers. Can. J. Soil Sci. 64:495-503.

Hammond, R.F., and V.F. Collins. 1983. Microfabrics of a sphagnofibrist and related changes resulting from soil amelioration. p.689-697. In P. Bullock and C.P. Murphy (eds.). Soil micromorphology. Proc. 6th. Int. Meet. London. 1981.

Kjemperud, A. 1981. Diatom changes in sediments of basins possessing marine/lacustrine transitions. In Frosta, North-Trondelag, Norway. Boreas 10:27-38.

Kubiena, W. 1953. The soils of Europe. Thomas Murby, London.

Latter, P.M., J.B. Cragg and O.W. Heal. 1967. Comparative studies on the microbiology of four moorland soils in the northern Pennines. J. Ecol., 55:445-464.

Lévesque, M.P., H. Morita, M. Schnitzer, and S.P. Mathur. 1980. The physical, chemical and morphological features of some Québec and Ontario peats. Agricult. Canada Monograph (L.R.R.I.62), Ottawa. 70 p.

Lévesque, M.P., S.P. Mathur, and P.J.H. Richard. 1982. A study of physical and chemical changes in a cultivated organic soil based on palynological synchronization of subsurface layers. Naturaliste Can. (Rev. Ecol. Syst.) 109:181-187.

Lévesque, M.P. and H. Dinel. 1982. Some morphological and chemical aspects of peats applied to the characterization of Histosols. Soil Sci. 133:324-336.

Lévesque, M.P. and S.P. Mathur. 1985. Reclaimation of cutover peatlands. In Symposium 85, A symposium on Peat and Peatlands, edited by T.E. Tibbett and J.O. Sheppard. Rivière-du-Loup, Que. 1985. pp. 264-278.

Lopotko, M.Z., G.A. Evdokimova and F.A. Puntus. 1980. Sapropels in Byelorussia: their types and possible applications. Proc. 6th Int. peat Congr. Duluth, U.S.A. 1980. 597-599.

Lortie, G. and Richard, P.J.H. 1986. Late-glacial diatom and pollen stratigraphy from Lake Boucanée, southeastern Québec, Canada. In Ricard, M. (ed). 8th. International Diatom Symposium, proceedings, (in press).

Lowe, L.E. 1986. Application of a sequential extraction procedure to the determination of the distribution of sulphur forms in selected peat materials. Can. J. Soil Sci. 66:337-345.

Lowe, L.E. and R.M. Bustin. 1985. Distribution of sulphur forms in six facies of peats in the Fraser River Delta. Can. J. Soil Sci. 65:531-541.

Marciniak, B. 1981. Late-glacial diatom phase in Western Pomerania. Acta Geologica Polonica. 31:147-167.

Markowski, S.D. 1976. Gyttja deposits at Pomerania region. Proc. 5th Int. Peat Congr. Poznan, Pol. (1976). 2:127-141.

Maas, E.F. 1972. The organic soils of Vancouver Island. Agriculture Canada, Sidney, B.C. Contrib. No.231. 135p.

McLean, A. and E.W. Tisdale. 1960. Chemical compositions of native forage plants in British Columbia in relation to grazing practices. Can. J. Plant Sci. 40:405-423.

McLean, A., H.H. Nicholson and A.L. van Ryswyk. 1963. Growth, productivity and chemical composition of a sub-alpine meadow in Interior British Columbia. J. Range Manag. 16:235-240.

Middeldorp, A.A. 1982. Pollen concentration as a basis for indirect dating and quantifying net organic and fungal production in a peat bog ecosystem. Rev. Paleobot. and Palyn. 37:225-282.

Nilsson, T. 1968. Notes de cours de paléoécologie - Textes et illustrations (en suédois). Université de Lunds. 238p., 63 planches.

Pals, J.P., B. Van Geel and A. Delfos. 1980. Paleoecological studies in the Klokkeweel bog near Hoogkarspel (Prov. of Noord-Holland). Rev. Paleobot. Palyn. 30:371-418.

Parent, L-E., F.J. Pauzé et G.-A. Bourbeau. 1983. Morphologie d'un mésisol fibrique sous forêt décidue. Naturaliste Can. 110:435-446.

Schothorst, C.J. 1982. Drainage and behaviour of peat soils. In Proc. of the symposium on peatlands below sea level. H. De Bakker and M.W. van den Berg (eds.). ILRI Publication 30:130-163.

Sheldrick, B.H. 1984. Analytical methods manual 1984. Res. Branch, Agriculture Canada. LRRI Contrib. No. 84-30.

Stabell, B. 1985. The development and succession of taxa within the diatom genus Fragilaria Lyngbye as a response to basin isolation from the sea. Boreas, 14:273-286.

Styan, W.B. and R.M. Bustin. 1983a. Petrography of some Fraser River Delta peat deposits: Coal maceral and microlithotype precursors in temperate-climate peats. Int. J. Coal Geol., 2:321-370.

Styan, W.B. and R.M. Bustin. 1983b. Sedimentology of Fraser River Delta peat deposits: A modern analogue for some deltaic coals. Int. J. Coal Geol. 3:101-143.

van Geel, B., D.P. Hallewas and J.P. Pals. 1983. A late holocene deposit under the Westfriese Zeedijk near Enkhuizen (Prov. of Noord-Holland, The Netherlands): Paleoecological and archaeological aspects. Rev. Paleobot. Palyn. 38:269-335.

van Ryswyk, A.L. and A.H. Bawtree. 1972. Management and improvement of meadows on organic soils of Interior British Columbia. B.C. Department of Agriculture, Public. 72-3. 11p.

van Ryswyk, A.L., W.L. Pringle and J.H. Neufeld. 1974. Response of reed canary grass grown on ten British Columbia organic soils to N, P, K and lime. Can. J. Soil Sci. 54:273-285.

van Heuveln, B. and H. De Bakker. 1972. Soil-forming processes in Dutch peat soils with special reference to humus-illuviation. Proc. 4th Int. Peat Congr. (Helsinki) Vol.1:289-297.

Table 1. Classification and general description of the organic soils

Location	Identification	Classification and general description
A. INTERIOR PLATEAU		
1. Bells Lake	BL	*Limnic Mesisol* Sedge peat (125 cm) over sedimentary peat; total depth: 340 cm; lake-centered meadow fen. Large area used for pasture and hay production; good response to fertilization. - 930 m elevation
2. Jones Lake	JL	*Limnic Mesisol* Shallow sedge peat (70 cm) over sedimentary peat; total depth: 450 cm; meadow fen. Pasture and hay production. - 915 m elevation
3. 134 Mile	134M	*Limnic Humisol* Shallow organic layer (40 cm) over deep sedimentary peat; total depth: 400^{+} cm; meadow fen. This site is in the vicinity of a creek bed. Good production of hay (Reed Canary Grass). - 765 m elevation.
4. Watch Lake	WL	*Humic Mesisol* Deep sedge fen peat (250 cm) over sedimentary peat; total depth: 400^{+} cm. Large area of this fen meadow used for hay production under improved conditions. - 1190 m elevation
5. Opax	OP	*Humic Mesisol* Deep sedge fen peat (up to 250 cm); lake-centered meadow fen (sub-alpine). - 1450 cm elevation.
B. SOUTHWESTERN COAST		
6. Pitt Meadows (Delta Area)	PM	*Limnic Mesisol* Sphagnum peat (30 cm) and woody sedge peat (up to 100 cm) over sedimentary peat (180 cm). This old fen meadow was tile-drained for more intensive cropping. - 6 m elevation
7. H.K. Farm (Saltspring Island)	HKF	*Limnic Humisol* Very compact humic layer (35 cm) over deep sedimentary peat (300 cm). This old basin fen meadow is under pasture (Reed Canary Grass). - 30 m elevation
8. Stone-Cutter Meadow (Saltspring Island)	SCM	*Limnic Humisol* Compact humic layer (45 cm) over deep sedimentary peat (300 cm). The basin fen meadow is used for pasture and hay production.

Table 2. General properties of the organic soils

Site	Depth cm	pH	Rubbed Fiber %	Ash %	PPi	CEC meq/ 100g	Total C %	N %	C/ N
Bells Lake									
1	0-25	6.15	12	12.5	50	226	44.2	3.2	13.8
2	25-50	5.40	26	9.7	22	190	44.7	2.8	16.0
3	50-100	5.45	20	9.0	15	142	46.1	2.7	17.1
*4	125-150	6.55	-	75.9	-	44	17.2	0.9	19.1
*5	150-200	6.40	-	83.8	-	40	15.7	0.8	19.6
Jones Lake									
1	10-40	5.8	30	12.1	35	178	43.0	3.3	13.0
2	40-70	6.2	8	21.4	40	134	40.7	3.1	13.1
*3	70-100	6.4	-	47.3	5	108	25.7	2.7	9.5
*4	100-150	6.2	-	71.2	-	64	21.0	1.5	14.0
134 - Mile									
1	0-50	4.8	10	50.7	185	102	27.1	1.7	15.9
*2	50-100	5.4	-	73.0	12	74	14.4	1.0	14.4
*3	100-150	6.0	-	82.0	8	70	9.9	0.6	16.5
Watch Lake									
1	0-50	6.0	40	8.7	25	178	44.7	2.6	17.2
2	50-100	5.6	18	12.6	40	166	43.2	2.7	16.0
3	100-150	5.4	28	10.4	35	150	46.1	3.0	15.4
*4	250-275	4.8	8	19.1	18	110	31.0	2.8	11.1
*5	275-300	6.2	-	50.2	-	70	17.8	1.3	13.7
Opax									
1	0-50	4.4	20	11.0	50	182	43.3	2.3	18.8
2	50-100	4.6	18	12.8	32	168	44.1	2.0	22.0
3	100-150	4.4	28	5.9	11	140	45.0	2.9	15.5
4	150-200	4.5	34	4.4	8	130	47.3	2.4	19.7
Pitt Meadows									
1	0-25	3.0	70	3.0	14	162	44.4	1.1	40.4
2	25-50	4.0	6	12.3	46	136	46.7	3.1	15.1
H.K. Farm									
1	10-30	4.4	10	19.4	150	204	43.2	2.0	21.6
*2	30-50	4.0	-	54.8	8	64	22.4	1.5	14.9
Stone-Cutter Meadow									
1	15-40	4.3	12	12.5	125	186	43.0	2.1	20.5
*2	40-60	4.9	5	19.3	50	110	32.7	2.0	16.4

* sedimentary layers

Table 3. Elemental contents of the organic soils

Site	Depth cm	P ppm	K ppm	Ca %	Mg %	Al %	Fe %	Mn ppm	Cu ppm	Zu ppm
Bells Lake										
1	0-25	1046	440	3.55	0.67	0.40	0.31	11	5.7	7.5
2	25-50	644	207	2.92	0.51	0.29	0.20	8	5.3	5.0
3	50-100	483	250	2.07	0.38	0.21	0.15	14	10.0	5.8
*4	125-150	483	257	15.5	0.72	0.21	0.27	332	9.5	7.3
*5	150-200	483	225	15.0	0.68	0.19	0.27	322	12.0	11.5
Jones Lake										
1	10-40	1046	294	2.68	0.72	0.26	0.24	20	11.3	7.5
2	40-70	1046	500	2.04	0.48	0.42	0.36	28	11.3	9.3
*3	70-100	885	1100	3.63	0.37	0.73	0.73	66	12.1	14.5
*4	100-150	805	1100	16.41	0.58	0.74	0.41	331	10.6	15.3
134 - Mile										
1	0-50	644	310	2.03	0.51	3.23	1.93	245	18.5	37.8
*2	50-100	644	450	2.39	0.46	5.51	2.66	362	18.8	49.3
*3	100-150	885	520	2.91	0.93	6.23	2.78	418	15.4	48.5
Watch Lake										
1	0-50	644	238	2.57	0.18	0.13	0.30	9.3	4.6	5.0
2	50-100	483	757	2.32	0.17	0.46	0.28	34.8	6.1	5.5
3	100-150	483	263	5.48	0.17	0.18	0.22	55.5	6.8	6.8
*4	250-275	322	669	2.56	0.34	0.43	1.15	149.3	12.8	22.0
*5	275-300	322	820	5.94	0.32	3.29	1.53	268.3	12.1	31.0
Opax										
1	0-50	885	392	3.16	0.36	0.64	0.42	26.5	9.5	8.3
2	50-100	885	380	1.75	0.36	0.98	0.35	34.8	9.0	8.3
3	100-150	644	288	1.63	0.44	0.43	0.25	76.5	7.5	4.0
4	150-200	483	300	1.31	0.28	0.33	0.24	116.0	5.5	4.8
Pitt Meadows										
1	0-25	644	294	0.42	0.08	0.16	0.27	18.0	4.0	9.3
2	25-50	483	1900	0.51	0.09	0.10	0.70	34.3	13.0	13.5
H.K. Farm										
1	10-30	1046	719	0.26	0.26	0.81	1.04	53.3	60.8	11.5
*2	30-50	644	4300	11.0	0.78	3.42	1.49	259.0	33.5	33.2
Stone-Cutter Meadow										
1	15-40	885	408	1.88	0.14	1.10	0.95	16.1	6.8	16.0
*2	40-60	644	1950	2.65	0.17	2.25	1.51	48.3	22.7	48.3

* sedimentary layers

Table 4. pH (before and after 1-year incubation) and sulfur content.

Site	Depth cm	pH Before	pH After	Sulfur %
Bells Lake				
1	0-25	6.15	5.0	0.325
2	25-50	5.40	5.2	0.242
3	50-100	5.45	5.1	0.451
*4	125-150	6.55	7.0	0.191
*5	150-200	6.40	7.0	-
Jones Lake				
1	10-40	5.8	5.4	0.599
2	40-70	6.2	4.8	0.644
*3	70-100	6.4	6.5	0.624
*4	100-150	6.2	6.6	0.594
134 - Mile				
1	0-50	4.8	4.0	0.572
*2	50-100	5.4	4.4	0.548
*3	100-150	6.0	4.6	0.354
*4	200-250	3.2	2.5	1.791
Watch Lake				
1	0-50	6.0	5.1	0.225
2	50-100	5.6	4.9	0.169
3	100-150	5.4	5.0	0.350
*4	250-275	4.8	4.1	1.761
*5	275-300	6.2	6.4	1.758
Pitt Meadows				
1	0-25	3.0	2.4	0.100
2	25-50	4.0	2.9	0.333
H.K. Farm				
1	10-30	4.4	3.8	2.286
*2	30-50	4.0	3.3	1.339
Stone-Cutter				
1	15-40	4.3	3.8	1.517
*2	40-60	4.9	3.9	1.801

* Sedimentary layers

Table 5. Botanical composition of the peat materials at the various sites (%)

Site and depth designation	Fraction*	Wood		Ericales			Sedges			Mosses		Aggregated fine material
		Bark	Tissue debris	Leaves & stems	Roots & rhizomes	Tissue debris	Leaves & stems	Roots & rhizomes	Tissue debris	Bryales	Sphagnum	
1. Bells Lake 10-25 cm	1							88	2			10
	2							69	10			21
	3							22	39			39
	% of Tot.							59.7	17.0			23.3
25-50 cm	1							67	8	12		13
	2							65	15	10		10
	3							32	30	5		33
	% of Tot.							54.7	17.7	9.0		18.6
50-100 cm	1							46	9	20		25
	2							34	20	16		30
	3							24	30	6		40
	% of Tot.							34.7	19.7	14.0		31.6
2. 134 Mile 25-50 cm	1		24					12	12	2		50
	2		12					23	20	2		43
	3		0					2	24	0		74
	% of Tot.		12.0					12.3	18.7	1.3		55.7
50-100	1		29				3	7	3	3		55
	2		19				2	10	14	1		54
	3		0				0	2	28	0		70
	% of Tot.		16.0				1.7	6.3	15.0	1.3		59.7

* Fractions: 1 = >1.0 mm
2 = 0.45 - 1 .0 mm
3 = <0.45 mm

Table 5. (Continued)

Site and depth designation	Frac- tion*	Wood		Ericales			Sedges			Mosses		Aggre- gated fine material
		Bark	Tissue debris	Leaves & stems	Roots & rhizomes	Tissue debris	Leaves & stems	Roots & rhizomes	Tissue debris	Bryales	Sphagnum	
3. <u>Watch Lake</u> 10-25 cm	1		0					71	0	20		9
	2		1					62	0	29		8
	3		0					22	23	7		48
	% of Tot.		0.3					51.7	7.6	18.7		21.7
25-50 cm	1	1						85	0	9		5
	2	0						55	8	6		31
	3	0						20	22	12		46
	% of Tot.	0.3						533	10.0	9.0		27.4
50-100 cm	1							32	36	2	1	29
	2							26	21	0	0	53
	3							1	17	7	0	75
	% of Tot.							19.7	24.7	3.0	0.3	52.3
4. <u>Pitt Meadow</u> 25-50 cm	1			1	3			3			93	
	2			1	8			0			91	
	3			0	25			1			73	
	% of Tot.			0.7	12.0			1.7			85.6	
50-100	1	8	23				0	45	0		0	24
	2	2	9				1	27	5		2	54
	3	0	1				0	10	36		0	53
	% of Tot.	3.3	11				0.3	27.3	13.7		0.7	43.7

Table 5. (Continued)

Site and depth designation	Fraction*	Wood		Ericales			Sedges			Mosses		Aggregated fine material
		Bark	Tissue debris	Leaves & stems	Roots & rhizomes	Tissue debris	Leaves & stems	Roots & rhizomes	Tissue debris	Bryales	Sphagnum	
5. H.K. Farm 10-25 cm	1	2	1				6	15	0		0	76
	2	3	1				2	9	7		0	78
	3	2	0				0	8	25		3	62
	% of Tot.	2.3	0.7				2.7	10.6	10.7		1.0	72.0
25-50	1							2	0		0	96
	2							3	0		0	95
	3							0	3		3	87
	% of Tot.							1.7	1.0		1.0	92.7

Table 6. Summary of micromorphological descriptions of the nine selected peat materials.

Peat Mat.	Basic components	S-matrix	Pedological features	Special features
BL_1	Fragmented herbaceous tissues; woody fragments; dense fine materials; network of small pores.	Pleistoplasmatic arrangment of aggregated tissue fragments; o-porphyroskelic distribution with plasma lying between fragments.	Mesofaunal droppings; clusters of fungal spores; fungal hyphae.	Interstices filled with rootlets of C. fusca; mycelia and spores inside Carex tissues; absence of diatoms.
BL_2	Herbaceous root fragments and coarse tissue remains; leaves and stems of bryale mosses.	Discontinuous mass of polymorphic materials; loosely aggregated fine substances associated with tissue fragments; no plasmatic material.	Abundant faunal droppings and fungal remains (spores); mass of mycelia associated dark and dull areas.	Well preserved leaves and stems of Aulacomnium sp.; absence of diatoms.
JL_1	Disintegrated plant tissue remains; aggregates of fine substances; herbaceous root fragments; various diatom populations.	Polymorphic fine materials embedding coarse particulates; pleistomatic internal arrangement; loosely connected units.	Various fungal remains; secondary cell inclusions; some faunal droppings; no sclerotia.	Various epiphytic diatoms scattered throughout the peat material.
JL_2	Herbaceous root fragments and tissue debris; dispersed faunal droppings; some diatoms and charcoal pieces.	Phellemic and granular aggregates of fine materials; plasmatic materials confined inside tissue fragments; aggregation with no specific pattern.	Large variety of fungal remains; some faunal droppings; phellemic substances accumulated inside tissue.	Diatoms are less numerous than in JL_1.
$134M_1$	Fragments of herbaceous roots and woody debris; fine limnic material including a large population of diatoms; some sedgy stems.	Monomorphic fine material embedding scattered plant debris; massive fabric; phellemic substances accumulated inside plant tissues.	Bundle of sclerotia and numerous fungal spores; dispersed faunal droppings.	Sclerotia found in bundles; large populations of epiphytic diatoms; oospores of filamentous green algae.

Table 6. (Continued)

Peat Mat.	Basic components	S-matrix	Pedological features	Special features
$134M_2$	Tissue fragments of aquatic plants; disintegrated faunal droppings; recent sedge roots; various diatom populations; fine limnic materials including quartz and sand grains.	Densely packed aggregates of fine materials; o-porphyroskelic distribution; plasmatic material restricted to skeleton-grains.	Dispersed faunal droppings re--worked into secondary particles (aggregates); a few fungal remains; presence of pyrite grains; no sclerotia.	Inclusions of pyritic materials into plant organs; more plant debris and less diatoms than in the upper layer ($134M_1$).
PM_1	Numerous recognizable plant fragments, Sphagnum leaves and stems, ericaceous leaves and roots; some fine material aggregates.	Predominantly made of particulate materials and granular units; plant fragments with coniatic internal arrangement.	Abundant (especially sclerotia) and diverse fungal remains; limited faunal remains; sclerotia highly disintegrated.	Numerous sclerotia and charred materials; fecal pellets of Oribate mites are the only sign of faunal activity.
PM_2	Limnic material embedding various diatoms; scattered tissue fragments.	Dense and massive matrix punctuated by round pores; tissue fragments distributed with no specific arrangement.	Degraded fragments with accumulated phellemic substances; few sclerotia and fungal spores; presence of oospores and rachis of green algae; numerous damaged diatoms.	Voids created by rachis of Chara sp.; round pores associated with putrefaction gas; large population of diatoms.
SCM	Fine limnic materials; fragments of green algae; partially disintegrated faunal droppings; rachis and roots filling many pores or cavities; large and diverse population of diatoms.	Dense and massive matrix of fine plasmic materials incorporting dark-brown granular units scattered throughout with no definite pattern; network of diatoms intermixed with matrix; round pores punctuating the matrix.	Some fungal remains; partially disintegrated faunal droppings; accumulation of phellemic substances inside scattered tissue fragments.	Presence of roots or stems in many cavities; a diverse population of diatoms; round pores; black pyrite grains.

Table 7. List of the eleven micromorphological features inventoried on the peat thin sections through point counting

Main features	Sub-units	Number
Voids	- between structural units	1
	- within structural units	2*
Fine material	- massive and plasmic	3
	- aggregated (including fecal pellets)	4
Recognizable tissues	- slightly degraded	5
	- highly degraded	6
Recognizable organs	- with original contour	7
	- little or no original contour	8
Fungal microfossils	- fungal hyphae	9
	- others: sclerotia, spores, oospores, etc.	10
Diatoms	- diatoms	11

* In sedimentary materials, feature No. 2 applies to rounded pores associated with putrefication activity.

Table 8. Proportions of the eleven micromorphological features

Item No.	Micromorphological features		BL_1	BL_2	JL_1	JL_2	$134M_1$	$134M_2$	PM_1	PM_2	HKF	SCM
1	Voids:	between structures	13.9	22.3	17.1	21.3	18.3	22.6	20.8	10.8	17.3	12.2
2		within structures	0.9	1.1	0.4	0.5	0.4	-	0.6	5.4*	4.8*	3.9*
			14.8	23.4	17.5	21.8	18.7	22.6	21.4	16.2	22.1	16.1
3	Fine materials	dispersed	29.5	21.9	37.3	33.1	34.3	34.8	20.1	50.9	54.6	43.2
4		aqgregated	37.5	18.8	20.4	20.0	14.2	18.1	25.3	20.6	2.3	9.5
			67.0	40.7	57.7	53.1	48.5	52.9	45.4	71.5	56.9	52.7
5	Tissues	slightly decomposed	1.3	1.5	1.0	1.4	1.1	1.0	3.5	1.5	0.7	0.9
6		highly decomposed	13.4	22.1	14.4	18.2	15.7	8.9	8.0	4.5	0.7	0.6
			14.7	23.6	15.4	19.6	16.8	9.9	11.5	6.0	1.4	1.5
7	Organs	with original contour	1.5	3.4	1.6	1.4	2.1	2.0	9.7	-	-	1.5
8		no original contour	1.1	4.8	2.2	0.6	3.0	5.5	8.5	0.3	-	-
			2.6	8.2	3.8	2.0	5.1	7.5	18.2	0.3	-	1.5
9	Fungal remains	fungal hyphae	0.5	1.5	3.5	0.7	-	-	1.1	-	-	-
10		others remains	1.0	1.0	1.1	1.3	1.9	0.9	2.5	1.7	0.5	2.3
			1.5	2.5	4.6	2.0	1.9	0.9	3.6	1.7	0.5	2.3
11	Diatoms		-	-	1.1	0.5	9.7	6.1	-	4.3	19.3	25.8

* Bubble-like pores

Table 9. List of diatom taxa found in the three selected gyttja samples.

	TAXA	$134M_1$	$134M_2$ %	SCM
ACHNANTHES	clevei	2.2	8.1	
	conspicua	4.3	2.5	
	elleptica et var. rostrata	1.0	4.1	
	exigua var. heterovalva	4.3	4.1	
	minutissima	10.0	3.5	
	af. stolida	0.5		
AMPHORA	ovalis var. affinis	2.6		
	pediculus	7.0	9.1	
	af. thumensis	0.5	1.0	
COCCONEIS	placentula et var. euglypta et lineata	11.0	12.0	
CYCLOTELLA	antiqua		0.5	
	bodanica	0.5		
	meneghiania	1.0	0.5	
	pseudostelligera			0.4
CYMBELLA	amphicephala	0.5		
	aspera			
	cymbiformis	2.6		
	diluviana	0.5		
	inaequalis			6.3
	af. lanceolata			
	microcephala	2.0	0.5	
	minuta		0.5	0.4
	muelleri fo. ventricosa			1.2
CYMBELLONITZSCHIA	diluviana	0.5		
DENTICULA	tenuis			0.4
DIATOMA	tenue var. elongatum			0.4
EPITHEMIA	argus	0.5		0.4
	adnata	0.5		0.4
	sorex	0.5		
	turgida		1.0	1.2
	serra var. diadema	0.5		
EUNOTIA	spp.			0.4
FRAGILARIA	brevistrita	10.9	9.6	59.0
	construens	0.5	0.5	7.1
	construens var. venter	0.5	7.6	15.5
	intermedia	4.0	1.0	
	lapponica	11.8	4.6	
	parasitica	3.5	0.5	
	pinnata	2.6	2.5	3.3
	spp.	1.7	3.5	
GOMPHONEMA	acuminatum		0.5	0.4
	dichotomum	1.0		
	intricatum	1.0		
	olivaceum		0.5	
	subclavatum	0.5		
	subtile			0.4
	truncatum		0.5	0.4
	spp.	2.2	2.5	0.8

Table 9. List of diatom taxa found in the three selected gyttja samples. (Continued)

TAXA		134M1	134M2 %	SCM
HANTZSCHIA	amphioxis	0.5		
MASTOGLIA	smithii var. lacustris	1.8		1.2
MELOSIRA	islandica subs. helvetica	0.5	1.0	
NAVICULA	amphibola	0.5	0.5	
	cuspidata	0.5		
	exigua		0.5	
	laterostrata	1.0		
	menisculus	0.5	1.2	
	minuscula	0.5	1.0	
	pseudoventralis		1.0	
	af. pseudolanceolata	1.0	1.2	
	pupula fo. rectangularis	1.0		
	radiosa		0.5	
	semen	0.5		
NEIDIUM	iridis			0.4
NITZSCHIA	amphibia	1.3		
	cf. dissipata	0.5		
	denticula			0.4
	palea var. tenuirostris	1.0	4.3	
OPEPHORA	martyi	0.5		
PINNULARIA	abrejensis var. rostrata		0.5	
	microstauron			0.4
RHOPALODIA	gibba	1.0	1.0	0.4
	musculus		1.0	
RHOISCOPHENIA	curvata	0.5		
STAURONEIS	anceps	0.5		
STEPHANODISCUS	af. hantzschii	1.0		
SYNEDRA	capitata	0.5		0.8
	ulna et var. constricta	2.6	0.5	0.4
SURIRELLA	ovata	0.5		
TABELLARIA	fenestrata	1.0	0.5	
Total taxa = 73	Total taxa	51	40	24
Total genera = 25	Total genera	20	15	14
	Exclusive taxa	22	6	9
	Exclusive genera	4	0	3

Table 10. Dominant and characteristic diatom taxa and their preference toward pH, habitat and trophic conditons

	pH		Habitat				Trophic conditions		
Diatom taxa	basophilous	Circum-neutral	planktonic	benthonic	epiphytic	aerophilous	eutraphentous	meso-eutraphentous	meso-traphentous
ACHNANTHES minutissima	x			x	x				
AMPHORA pediculus	x				x		x	x	
COCCONEIS placentula	x			x				x	x
CYMBELLA inaequalis	x				x			x	x
FRAGILARIA construens et var. venter	x		x	x	x			x	x
FRAGILARIA brevistrita	x		x					x	x
MELOSIRA islandica subsf. helvetica	x		x				x		
RHOPALODIA gibba	x				x		x		
TABELLARIA spp.		x	x						x

Table 11. The matrix: framework ratios[1] of peat materials from surface and subsurface layers

Sites	10-15 cm	50-55 cm
Bells Lake	3.87	1.30
Jones Lake	3.00	2.46
134 Mile	2.21	3.04
Pitt Meadows	1.53 (2)	11.4 (3)
H.K. Farm	-	40.6 (4)
Stone-Cutter Meadow	-	17.6 (4)

(1) Fine substances / recognizable plant fragments
(2) 20-25 cm
(3) 60-65 cm
(4) 35-40 cm

List of figures

Figure 1. Examples of peat landforms and land use options related to the sites described in Table 1: (1) H.K. Farm; (2) Stone-Cutter Meadow; (3) Bells Lake; (4) 134 Mile; (5) Jones Lake; (6) Opax.

Figure 2. Microphotographs of thin sections from peat materials: (1) BL_1; (2) BL_2; (3) JL_1; (4) JL_2; (5) $134M_1$; (6) $134M_2$. Magnification: 30X.

Figure 3. Microphotographs of thin sections from peat materials: (1) PM_1 - 30X; (2) PM_2 - 30X; (3) PM_1 - 80X; (4) PM_2 - 80X; (5) SCM - 30X; (6) SCM - 80X. Numerous diatoms present (*Cymbella*, *Epithemia*, *Pinnularia*).

Figure 4. Microphotographs of thin sections from peat materials: (1) BL_1; (2) BL_2; (3) JL_1; (4) $134M_1$ - Diatoms (*Cymbella*, *Epithemia*, *Rhopalodia*); (5) $134M_1$; (6) PM_1. Magnification: 80X.

Figure 5. Selected plant macrofossils:
- (1) Fragment of a deciduous tree leaf - PM_1, 18X.
- (2) Agglomerated spores (algae ?) - BL_1, 10X.
- (3) Vascular tissue of Gramineae - BL_3, 9X.
- (4) Remains of a deciduous leaf - PM_1, 9X.
- (5) Herbaceous root (c.f. *Eriophorum* sp.) - BL_1, 8X.
- (6) Node of Cyperaceae - HKF_1, 5X.

Figure 6. Selected plant macrofossils:
- (1) Stem leaves of a bryale moss - BL_2, 8X.
- (2) Leaf of *Aulacomnium* sp. - BL_3, 8X.
- (3) Branch and stem leaves of *Sphagnum* sp. - PM_1, 8X.
- (4) Stem leaves of *Drepanocladus* sp. - WL_3, 5X.
- (5) Seed of *Potamogeton* sp. - $134M_3$, 6X.
- (6) Seed of a herbaceous plant - $134M_1$, 15X.

Figure 7. Selected plant macrofossils and others:
- (1) Seed of Cyperaceae - PM_2, 8X.
- (2) Seed of a herbaceous plant - HKF_1, 8X.
- (3) Oospore of *Chara* sp. - SCM_1, 18X.
- (4) Statoblast of *Cristatella mucedo* - BL_2, 15X.
- (5) Ephippium of *Daphnia* sp. - BL_3, 24X.
- (6) Elyter of an insect - PM_1, 15X.

Figure 8. Photomicrographs of diatoms in selected limnic materials (the bar = 10 μm)

1. *Melosira islandica* subsp. *helvetica* O. Müller
2. *Cyclotella bodanica* Eulenstein
3. *Cyclotella antiqua* W. Smith
4. *Stephanodiscus* af. *hantzschii* Grunow
5. *Fragilaria* sp.
6. *Fragilaria intermedia* Grunow
7. *Fragilaria construens* (Ehr.) Grunow
8. *Fragilaria lapponica* Grunow
9. *Fragilaria construens* (Ehr.) Grunow
10. *Fragilaria brevistriata* Grunow
11. *Fragilaria* sp.
12. *Synedra capitata* Ehr.
13. *Achnanthes clevei* Grunow
14. *Achnanthes lanceolata* (Bréb.) Grun.
15. *Cocconeis placentula* var. *euglypta* (Ehr.) Cleve
16. *Nitzschia denticula* Grunow
17. *Diatoma tenue* var. *elongatum* Lyngbye
18. *Eunotia serra* var. *diadema* (Ehr.) Patrick
19. *Tabelleria fenestrata* (Lyngbye) Kütz.

Figure 9. Photomicrographs of diatoms in selected limnic materials (the bar = 10 μm)

1. *Neidium iridis* Ehr.
2. *Stauroneis anceps* Ehr.
3. *Navicula pseudolanceolata* Lange-Bertalot
4. *Navicula pupula* fo. *rectangularis* (Greg.) Grun.
5. *Cymbella muelleri* Hust.
6. *Pinnularia abaujensis* var. *rostrata* (Patr.) Patr.
7. *Epithemia turgida* (Ehr.) Kütz.
8. *Amphora ovalis* var. *affinis* (Kütz.) V.H. *ex* De T.
9. *Amphora pediculus* (Kütz.) Grun.
10. *Rhopalodia musculus* (Kütz.) O. Muller
11. *Nitzschia palea* var. *tenuirostris* Grun.
12. *Cymbellonitzschia diluviana* Hust.
13. *Nitzschia* sp.
14. *Epithemia sorex* Kütz.
15. *Gomphonema* sp.
16. *Gomphonema dichotomum* Kütz.
17. *Mastoglia smithii* var. *lacustris* Grun.
18. *Surirella ovata* Kütz.

APPENDIX I

Detailed micromorphological descriptions of the organic soils

Bells Lake - Limnic Mesisol
BL_1 - (10-15 cm) - (Figure 2.1)

Basic components - These are made of small fragmented plant tissues, highly disintegrated, yellow-brown to brown in colour, and mostly of herbaceous origin. Some woody fragments and charcoal pieces could be found. The fine material is moderately packed so as to leave only a network of small pores.

Fabrics - The disintegrated tissue fragments are aggregated as granules, and present a phellemic internal arrangement. The O- porphyroskelic distribution shows some plasmic material lying between the aggregated tissue debris which appears somewhat disconnected. In several areas, the O- porphyroskelic fabric is densely packed. Although varying in origin, size and colour, the O- matrix seems rather homogeneous (monomorphic - Bullock et al. 1977) due to its highly disintegrated condition.

Pedological features - Signs of profound transformations in the peat materials are omni-present, such as the disintegrated nature of the organic components; secondary units seem to be formed mainly through the re-working of mesofaunal droppings. The main pedological features identified here are one sclerotium, some clusters of fungal spores (one type may belong to Geoglossum sp.), and fungal hyphae.

Special features - (Figure 4) - Most of the interstices or cracks in the material are filled with roots or rootlets of Carex fusca, as evidenced by the characteristic spines showing on the contour of the rootlets (Nilsson 1968). The roots were under fungal attack as revealed by the numerous mycelia and spores inside the tissues. Decomposition products have accumulated to a limited extent in the fossilized plant material.

BL_2 - (50-55 cm) - (Figure 2.2)

Basic components - Coarse tissue fragments and recognizable organ debris, many of them still with their original contour, constitute the primary components. The fragments are predominantly herbaceous; however, bryale remains concentrated in several areas and constitute an important botanical component.

Fabrics - These are made of loosely aggregated fine materials associated with the coarse fragments showing phellemic internal arrangement, all of these forming a discontinuous mass of polymorphic materials. There is no plasmatic material between the various basic units, which is in contrast with the s-matrix of the upper layer. In spite of a moderately advanced stage of decomposition, the porosity remains reasonably high.

Pedological features - In addition to fecal pellets and mesofaunal droppings, various fungal remains are found: spores, ascospores, conodia, hyphae, sclerotia and fruit bodies; these elements are in great variation and particularly abundant. The faunal droppings in this sublayer are numerous and easily observed, contrasting with small dark reddish brown cell inclusions; fungal mycelia predominate in the dull darker areas.

Special features - (Figure 4.2) - In spite of the presence of numerous decomposing organisms, well preserved bryale mosses (probably Aulacomnium sp.) can be observed. The absence of diatoms is a characteristic feature of this Limnic Mesisol.

Jones Lake - Limnic Mesisol
JL_1- (10-15 cm) - (Figure 2.3)

Basic components - They consist of highly disintegrated tissue remains, fine material aggregates and clusters of various diatoms. The recognizable leaf fragments and plant tissue debris point to an herbaceous origin; the presence of diatoms implies a period of aquatic milieu during the formation of the fen meadows.

Fabrics - Polymorphic fine materials concentrate around the coarser plant fragments, showing a pleistoplasmatic internal arrangement. The plasmatic accumulation between the basic components is limited; the units are loosely connected so as to leave plenty of voids.

Pedological features - These are mostly fungal remains of different nature (spores, conidia, ascospores); but there are no sclerotia. Some of the fungal remains show an opaque and dull appearance; these are usually associated with faunal droppings. In contrast with the particulate fine materials, the coarser plant fragments are of a brilliant reddish - brown colour.

Special features - (Figure 4.3). Various diatoms, mostly of the epiphytic type (that is, diatoms developed in association with water plants), are scattered throughout the peat layer; a particular faunal organism can be seen in the center of Plate 4.3.

JL_2-(50-55 cm) - (Figure 2.4)

Basic components - The loose O-matrix is made of numerous organ and tissue fragments, fine materials consisting of droppings and fecal pellets, and a limited number of diatoms. A few recognizable plant organs have retained their original contour; the internal arrangement is mostly coniatic and phellemic. The faunal droppings are rather diffuse and loosely aggregated. The colour is generally light (yellow-brown) with some darker areas where there is a concentration of fungal mycelia and charcoal pieces. These features contrast with the denser and darker material of the upper layer.

Fabrics - The overall fabric would be phellemic and granular; the plasmatic substance is mostly confined inside the tissue fragments; there are some pleistomatic areas associated with the faunal droppings which are very loosely aggregated and distributed in no specfic pattern.

Pedological features - These features consist of faunal droppings, organic plasma (melanon) and numerous fungal remains. The peat material remains at an early stage of decomposition in spite of fungal activities indicated by numerous fungal remains.

134 Mile - Limnic Humisol
$134M_1$ - (10-15 cm) - (Figure 2.5)

Basic components - The prominent presence of diatoms and the general greyish appearance of the peat material indicate a definite sedimentary nature. Scattered plant organs and tissue fragments bring in contrasting brown areas to the grey matrix owing to the cell inclusions. Recent and well preserved stems and roots occupy permanent cracks in the sedimentary peat. In spite of the contribution from the voids created by plants, the densely packed fine material and diatomaceous earth would limit the overall porosity.

Fabrics - A prominent monomorphic fine material embeds a large population of diatoms and forms a massive-appearing fabric. The accumulated phellemic material in the scattered plant debris diffuse out into the dense matrix.

Pedological features - There are numerous sclerotia (sometimes found in bundles (Figure 4.5), and a large number of various fungal spores which are associated with the rather sparse tissue residues; so, there is a rich microflora. A good portion of the fine material would come from disintegrated faunal droppings, although the large population of diatoms makes it difficult to ascertain.

Special features - The sclerotia are found in bundles rather than distributed at random through the peat layer (Fig. 3.5). The roots or rootlets of Carex fusca occupy the rounded pores (vughs). These plant materials would be contemporary to the large population of epiphytic diatoms. Epithemia, Rhopalodia, Cymbella, Amphora and Achnanthes genera which are found in shallow waters predominate the diversified diatom population (Figure 4.4). The large and loose cells found in the peat material are those of oospores from a filamentous green algae (Chara or Nitella).

$134M_2$ - (50-55 cm) - (Figure 2.6)

Basic components - These are made of scattered tissue fragments of aquatic plants; disintegrated faunal dropping which were re-worked into dense aggregates; a population of diatoms (less numerous than in the upper layer); a few recent roots and rootlets showing little coloration; some dark aquipherous cells, containing at time some iron concretions (pyrite grains); and finally, quartz and sand grains scattered through this limnic layer. An opaque grey colour with a general dull appearance characterizes the limnic material; phellemic substances accumulated in tissue debris bring in some brilliant patches to the grey matrix.

Fabrics - Densely packed aggregates of fine materials; o-porphyroskelic distributions of the aggregates; plasmatic material restricted to the skeleton-grains.

Pedological features - there are disintegrated faunal droppings re-worked into secondary particles (aggregates); thin fungal hyphae bring in a dull and opaque appearance. Aggregation is probably enhanced by the presence of some inorganic materials. Some pyrite grains reveal the presence of reduced iron-sulfur compounds. There are a few fungal remains (spores, ascospores, clamydospores, conidiae) but no sclerotia. The scarcity of these elements contrasts with the abundant faunal and fungal residues of the upper layer.

Pitt Meadows - Limnic Mesisol
PM_1 - (20-25 cm) - (Figure 3.1).

Basic components - Numerous fragments of herbaceous stems and ericaceous leaves form stratified layers intermixed with aggregated fine materials; fungal remains are abundant. Most plant organs are recognizable and retain their original contour.

Fabrics - The s-matrix is made predominantly of plant fragments with coniatic internal arrangement; some brilliant plasmatic materials are found around and inside plant structures. The fine material, exclusively made of fragmented plant debris and fungal remains, is distributed inside and along the stratified plant structures. So, granular units and particulate material form the overall fabric.

Pedological features - Abundant and diversified fungal elements; sclerotia are especially numerous. These elements indicate a very active microbial habitat, rather well aerated conditions, and a good supply of easily degradable organic substrates. The very limited faunal activity here is in marked contrast with the other sites.

Special features - Very numerous sclerotia (filled or empty) and the presence of carbonized material (charcoal) showing original structures of plant organs (Figure 4.6); root x-sections exposing cortex and parenchymatic tissues. Well defined fecal pellets of Oribate mites located inside plant structures are the only signs of faunal activity here.

PM_2 - (60 - 65 cm) - (Figure 3.2)

Basic components - These consist of dense greyish fine material of sedimentary nature which incorporate some mineral materials and various diatoms; a few brown plant fragments which have accumulated phellemic materials diffuse out some coloured substances into the grey matrix; small scattered plant fragments partially carbonized.

Fabrics - Predominantly made of a dense and massive matrix of finely divided organic particles and diatomaceous earth; the fragmented tissues are distributed with no special arrangement and connection; the dense matrix is punctuated by rounded pores.

Pedological features - Phellemic materials accumulated in degraded plant fragments; oospores and rachis of green algae (Chara) are present along a few fungal spores and sclerotia; herbaceous roots occupy cracks and voids; small fungal hyphae remains are associated with algae rachis and herbaceous roots.

Special features - (Figure 3.4) - The matrix is punctuated by rounded pores of two possible origin: (1) voids created by x-section of rachis (hamps) or oospores of green algae; (2) bubble-like pores created by putrefaction gases. A diversified population of diatoms.

Stone-Cutter Meadows - Limnic Humisol
SCM - (35-40 cm) - (Figure 3.5)

Basic components - Dense fine materials of coprogeneous nature; fragment of filamentous green algae; the accumulated phellemic substances diffusing into the matrix and bringing in some colour; dark brown faunal dropping partially disintegrated; hamps and roots of recent origin filling some of the pores; large and diversified diatom population.

Fabrics - Dense massive matrix of fine plasmatic substances, incorporating dark brown granular units scattered through the matrix with no definite pattern or arrangement; network of diatoms distributed through the matrix; the dense matrix is punctuated by rounded pores which at times are filled with recent roots.

Pedological features - There are some fungal spores but no sclerotia; partially disintegrated faunal droppings re-worked into secondary particles (aggregates); some dark pyrite grains, a reduced form of iron-sulfur compounds; accumulation of phellemic material in highly degraded tissue fragments; brown phellemic substances diffusing throughout the matrix.

Special features - Cross-sections of herbaceous roots and algae rachis; a diversified diatom population (Figure 3.6); rounded pores created by the evolution of putrefaction gases; black pyrite grains.

APPENDIX II

Comments on Sedimentary Peats

Gyttja is a swedish word that means faeces. In peat literature the term is used either as a synonym for all sedimentary peats or for a specific variety. Also, gyttja, dy, sapropel, ooze, aquatic peat, limnic and coprogeneous materials have all been used to designate various types sedimentary peats (Babel 1975, Markowski 1976, Lopotko et al. 1980, Barry 1980). This terminology is rather imprecise and confusing, obviously in need of clarification.

Babel (1975) refers to sedimentary peats as non peaty submerged humus formations. Thus, these materials would have originated from about the same starting material as the rest of the deposit, and accumulated at the bottom of waters rich in humus and providing sustenance to aquatic organisms (plants, algae, micro- fauna and -flora). The distinctive features among the first three materials listed above (dy, gyttja and sapropel) would be associated with the "milieu" under which they were formed, that is, under marine, brackish or fresh waters.

Dy is a humic material. It forms in acidic waters rich in humus. It could also be associated with humus gel precipitates sometimes called dopplerite (van Heuveln and De Bakker 1972). Recognizable plant residues are rare. According to Babel (1975), large quantities of recognizable plant debris would characterize transitional forms of gyttja.

Gyttja is a muddy, organism-rich humus formed under anaerobic conditions at the bottom of either eutrophic or oligotrophic waters. Recognizable plant residues can be found in large amounts (coarse and fine detritus of littoral plants). Droppings and residues of aquatic mesofauna are also characteristic of these humus formations. Different types of gyttja could be recognized, based mainly on the presence, in various proportions, of inorganic materials, and on the kind of waters in which gyttja was formed. Usually, gyttja developed in brackish waters which are richer in sulfur (Styan and Bustin 1983b). Kubiena (1953) specified eight varieties of gyttja while Markowski (1976) distinguished three groups of gyttja with ten subgroups. In addition, some gyttja have an important component of algal material. A common feature associated with gyttja is the presence of diatoms which vary qualitatively and quantitatively according to the aquatic environment (Cook and Whipple 1982). Mineral material could be present in significant amounts whether in the form of molluscan shells (gastropods) or in fine crystalline particles similar to clay.

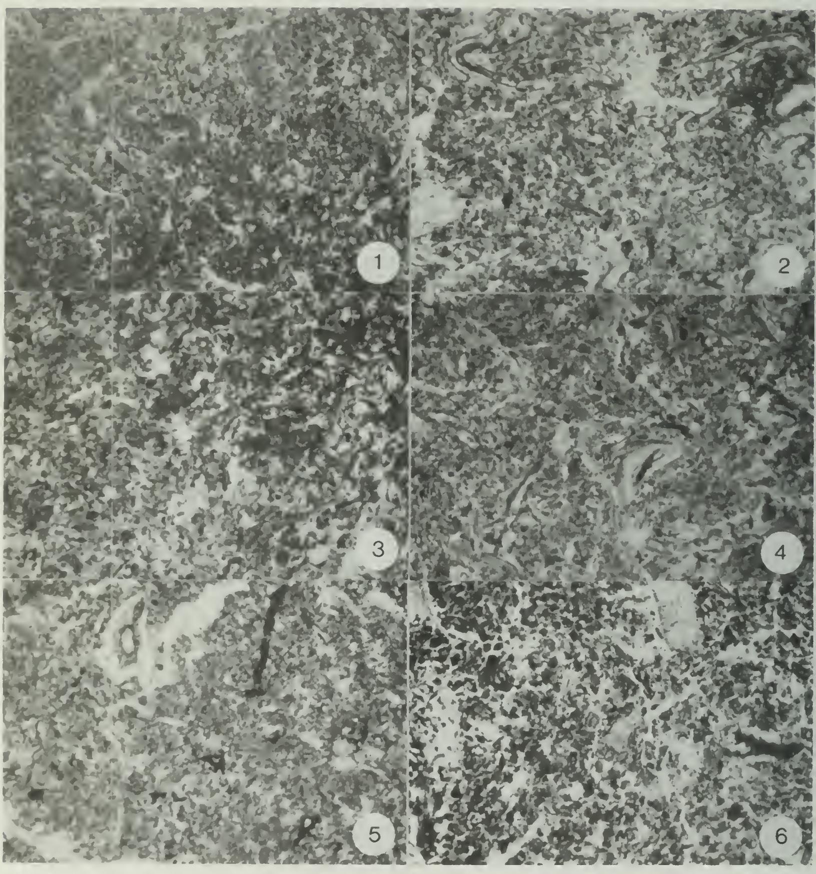
Sapropel is a brackish and muddy humus formation which has developed at the bottom of eutrophic waters (always under anaerobic conditions). It originates from similar materials to gyttja, but the droppings of the mesofauna are rare or absent. Sapropels share certain features with gyttja, namely the presence of organic-bonded sulfur which has a high acidification potential upon oxidation (Lowe 1986). The occurrence of hydrogen sulfide and methane (marsh gas) would be associated with the presence of bubble-like pores due to gas formation and subsequent activities.

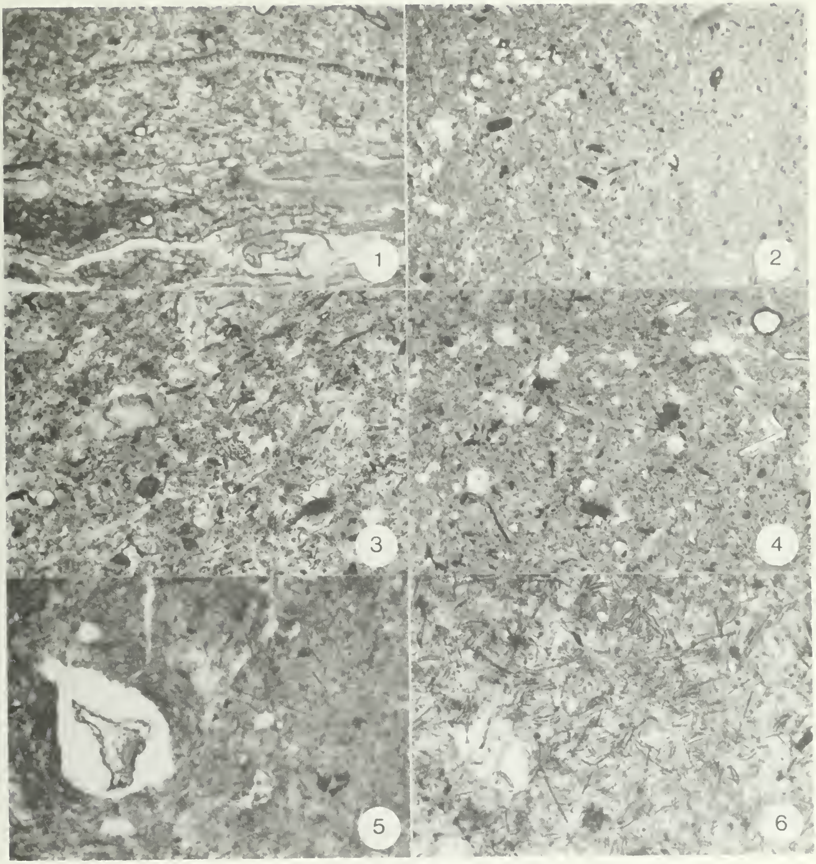
The concepts held by Babel (1975) and Kubiena (1953) are that dy, gyttja and sapropels are variants of same kind of submerged humus forms. Further, dy is formed under oligotrophic conditions (acidic) whilesapropels develop under eutrophic conditions (neutral to alkaline); gyttja is found in between, associated with mixed situations. At fortiori, gyttja could be used as a generic term, encompassing the three materials mentioned above (Styan and Bustin 1983a).

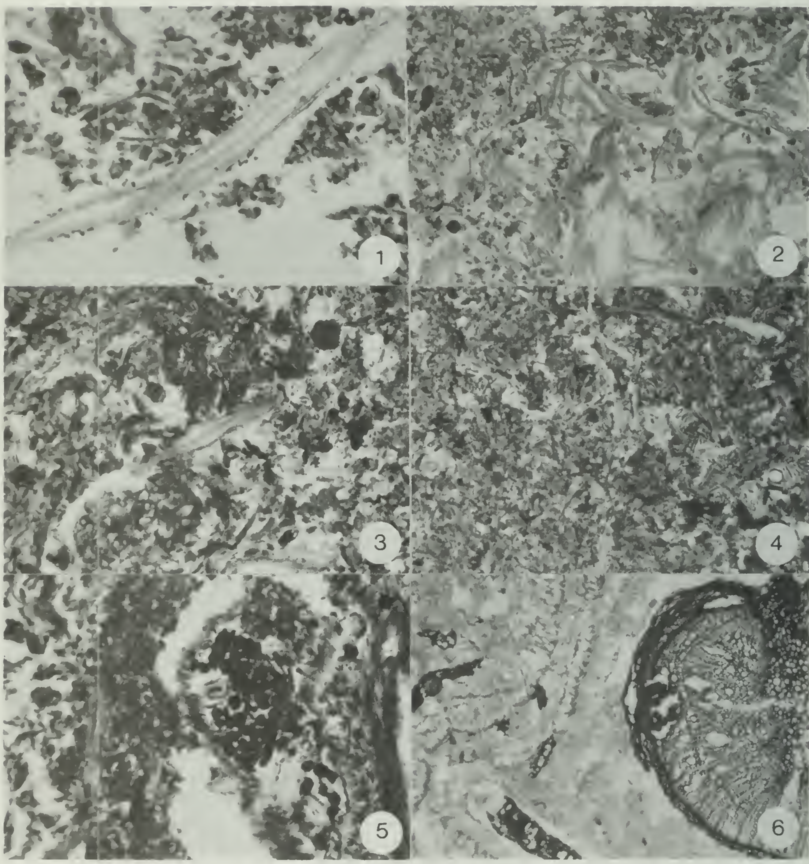
Briefly, here are some distinctive features of these three types of sedimentary peats, listed according to a trophic gradient:

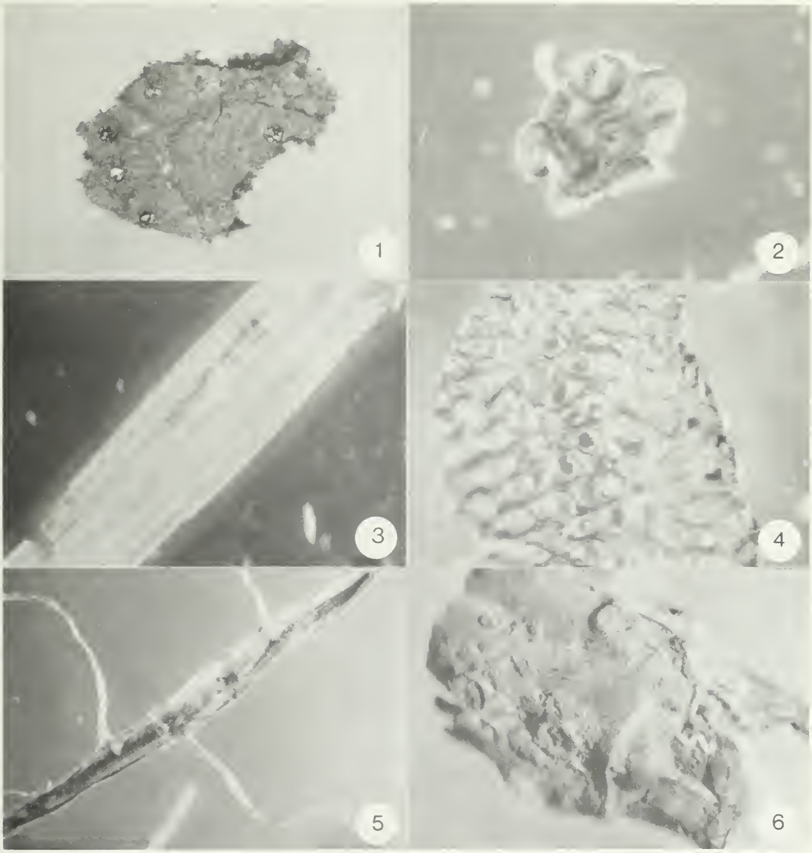
	Dy	Gyttja	Sapropel
Trophism:	Oligotrophic	mesotrophic	eutrophic
pH:	acidic	acidic to neutral	neutral to akaline
Waters:	fresh	fresh to brackish	brackish to marine
Sulfur content:	lower	variable	higher
Ash content:	lower	variable	higher
Shrinkage:	higher	variable	lower
Diatoms: (dominant taxa)	Melosira	Tabellaria, Fragilaria, Nitzchia	Amphora, Cymbella

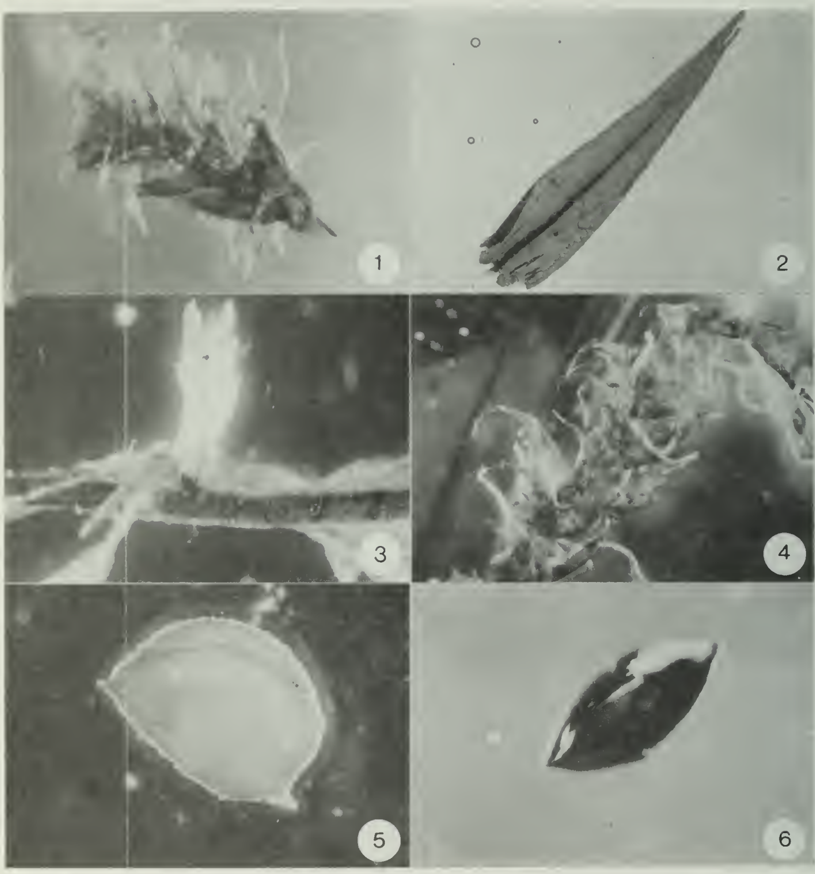

1
2
3
4
5
6

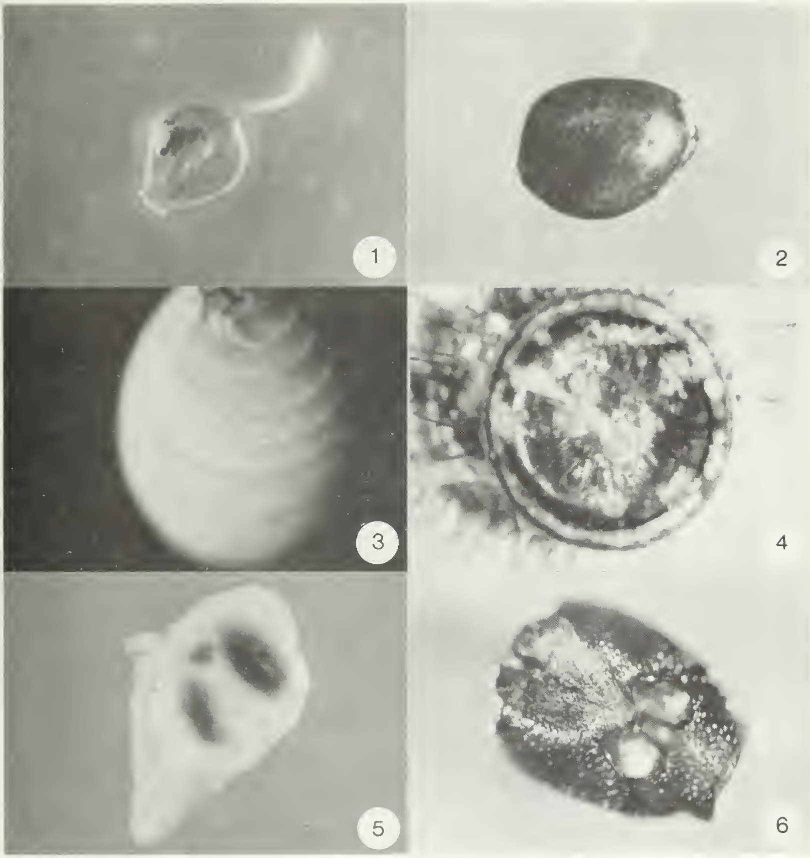



1
2
3
4
5
6

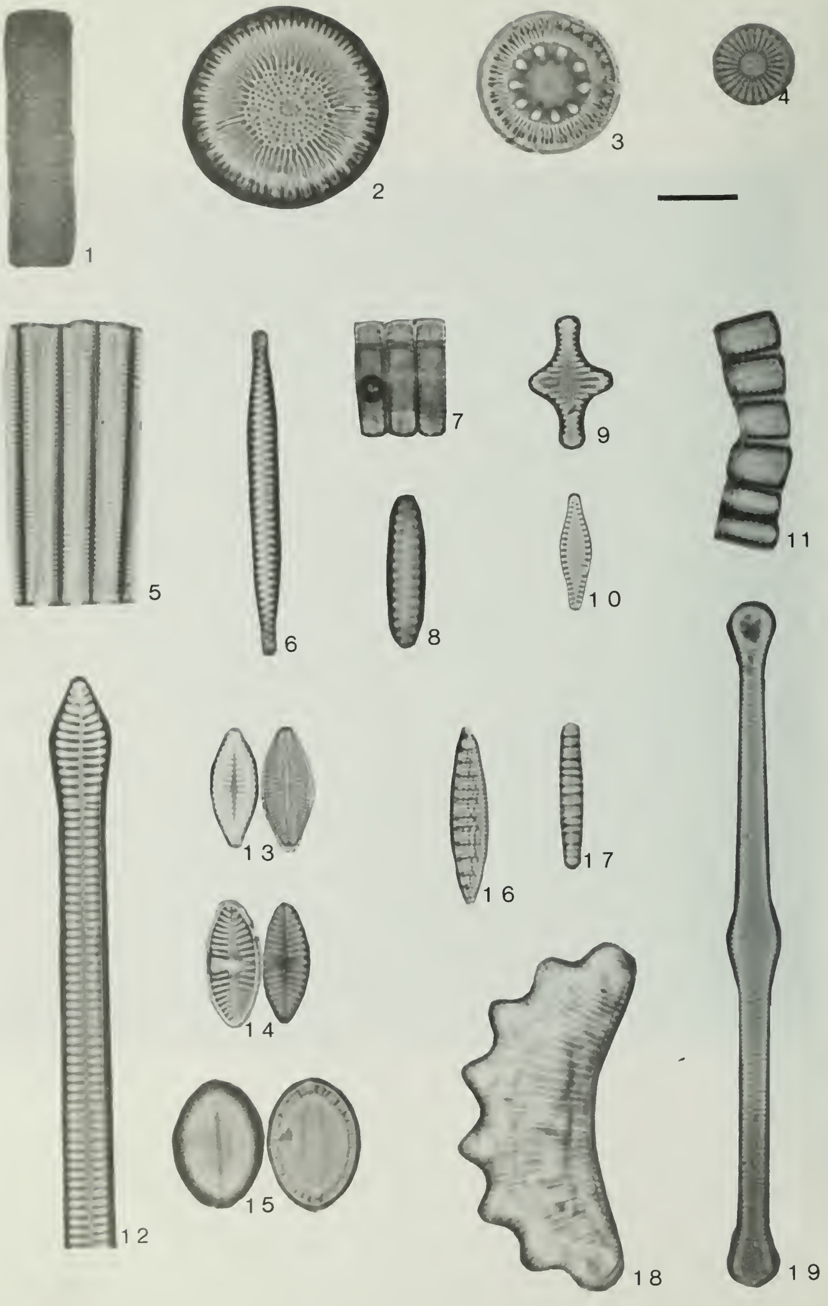

1
2
3
4
5
6

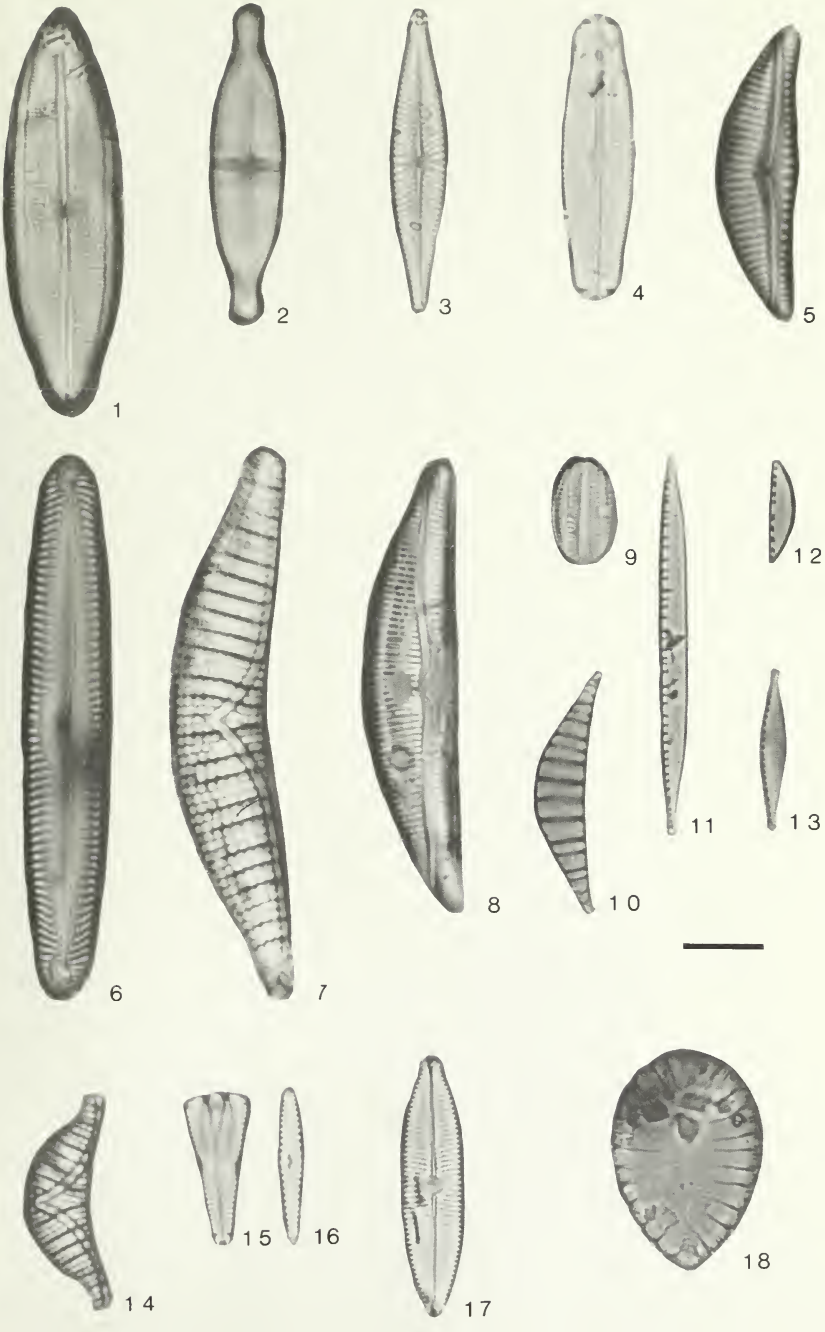

1
2
3
4
5
6


1
2
3
4
5
6


1
2
3
4
5
6

I




1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18