# BOTANICAL-CHEMICAL ANALYSIS OF PEAT MONOLITHS FROM THE ARCHEOLOGICAL SITE AT L'ANSE AUX MEADOWS NATIONAL HISTORIC SITE

by
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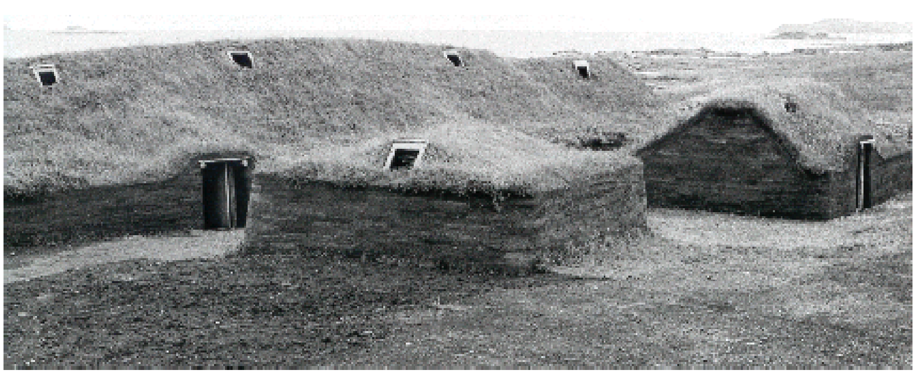
## INTRODUCTION

As part of a multi-disciplinary study to support archeological investigations of an ancient Norse settlement at L'anse aux Meadows a detailed botanical-chemical analysis of the peat stratigraphy was carried out. The object of these chemical analyses was to interpret the biostratigraphy of peat soils in relation to vegetation complexes that previously existed at the excavation site and to detect anomalies that may have been associated with anthropogenic influences.

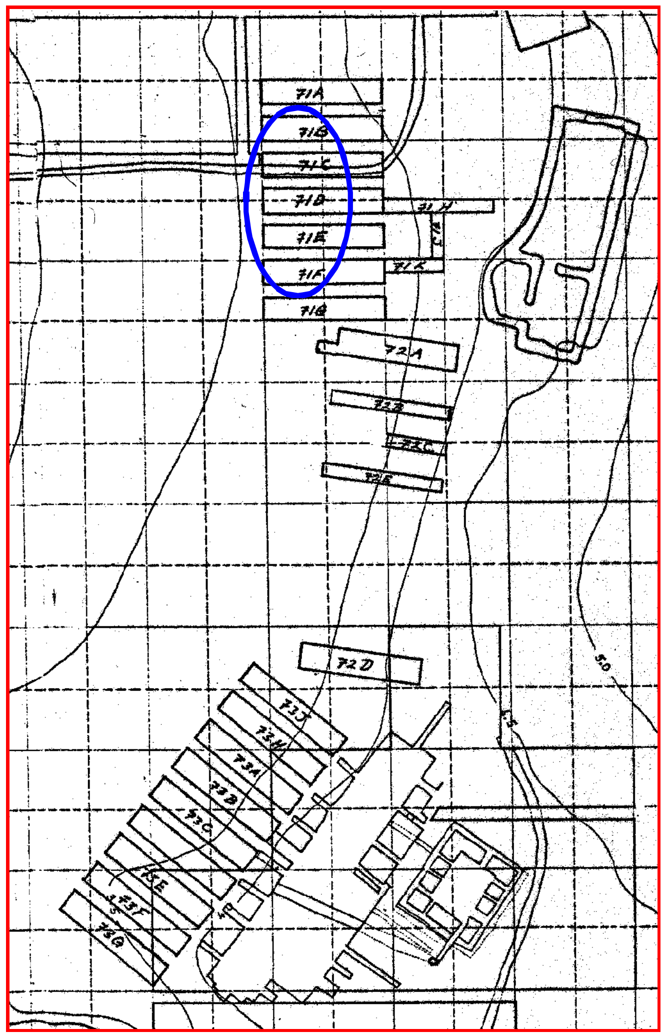



## L'anse aux Meadows Norse Site

View of the L'Anse aux Meadows archeological site in 1976.

The site of the Norse settlement as it was in 1975. The sod houses were on a knoll under the large ’protective’ building (top-centre) which was removed a year or so later to better preserve the remnants. A pair of exploratory trenches are visible below and to the left of the building. New archeological digs in the vicinity of where other Norse buildings stood have begun (centre). A series of shorter exploratory trenches was dug in 1976, from the original trenches in the direction of Black Duck Brood (Figure 2). This botanical-chemical study is based on the monoliths obtained from the new series.

Section of a typical archeological trench from which monoliths were sampled for botanical-chemical analysis.




Map of archeological trenches. The blue elipse is the approximate area of a lense of high iron (Fe) concentration.

## GEOLOGY

The archeological site is situated in the Maiden Point Formation underlain by a zone of Mélange (Cumming, 1975). The Maiden Point Formation consists of greywacke, quartz pebble conglomerate, sandstone, some diabase sills and pillow lava. The Mélange is composed of tectonic fragments and blocks of various sizes and lithologies of greatly discordant orientation set in a matrix of intensely deformed black shale (Gillis, 1966 and Tuket 1966). The site is part of a low-lying area with extensive infilling of marine sediments which formed terraces and beach ridges when sea-levels were higher than present. The sod houses are located on one of these terraces about 4-6 m above sea level. The terrace dates from the Calais IV transition, ca 4500-4000 BP. Five beach berms between the occupation terrace and the present shoreline have been recognized. The fossil storm beach immediately seaward of the occupation terrace date from the Dunkirk 0 eustatic rise at ca 3500 BP. (Grant, 1975). Radiocarbon dates for the bottom sample of the palsa bog between the terrace and the fossil storm beach gives an age of 5320 $\pm$ 60 BP. (Nydal, 1977). Three other beach berms seaward of the fossil storm beach are related to the Dunkirk II, III and IIIa transgressions dated at 1800, 1100, and 600 BP., respectively. These occur at 2 m, 1.5 m and 1 m above high tide mark (Grant, op. cit.). As McAndrews and Davis (1975) point out, these do not coincide with a sea level at ca 1000 BP at 3 m asl proposed by Kuc (1975). Also the dates 1780 $\pm$ 280 BP. given for detrital material considered to be part of the fossil beach ( op. cit.) is inconsistent with those proposed by Grant (op. cit.). However, the dates proposed for bog initiation and development indicate a minimum age of 2,500 BP.

## VEGETATION

The vegetation of L'anse aux Meadows is closely related to forest- tundra stretching across northern Canada from the Mackenzie Delta to northern Newfoundland. However, the disjunct distribution of permafrost and the presence of southern elements in the flora of L'anse aux Meadows make the site unique in the context of forest tundra. Thirteen natural and ten anthropogenic plant communities have been described within the park (Meades, Pollett and Robertson. 1975). Of particular interest to this study are the slope fen and fluvial marsh communities since these are the ones most closely related to the archeological excavation site.

The slope fen is the most widely distributed wetland type in the park area. The nutrient status is mesotrophic since surrounding soils are slightly more acidic than the **Potentilla-Carex aquatilis** fen. The peat underlying the **Scirpus-Sphagnum papillosum** unit is a sedge dominant ferric-humisol. The **Myrica-Betula Michauxii** community is common along stream margins throughout the park, most frequently follows small streams through the **Scirpus Sphagnum papillosum** unit. The lush communities originate on moist soil at the stream's edge where light, oxygen content and periodic flooding favour maximum productivity. The site lies in a mosaic of different vegetation units, but the natural content of these communities has been greatly disturbed by anthropogenic influences.

## METHODS AND MATERIALS

Figure 1a,b shows the location of a series of archeological trenches dug in 1976, from which the author obtained twenty-two peat monoliths. Laboratory analysis of their botanical-chemical stratigraphy was carried out on the monoliths.

Peat monoliths were subjected to a monothetic divisive classificatory treatment based on phytosociological analysis of the dominant macrofossil assemblage. The resulting groupings are as follows:- sedge peat**(s)**; sphagnum peat **(sp.)**; sedge plus sphagnum peat **(s + sp.)**; sedge plus wood peat **(s + w)**; sedge plus sphagnum plus wood peat **(s+ sp + w)**; cumulo **(c)**; and bog iron precipitates **(Fe)**.

Samples were taken from each grouping in each monolith and chemically tested for **N, P, K, Ca, Na, Fe, Mg, ash** and **pH**. Total **N** content was determined by the modified macro Kjeldahl method (Jackson, 1958). Total **P** content was determined by the chlorostannous reduced molybdophosphoric blue colour method (Truog and Meyer, 1929). Total potassium, calcium, sodium, iron and magnesium content were determined by dry ashing digestion, analysed by atomic absorption. Soil reaction (pH) was determined by the thin paste method (Jackson, op. cit.). The total element and ash content were calculated as percent weight on an air-dry moisture content basis.

To simplify the biostratigraphical interpretation, particularly as it relates to bog development and growth, the macrofossil assemblage groupings were correlated between each monolith and the resulting stratigraphy was classified into soil groups according to National Soil Survey Committee of Canada - soil classification system (1972). In this system only two major soil groups were identified; viz. feno-fibrisols and silvo-fibrosols. The two groups correspond to Turfa herbacea - magno caricion (sedge peat) and Turfa lignosa (wood peat) of European literature (Troels-Smith, 1955). A third soil group was included; namely, the bog iron precipitate layer, which forms a distinctive horizon in almost every monolith. The presence of sediments, notably sand grains and beach pebbles, were also noted and incorporated into the analysis.

Tree rings of wood samples taken from the archeological trenches were counted with the aid of a dual linear comparator. The dual linear comparator was also used to obtain the dimensions of fossil seeds and insect remains that were found in the monoliths.

## RESULTS AND DISCUSSION

The chemical pattern and slight sedimentation shows minerotrophic conditions throughout the development of the peat spoils - characteristic of a rich fen. The chemical analyses of the peat monoliths indicate changes in precipitation as well as soligenous/botanical changes as a result of anthropogenic disturbances on the surface.

The low ash content and slightly higher percentages of nitrogen and phosphorus are indicative of low precipitation. Conversely, the higher value for ash content, and corresponding lower percentages of nitrogen and phosphorus in the upper and middle strata indicates a periodic water covering due to flooding. This is confirmed by a higher content of sediment in these strata. Also there is a correlation between high ash content in the silvo-fibrosol soil group and a low ash content in feno-fibrosol group, indicating a characteristic change from soligenous regime in silvo-fibrlsols to a somewhat ombrogenous regime in feno-fibrosols. The high ash content in the subsurface layers is interpreted as mineral salt uptake in plant cover due to sea spray. Sea spray is also the reason for the relatively higher pH values normally encountered in coastal fens of this type.

The high potassium values result from a significant fraction bound in undecomposed plant remains more commonly found in the feno-fibrosol group, especially where there is a strong tendency toward the sphagno-fibrosol regime, which is never fully developed in this fen. The Ca/Mg ratio is consistently higher with depth. Although the variation in Mg content generally follows the variation in ash content, there is a lower Ca/Mg ratio in the silvo-fibrosols in the upper strata. Presumably, these variations are related to the degree of salt spray but it is more closely related to the degree of humification, which, in terms of the von Post scale, varies from H6-7 in the lower strata to H3-4 in the upper strata. High ash content and Ca/Mg ratio in this stratum is also correlated with occurrence of ferric oxide precipitates.

There is a distinctive layer of bog iron precipitates in the silvo- fibrosols near the surface of the bog. An isolated 'lense' of bog iron precipitates was also detected at the 35-40 cm depth in monolith 4A71B-23. It has been suggested that the iron, common in the matrix of the Mé1ange, was transported by ground waters from pyrite cubes and nodules and, coupled with subsequent biological action, produced bog iron concentrates in lowland areas underlain by Mé1ange (Cumming, 1975).

However, it should be noted that the conditions necessary for the conversion of ferrous hydroxide precipitates to ferrous carbonate are low pH and high pressure of carbon dioxide (Puustjarvi, 1952).

In any case the ferrous oxide content of bog water is higher than mineral soil water because the iron is stabilized by humic complexes due to the absorption of large amounts of humus by the colloidal iron precipitates. Layers of bog iron, as noted above, are restricted to silvo-fibrosols in the upper layers of deep peat, with the exception of the 'lense' in the ferro-fibrosol strata. In both these cases the groundwater contained a high oxygen content and percolated to well below the surface. The flow of oxygenated water enhanced the bacteriological activity necessary in the formation of bog iron. Bacteria of the **Thiobacillus-Ferrobacillus** group alter the carbon dioxide and oxygen equilibrium considerably to conditions which favour biochemical precipitation of iron minerals. At greater depth, and in ombrogenic feno-fibrosols, the supply of oxygenated water was not sufficient to promote the conditions necessary for the formation of bog iron.

But in a sense, i.e., excluding the anomalies of high Fe content of bog iron zones, there is a general agreement with Pollett (1971) that the percentage of Fe increases with depth in deep peats. In this context we see no anomalies in the chemical pattern that can be attributed to ancient anthropogenic influences that would cause an artificial change from an ombrogenous to a soligenous regime, except the "lense' of, iron precipitates in the vicinity of monolith 4A71B#23.

Artificial change caused by anthropogenic disturbances in recent decades has caused a manifold change in the vegetation and soil structure by creating artificial water-flow patterns which have accelerated precipitation of iron minerals and a change towards a silvo-fibrosol soil type over feno-fibrosols. Another factor which has resulted in these changes is the formation of palsa which invariably affects the water-flow pattern, and subsequently the floristic composition. In the lower strata the low Na content indicates a fresh water regime; as opposed to sea water proposed by Kuc's 'driftwood bay' theory. The chemical pattern suggests that there was some ponding of fresh water behind the storm beach, but that paludification was the main cause of peat accumulation. This is consistent with pollen analysis by Henningsmoen (1977) and McAndrews and Davis (1978).

The silvo- and feno-fibrosols reflect a lush grassy-herbaceous vegetation during the early development of the bog. Slight sphagno-fibrosols were limited to the lower strata which suggest that a hydroseral development was of minor significance forming in one or several small shallow ponds. This is somewhat contrary to Kuc's (1975) "Driftwood Bay" theory. As pointed out by McAndrews add Davis (1978), $C^{14}$ dating of driftwood in the fossil storm beach is younger than the dates given for the establishment of the beach. However, the $C^{14}$ dates of wood samples found at varying depths in the palsa bog (Mott, 1975) correspond approximately to Kuc's driftwood age and it was suggested that the detritus was washed over an already established beach. Henningsmoen (1977) has suggested that fen initiation was caused by a small slow flowing brook with or without a threshold. This assumption is plausible because the pollen samples from the lower strata were badly corroded indicating oxygen-rich conditions characteristic of silvo- fibrosols.

There is a general curvature of the stratigraphical lines as a consequence of secondary compression of the bog. The bottom layer profile includes sedimentary peat (cumulo) containing sand and beach pebbles. This zone represents the final stages of hydroseral development but it is restricted to deepest parts of the palsa bog. The silvo-fibrosols in the lower strata consist of moderately decomposed *Sphagnum* remains, root fibres of *Eriophorum*, *Carex* radicels and small twigs. This is also the zone that contains the root systems of fossil trees. The silvo-fibrosols represent the true minerotrophic element in the palsa bog. Wood samples from fossil trees were examined and the results generally agree with those previously described by Mott (op. cit.). Undoubtedly, some driftwood does exist in the palsa bog but most of it weathered wood of trees killed in situ by paludification. For comparison, there are many slope fens within the park that show weathered remnants of trees killed by paludification which look very much like driftwood. The chemical and physical characteristics imply that the site was wooded but not as extensively as Perem (1974) suggests. This view is consistent with palynological studies by Henningsmoen and McAndrews and Davis which indicates the presence of such light demanding species as *Myrica gale*, *Thalictrum polygamum*, and *Sanguisorba canadensis*. These species are characteristic of a **Thalictrum-Potentillio** fen consisting of scattered black spruce trees, some larch and balsam fir on the drier knolls, and lush grassy-herbaceous meadows. The physiognomy of such a community would comprise four strata:- scattered clumps of black spruce and larch trees (1-8 m); shrub layer (50-60 cm); herb layer (15-35 cm); and ground layer (0-10 cm) consisting of mosses and creeping shrubs. In many ways, it is similar to an inland black-spruce fen but differs by the presence of salt tolerant species. Zones of very high sedge content in the lower strata are interpreted as the final stage of hydroseral development characterized by floating mats of *Carex rostrata*. A good example of such a community exists on the east side of Black Duck Brook about mid-way between the palsa bog and Black Duck Pond.

The floristic composition would be somewhat as follows:

**Scattered Trees**

| | |
|---|---|
| Picea mariana | Abies x phanerolepis |
| Larix laricina | |

**Shrub Layer**

| | |
|---|---|
| Amelanchier bartramiana | Chamaedaphne calyculata |
| Lonicera villosa | Ledum groenlandicum |
| Myrica gale | Andromeda glaucophylla |
| Thalictrum polygamum | Potentilla fruticosa |
| Kalmia polifolia | Rosa nitida |
| Sanguisorba canadensis | Betula pumila |
| Betula michauxii | |

**Herb Layer**

| | |
|---|---|
| Clintonia borealis | Platanthera dilatata |
| Conioselinum chinense | Fragaria virginiana. |
| Solidago purshii | Calamagrostis inexpansa |
| Carex aquatilis | Agrostis scabra |
| Carex buxbaumii | Coptis groenlandicum |
| Carex flava | Spirea latifolia |
| Carex cephalantha | Aster puniceus |
| Carex viridi | Aster nemoralis |
| Eriophorum viridi-carinatum | Cornus canadensis |

**Ground Layer**

| | |
|---|---|
| Sphagnum robustum | Campylium stellatum |
| Sphagnum magellanicum | Bryum pseudo-triquetrum |
| Sphagnum fuscum. | Pleurozium schreberi |
| Sphagnum papillosum, | Linnaea borealis |
| Sphagnum. warnstorfianum, | Vaccinium oxycoccus |
| Drosera intermedia | Viola pallens |

$C^{14}$ dating for the lower peat strata is 2500 BP Peat accumulation is expected to be slow because of the current warming trend in the global climate which induces a relatively higher, but not complete, decomposition rate of organic material. The *Carex rostrata* peat should be considerably younger because of the longer time span for pond infilling. Unfortunately no $C^{14}$ dating has been done to substantiate the existence of a floating mat of *Carex rostrata*. Palynological results (McAndrews and Davis, 1978) also suggest an aquatic environment by the presence of pollen of Nuphar and Isoetes although they indicate the possibility that these species were introduced from upstream.

At 35-40 cm depth, a $C^{14}$ date of 1340 $\pm$ 60 BP has been given (Mott, .). The feno-fibrosols had expanded considerably. The vegetation was dominated by sedges due to a change from a minerotrophic to a somewhat ombrogenic regime, characteristic of the **Scirpus-Sphagnum papillosum** slope fens that are widespread throughout the park. These fens are wet, with a water table at or near the surface. The vegetation is dominated by *Scirpus cespitosus, Carex* *aquatilis, Sphagnum papillosum, Chamaedaphne calyculata, Andromeda glaucophylla, Myrica gale* and *Eriophorum angustifolium.* The floristic composition would be somewhat as follows:-

**Shrub and Sedge Layer (10-40 cm)**

| | |
|---|---|
| Chamaedaphne calyculata | Sanguisorba canadensis |
| Andromeda glaucophylla. | Sarracenia purpurea |
| Kalmia polifolia | Solidago uliginosa |
| Betula michauxii | Aster nemoralis |
| Gaylussacia. dumosa | Calamagrostis inexpansa |
| Myrica gale | Carex limosa |
| Larix laricina var. depressa | Carex cephalantha |
| Picea mariana forma semiprostrata | Carex oligosperma |
| Ledum groenlandicum | Carex aquatilis |
| Platanthera dilatata | Carex exilis |
| Smilacina trifoliata | Scirpus cespitosus |
| Eriophorum angustifolium | |

**Ground Layer (0-10 cm)**

| | |
|---|---|
| Empetrum nigrum | Sphagnum pulchrum |
| Vaccinium oxycoccus | Sphaguum papillosum |
| Drosera intermedia | Sphagnum subnitens |
| Linnaea borealis | Sphagnum subfulvum |
| Cephalozia connivens | Sphagnum magellanicum |
| Riccardia palmata | Selagenella selaginoides |
| Ptilidium ciliare | Lepidozia reptans |
| Drepanocladus revolvens | |

Fairly well-developed bog iron found in a fen on the bank of Black Duck Brook.

Pollett (1971) defined this type of bog as intermediate between 'bog' and 'fen' because many of the species are recognized as 'fen' species, such as *Calamagrostis inexpansa, Solidago uliginosa*, and *Carex exilis* and states that "physiognomically these areas are not unlike gently rolling fields with sedge and grasses set in a Sphagnum mat." The zone at 35-45 cm depth marks the period of maximum expansion of feno-fibrosols with some encroachment of silvo-fibrosol development over the feno-fibrosols from the seaward side of the bog. This indicates a slight alteration in the moisture regime probably as a result of a long term climatic change to warmer stumer temperatures which correspond to the period preceding and during the Norse occupation.

More directly related to the period of Norse occupation is the very thin 'lens' of bog-iron precipitation at 35 cm below the surface. This is not characteristic to the bog-iron precipitate zone near the surface because it is strictly in an ombrogenous stratum where one would least expect iron precipitates to form. Obviously for a very short period of time the rate of water flow had increased sufficiently to allow for the conditions necessary for bog-iron formation. Permafrost was encountered at 30 cm below the surface of the palsa bog and subsequent $C^{14}$ dating of the age of the palsa is 460 ± 80 BP (Henningsmoen 1977). She suggested that the palsa developed during the 'little ice age' period (during the most recent arctic expansion 700-100 BP). The palsa would directly influence water-flow pattern since it provides a pseudo-bottom and the moisture regime reverts back to minerotrophic conditions from an ombrogenous one. This phenomenon is reflected by a reversion to a grassy-herbaceous vegetation and also the development of zones of iron precipitation near the surface. In recent years the process has been accelerated by extensive modification due to anthropogenic influences, i.e., by trampling, digging and the creation of artificial drainage patterns. On the surface layers down to 10 cm silvo-fibrosols have all but covered the palsa bog and only two small areas of feno-fibrisols.

A third patch of feno-fibrosol is located in the vicinity of the 4A73 trench series. This is a small patch of **Scirpus - Sphagnum papillosum** fen in a very early stage of development. It probably marks the ancient course of Black Duck Brook. However, it is unlikely to develop into a substantial ombrotrophic bog because of anthropogenic disturbances; in fact, indications are that it too is converting to a grassy, herbaceous fen.

The surficial vegetation on the palsa bog is an unusual transition from **Scirpus -Sphagnum papillosum** fen and **Thalictrum -Potentillio** fen and one is tempted to call it an 'anthropogenic fen' because it contains true anthropogenic elements such as *Ranunculus acris, Achilles millefolium, Angelica sylvestris* and *Phleum pratense.* Saline species normally associated with beach berms are also found in the fen matrix such as *Lathyrus japonica, Potentilla anserina, Elymus arenarius var. villosus* and *Iris versicolor*. Grazing by sheep, horses and cattle obviously have a strong influence on the floristic composition. *Angelic sylvestris,* for instance, is a favourite forage plant and is most abundant along the grassy beach berms, however it is cropped so low that it is almost unrecognizable. Many other plants share the same fate particularly on the lush palsa bog. In this community *Thalictrum polygamum, Chamaedaphne calycullata, Andromeda glaucophylla, Ledum groenlandicum, Amelanchier bartramiana, Picea mariana, Larix laricina* and other species characteristic of **Thalictrum -Potentillio** fen, are absent from the palsa bog. Because of exposure, grazing and proximity to the sea, the vegetation is dwarfed.

The floristic composition of the palsa bog is as follows:

**Herb Layer (15-25 cm)**

| | |
|---|---|
| Calamagrostis canadensis | Sanguisorba canadensis |
| Solidago uliginosa | Carex atratiformis |
| Achillea millefolium (paths) | Carex aquatilis |
| Viola pallens | Scirpus cespitose |
| Smilacina trifoliata | Eriophorum angustifolium |
| Elymus arenarius (rare) | Eriophorum viridi-carinatum |
| Iris versicolor (rare) | Kalmia polifolia |
| Juniperus communis | Salix vestita |
| Potentilla fruticosa | Aster nemoralis |
| Potentilla anserina (rare) | Betula michauxii |
| Potentilla tridentata (rare) | Platanthera dilatata |
| Ranunculus acris (paths) | Lathyrus japonicus (rare) |
| Fragaria virginiana | Rubus chamaemorus |
| Cerastium vulgatum (paths) | Juncus effusus |
| Cornus canadensis | Juncus balticus (rare) |

**Ground Layer (0-5 cm)**

| | |
|---|---|
| Campylium stellatum | Vaccinium oxycoccus |
| Drepanocladus revolvens | Linnaea borealis |
| Sphagnum warnstorfianum | Drosera intermedia |
| Sphagnum robustum | Empetrum nigrum |
| Sphagnum papillosum | Riccardia palmatum |

Dawson (1977) found walnut seeds (Juglans cinerea) at the site. However, site conditions and the absence of Juglans pollen in the pollen diagrams preclude any possibility of walnut ever having grown at L'anse aux Meadows. Two other possibilities have been considered, namely, their introduction by currents via the St. Lawrence or by anthropogenic transportation. The introduction by ocean currents seems reasonable since debris can be brought to the site f4tm northerly and southerly currents. But since walnut seeds are pervious to water, it is doubtful that they would float for long distances. The introduction by either Norse or Indigenous peoples, however, seems to be the only plausible solution.

Dawson (1977) also found seeds of pin cherry (*Prunus pennsylvanica*) in the peats. Pin cherry occurs in the southern half of Labrador and most of Newfoundland but is virtually absent from the northern part of the Great Northern Peninsula. So far as we know, pin cherry is absent within the National Historic Park. However, that it existed in the vicinity of L'anse aux Meadows in the past is highly probable.

Excluding the walnut and pin cherry seeds, the general pattern of seed distribution is consistent with the stratigraphical evidence of plant succession described in this report and accords well with palynological evidence presented by Henningsmoen (1977.), Mott (1975) and McAndrews and Davis (1978).

Sedge is associated with the formation of bog iron resulting from anthropogenic influences. This is association is well-known in mediaeval agriculture in northern Europe. For example, in early Icelandic, Swedish and Finnish pastoral sedge bogs, sufficient bog iron developed in sedge pastures to produce a low grade ore in abundance for iron works. Bog iron precipitates are also common in ancient peat workings in Denmark where the Grauballe and Tollund corpses were found. Similarly, the age of the 'lense' of Fe precipitates in the early stages of bog iron formation is the same age as the iron-rich sods used in the construction of Norse buildings.

At a depth of 35 cm in the deepest and wettest part of the fen there is 3 cm thick lense of bog iron. Cummings, addressing the origin of bog iron in general, suggests that Fe is transported by ground water from pyrite cubes and nodules in the matrix of the mélange and, by biochemical reaction, produces bog iron concentrates in lowland areas underlain by the mélange. However, as far as the 'lense' of bog iron in question is concerned, it does not lie in a low-lying area, but in a slope fen. Similarly, the iron-sods of the remnant Norse buildings are on a relatively dry knoll. Also, it should be noted that the conditions necessary for the conversion of ferrous hydroxide to ferrous carbonate (i.e., conversion from a liquid to a solid) are low pH and high pressure of $CO_2$. Furthermore, the ferrous hydroxide content of bog water is higher than mineral water because the iron is stabilized by humic complexes due to absorption of large amounts of humus by colloidal iron precipitates. The flow of oxygenated water enhances the biochemical activity necessary for the formation of bog iron; in other words, bacteria of the Thiobaccillus-Ferrobacillus group alter the $CO_2$ and $H_2O$ equilibrium.

This type of physico-biochemical reaction is the direct result of a manifold change in the vegetation structure; i.e., a shift from an ombrogeneous sphagnum peat, to a minerotrophic sedge-dominated peat caused by a change from stagnant to surficial water-flow patterns as a result of compaction - perhaps by trampling and grazing. In fact, modern equivalent of this anthropogenic influence, is reflected by the fact that the surface layer is accentuated by very high Fe concentration resulting from compaction associate with modern animal husbandry and archeological activities.

At about 1000 BP the fen was obviously much smaller than it is now and it is possible that the ‘lens’ of bog iron represents a residual area that was unsuitable for sods, because it was dominated by aquatic sedges.

Because, settlement was comparatively short, bog iron would not reform on the areas stripped for sod houses, while, above the ‘lens’ the fen would have reverted back to its original ombrogeneous condition.

## CONCLUSIONS

1. The chemical and physical pattern of the lower strata show that the bog developed from a **Thalictrum-Potentillio** fen community and possibly hydroseral succession from a shallow fresh water pond.

2. The middle strata were characteristic of ombrogenous conditions. An anomalous 'lense' of iron precipitation developed in the zone attributed to the period of Norse occupation, i.e., 1000-800 BP The feno-fibrosol soil group in the middle strata are characteristic of **Scirpus-Sphagnum papillosum slope** fens.

3. The upper strata reflect a reversion from an ombrogenous regime to a minerotrophic one due to palsa development during the 'Little-ice age Recent anthropogenic disturbances such as animal husbandry and archeological diggings have also altered the vegetation matrix and moisture regime.

4. The paleoenvironmental conditions, particularly during 1000 BP were not substantially different than they are now. Although during the warm period, 800-1500, the flora may have consisted of southern elements and contained less Arctic-alpine species than now.

5. Soil and climatic conditions would never have been conducive to the growth of *Juglans cinerea* (or vines) within the time frame of 2500 BP since soils are not sufficiently well developed. However, the absence of pin cherry (*Prunus pennsylvanica*) in the district is surprising - especially, since it occurs on the opposite side of the Straits of Belle Isle in southern Labrador.

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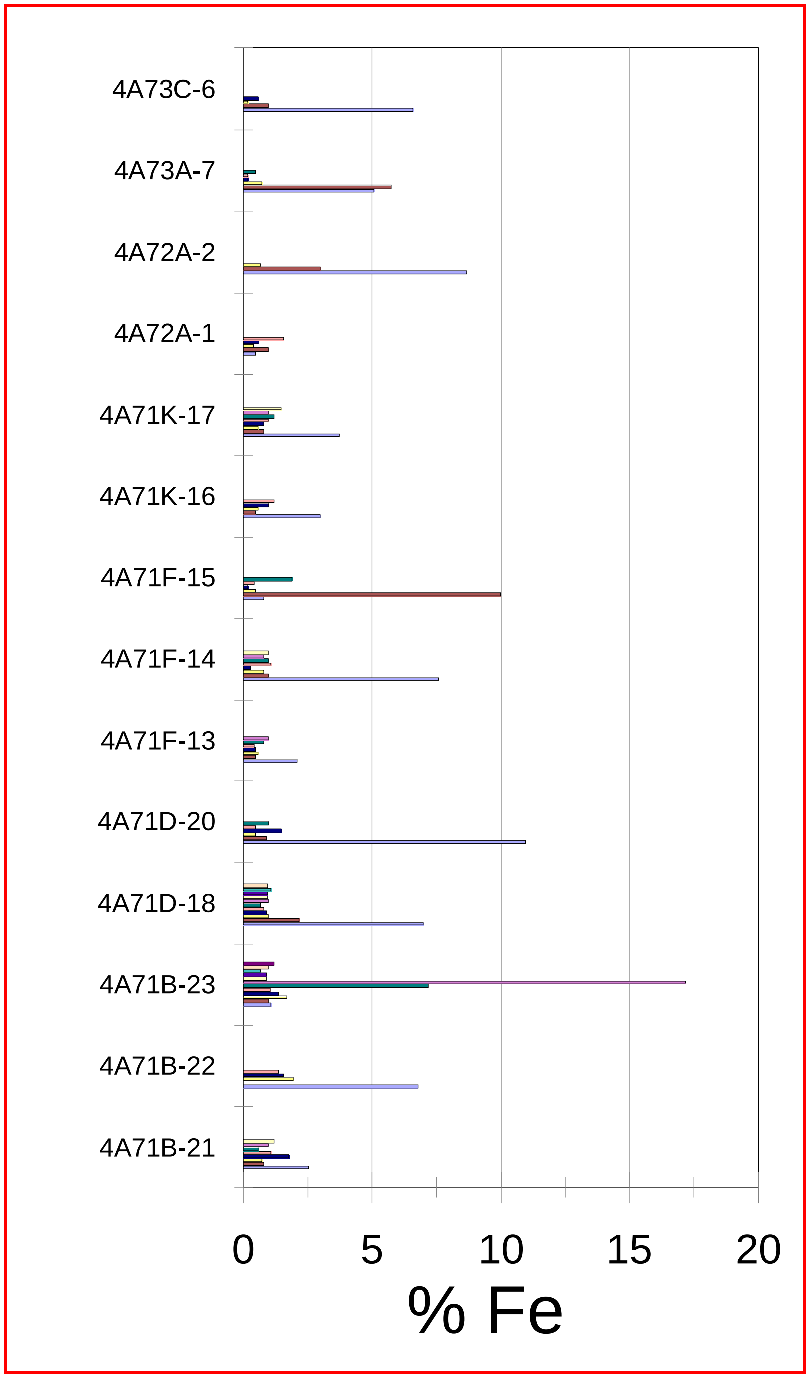
**APPENDIX**

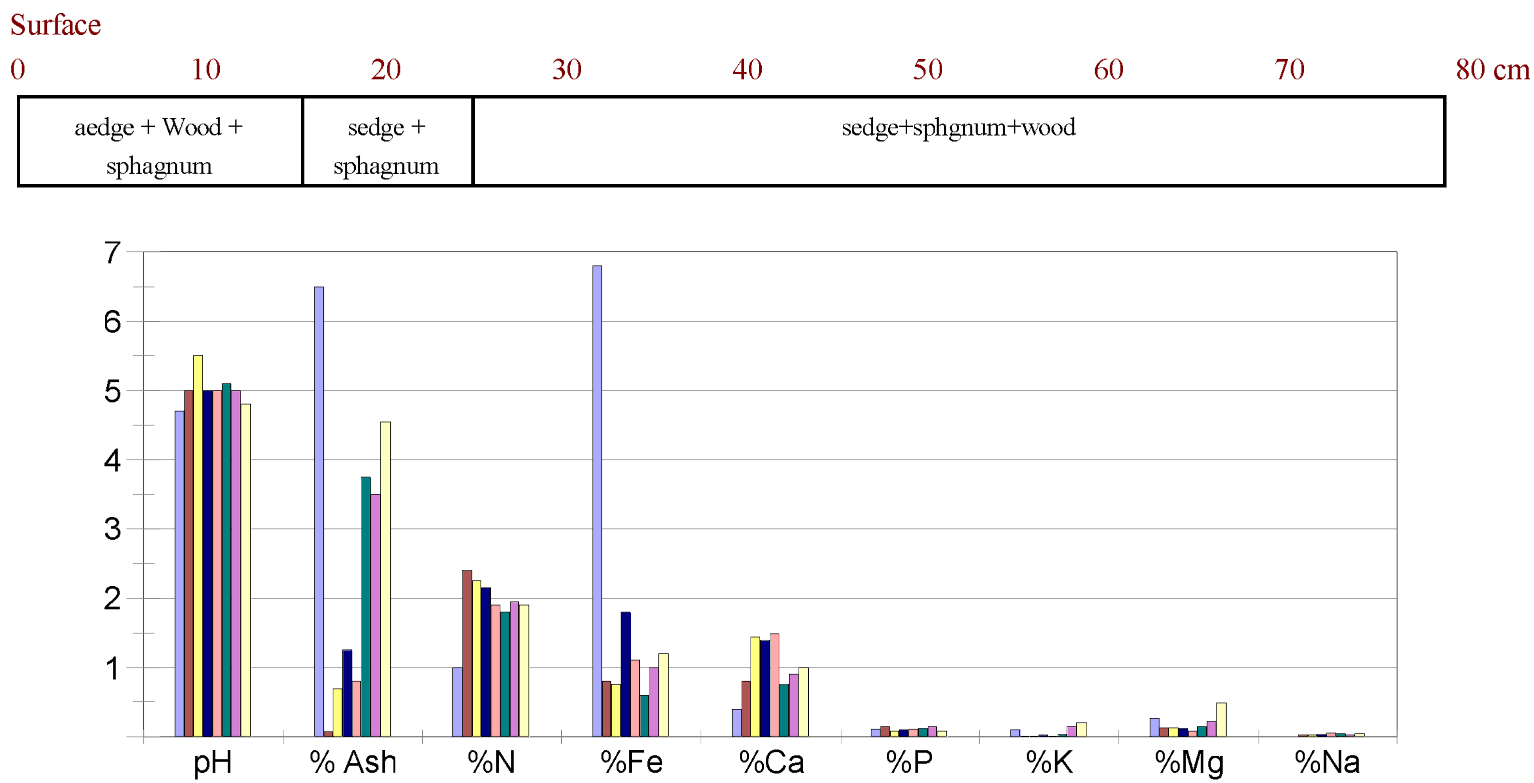
*Chemical Analysis of Peat Profiles L'anse Aux Meadows Norse Site*

A: % Fe Concentration at Various Depths of Peat Profiles

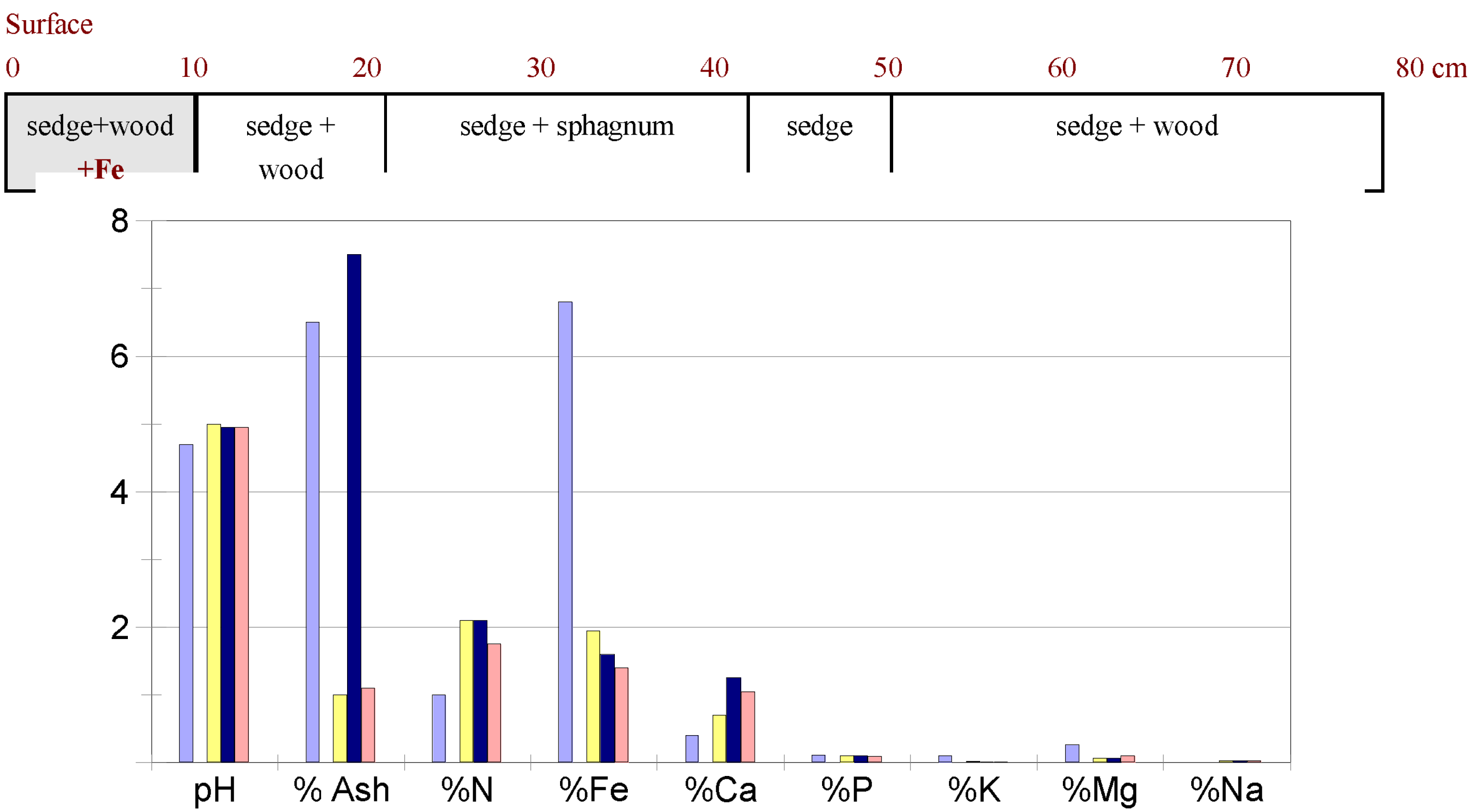


B: Examples of botanico-chemical analyses from deep peats
(strata with exceptionally high %Fe are shaded).

## Monolith 4A71B - 21 Silvo-Fibrosol



# Monolith 4A71B - 22 Silvo-Fibrosol

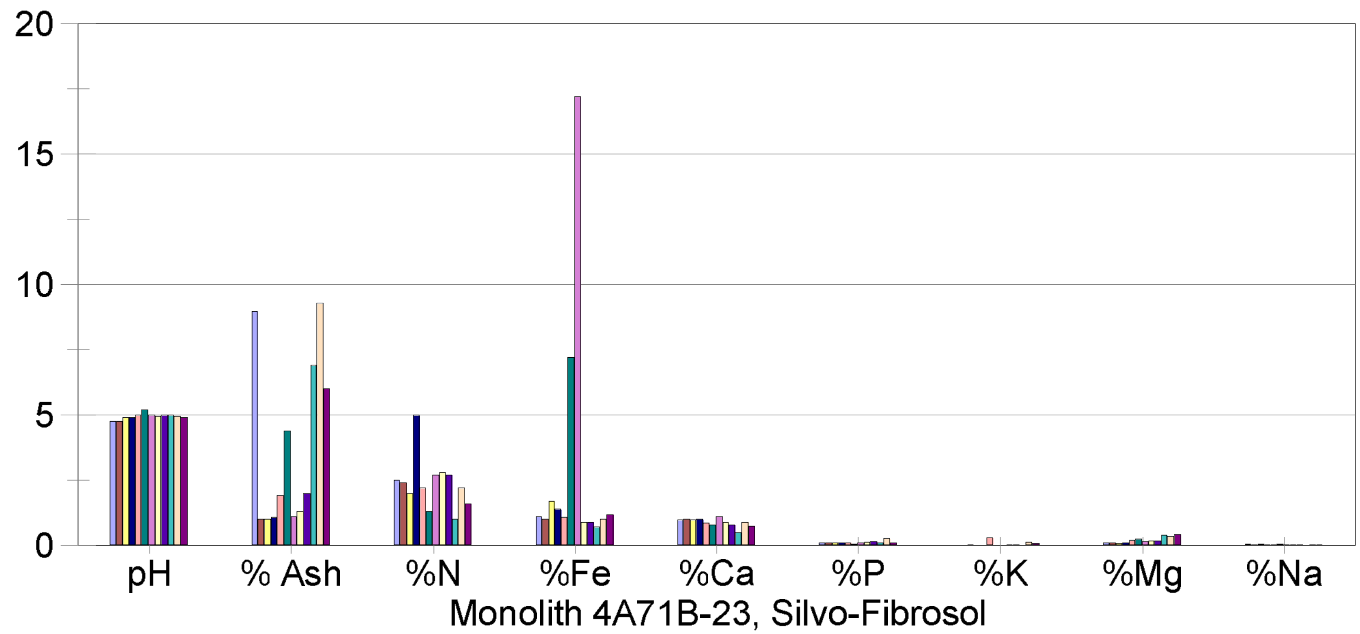


# Monolith 4A71B - 22  Silvo-Fibrosol

Surface

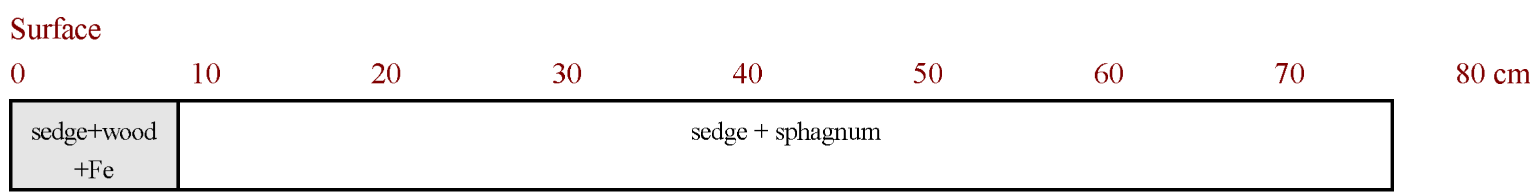
0 10 20 30 40 50 60 70 80 cm

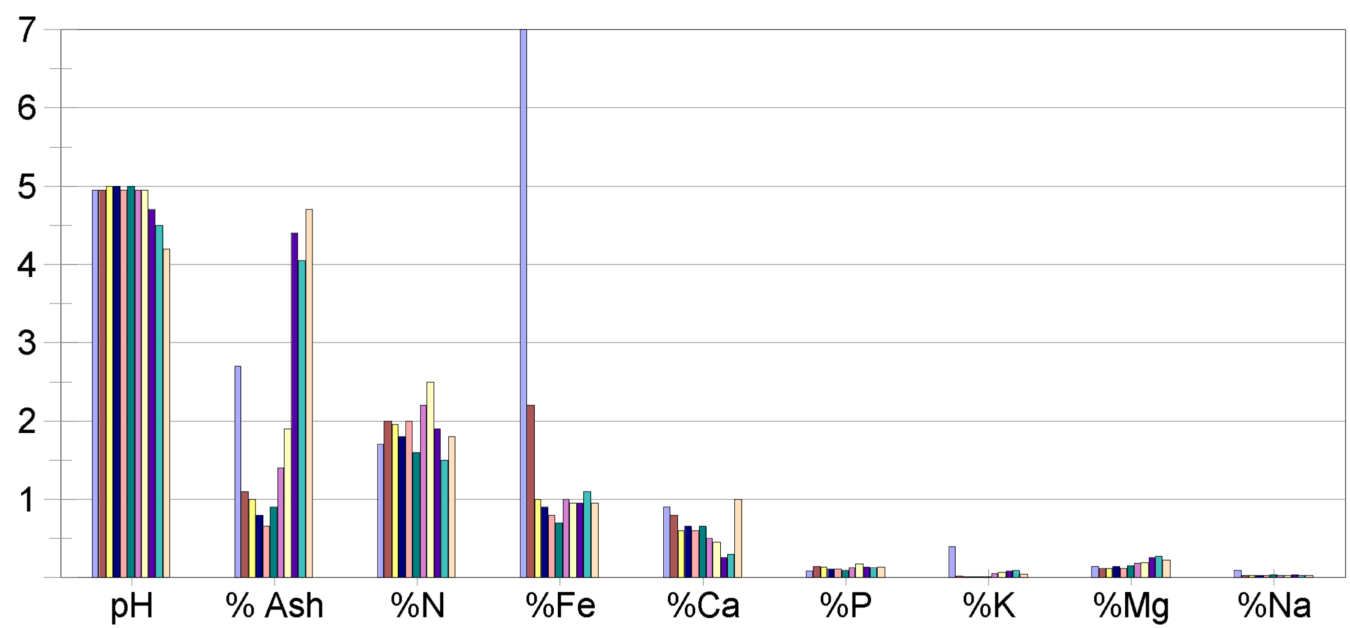
| | | | | |
|---|---|---|---|---|
| sphagnum | sedge + sphagnum | sedge | **Fe** | sedge + sphagnum |



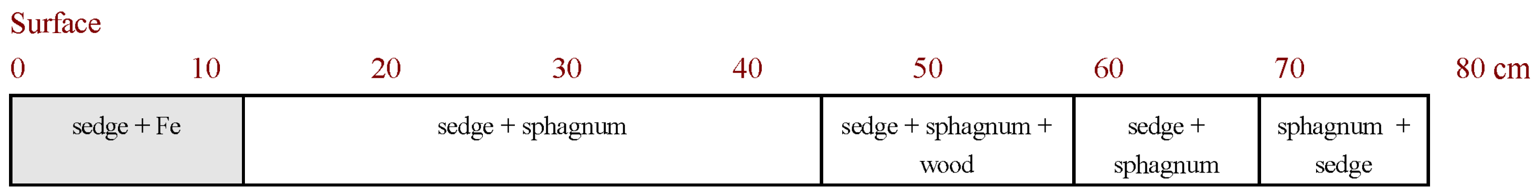

Mon
olith

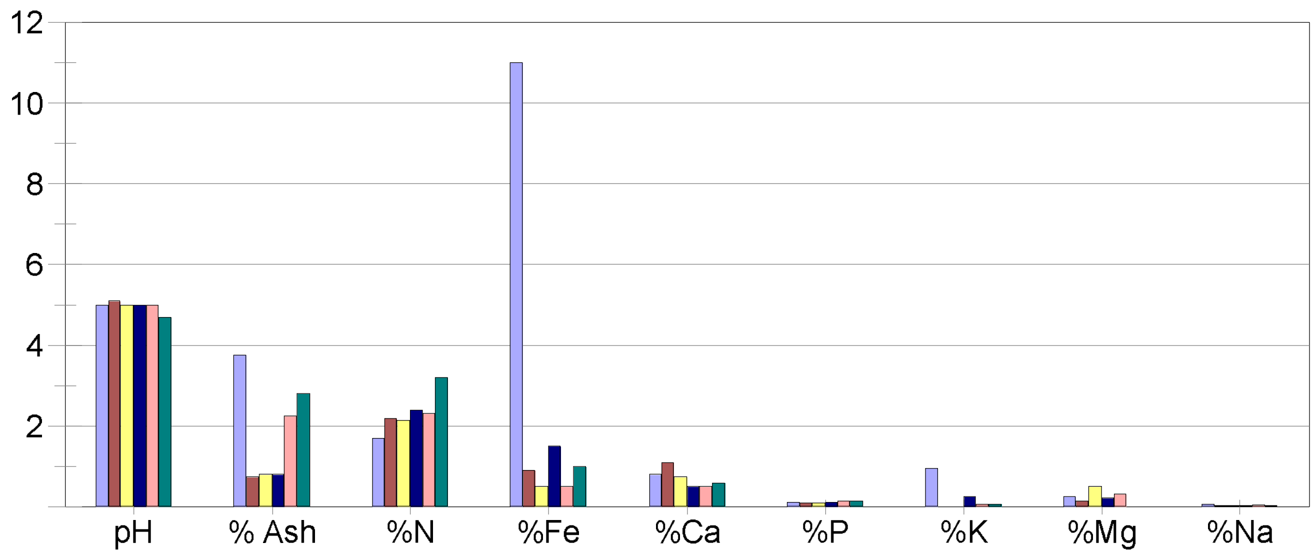
# 4A71D - 18 Feno-Fibrosol



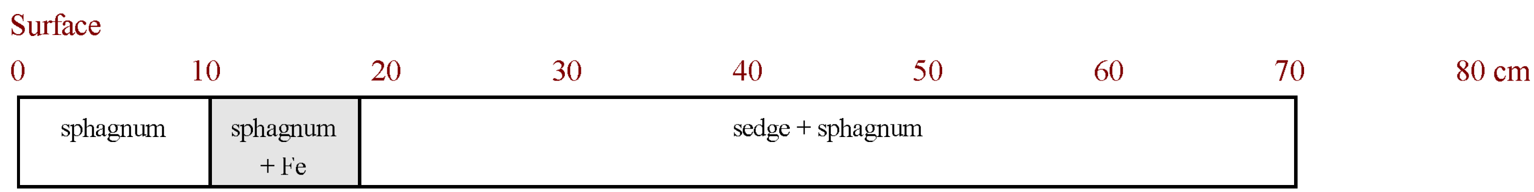
# Monolith 4A71D - 20 Feno-Fibrosol

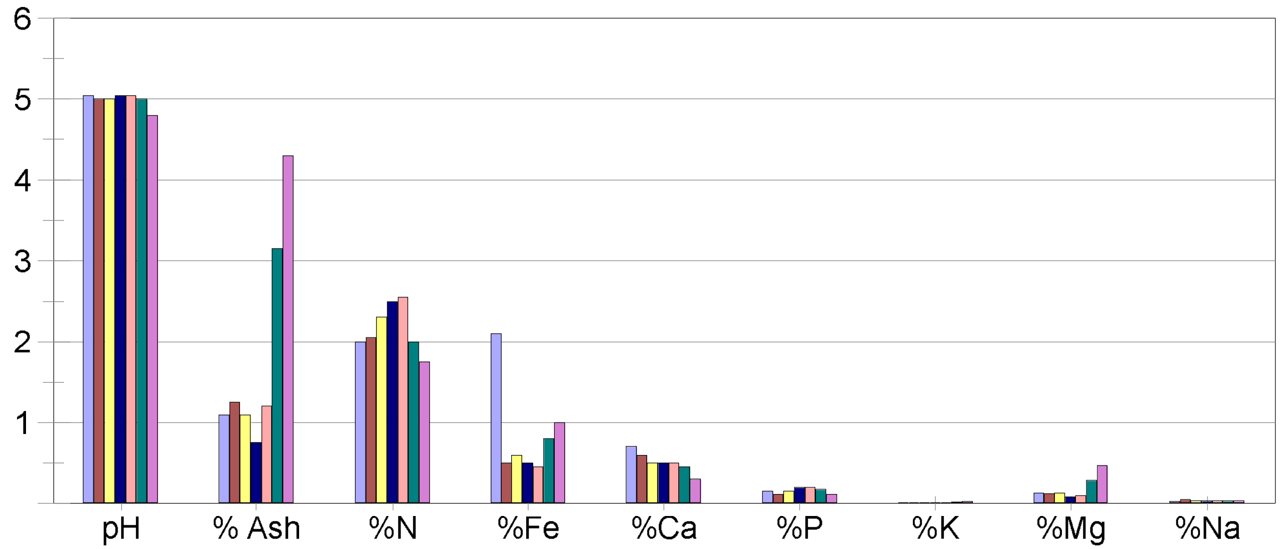





Monolith 4A71F - 13

Feno-Fibrosol


Surface
0
10
20
30
40
50
60
70
80 cm
sphagnum
sphagnum + Fe
sedge + sphagnum

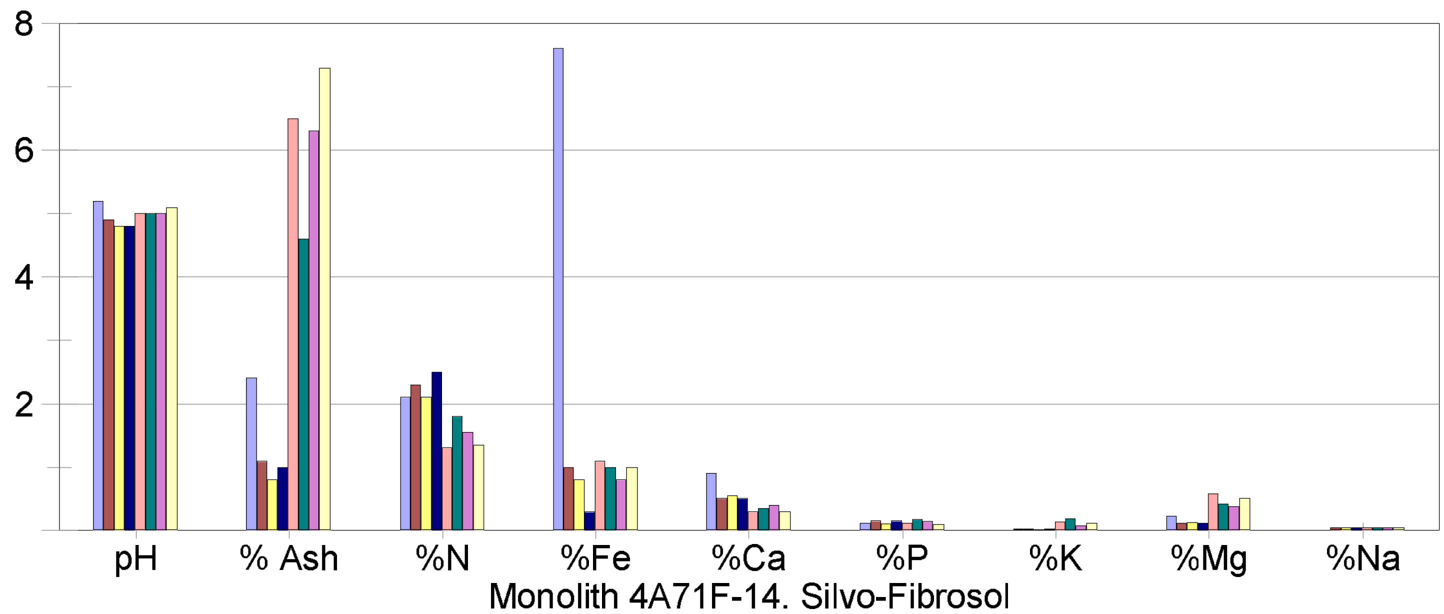

6
5
4
3
2
1
pH
% Ash
%N
%Fe
%Ca
%P
%K
%Mg
%Na

# Monolith 4A71F - 14 Feno-Fibrosol

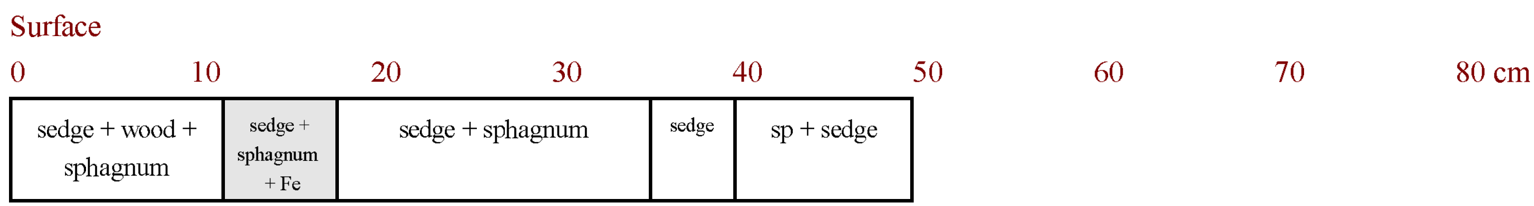
Surface

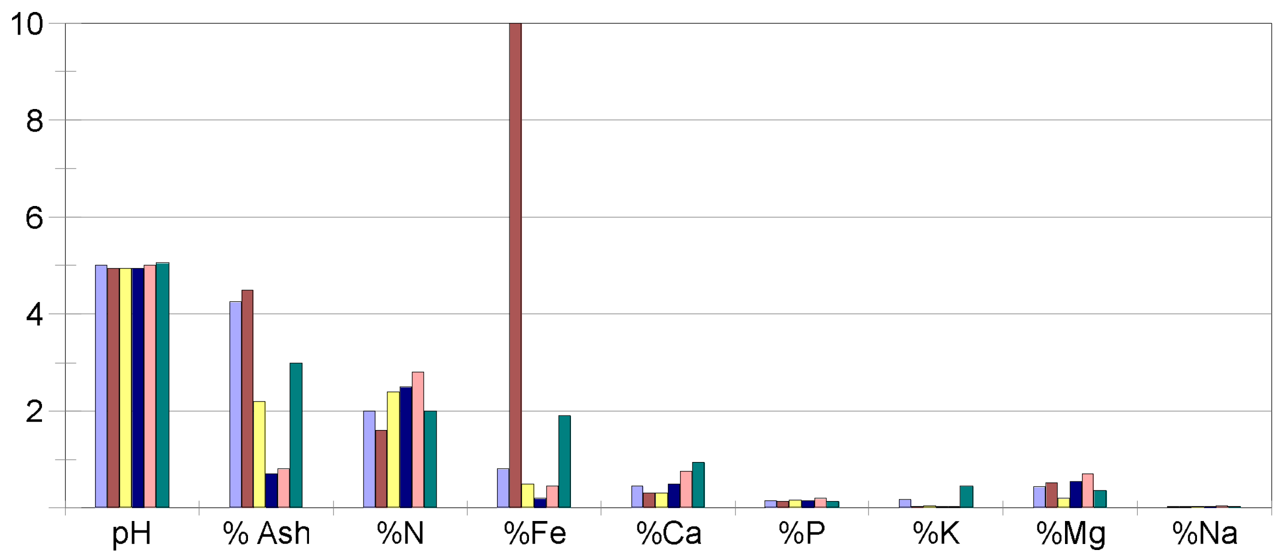
0 10 20 30 40 50 60 70 80 cm

| | | |
|---|---|---|
| sedge + sphagnum + Fe | sedge + sphagnum | cumulo |

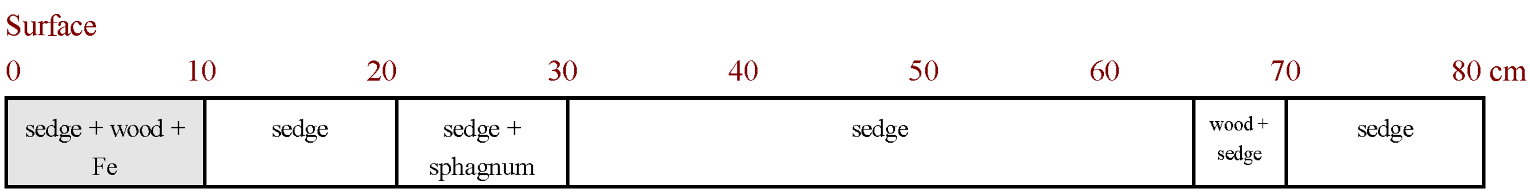

8
6
4
2
pH
% Ash
%N
%Fe
%Ca
%P
%K
%Mg
%Na
Monolith 4A71F-14. Silvo-Fibrosol

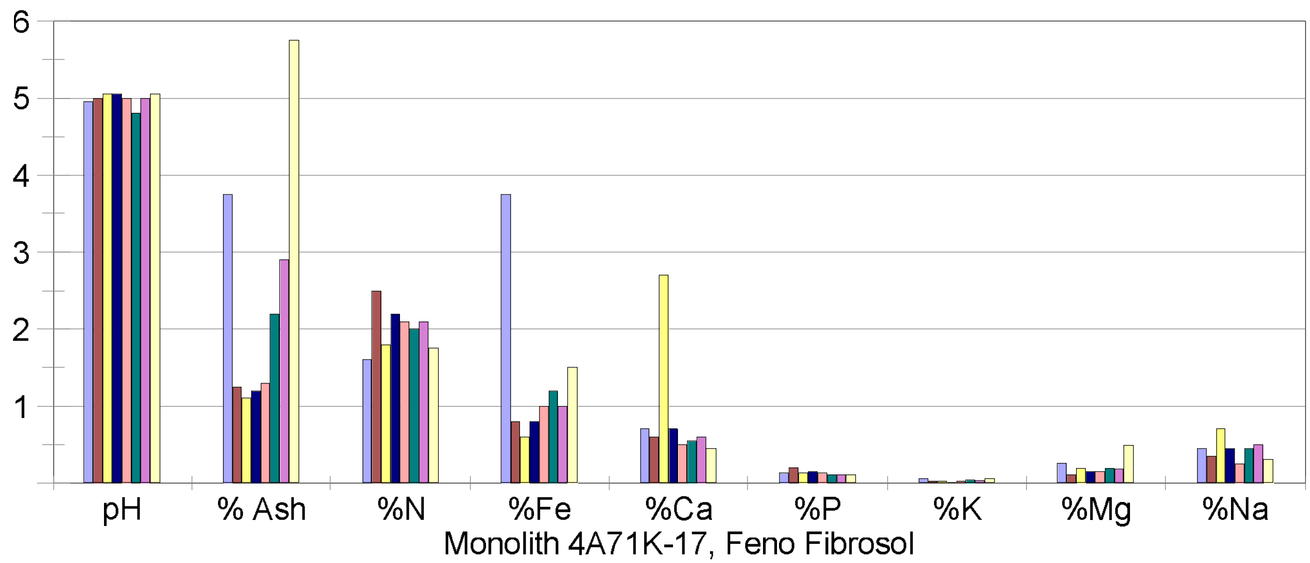
# Monolith 4A71F - 15 Sphagno-Fibrosol



# Monolith 4A71K - 17 Feno-Fibrosol




6
5
4
3
2
1
pH
% Ash
%N
%Fe
%Ca
%P
%K
%Mg
%Na
Monolith 4A71K-17, Feno Fibrosol