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ABSTRACT

Diatom and pollen analyses have been carried out on samples from three mires in northern Uppland in eastern Sweden. The mires are situated in basins with thresholds at 36.3 m, 42.0 m and 48.4 m above sea level. The isolations of two of the basins from the Litorina Sea were established by means of diatom analyses and radiocarbon age determinations at c. 5300 and 4100 B.P., respectively. At the third site isolation sediments were lacking, probably due to erosion and rapid shore displacement in combination with surrounding coarse glaciofluvial deposits. Pollen analytical levels dated are the *Ulmus* decline c. 4500 B.P. and the immigration of *Picea* c. 3000 to c. 2700 B.P.

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INTRODUCTION

Three mires were stratigraphically investigated in connection with the geological survey for the Quaternary map sheet Östhammar NV (Persson 1984) in northern Uppland. The rather flat map area is situated at altitudes between 25 and 50 m above sea level. The main part of the mires in the area were formed through overgrowth of ancient lakes (von Post & Granlund 1926). The largest and most well known mires in the area are Florarna which today is a nature reserve (Ingmar 1953, 1963). The mire Rässan in the eastern part of Florarna has been studied by Ericsson (1973). The mires investigated (Fig. 1) are located in basins with thresholds at 36.3 m, 42.0 m and 48.4 m above sea level.

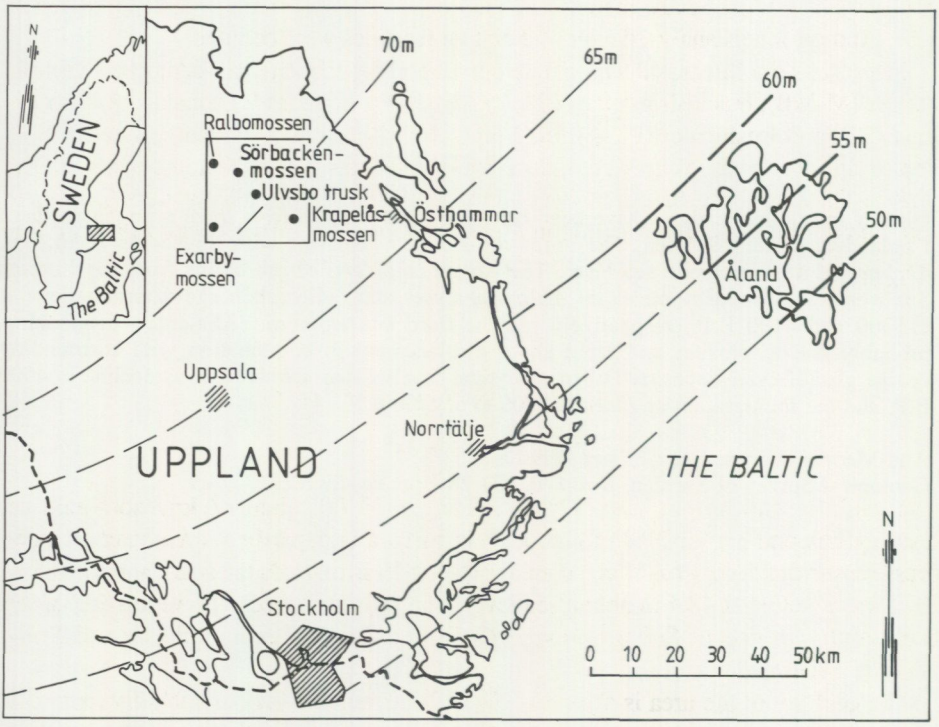

Fig. 1. Location of the map area Östhammar NV, the three mires investigated and other sites referred to in the text. Isobases for the highest Litorina shoreline on the Åland Islands according to Glückert (1978, Fig. 2).

SAMPLING AND ANALYSES

The field investigations were carried out in 1982 and 1983. The determination of the stratigraphy and sampling for analyses were performed with a Russian peat sampler of 5 cm diameter and 50 cm length. Parallel cores were taken in the organic sediments and peat layers in order to obtain material for radiocarbon datings.

The pollen and diatom analyses were carried out by Irma Ortman and Håkan Modig at the Micropaleontological laboratory, Geological Survey of Sweden. The radiocarbon datings were made at the Laboratory for Isotope Geology in Stockholm. The datings are calculated with the half-life 5568±30 years and the standard deviation 1 ∂. Age B.P. is given as conventional years before 1950.

Material for pollen analyses was concentrated according to conventional methods (Faegri & Iversen 1975). About 300 tree pollen were counted at each level analysed. The results are presented as silhouette curves for different trees. A total diagram is also included representing pollen of trees, shrubs and herbs (terrestrial plants).

Samples for diatom analyses were treated according to the method described by Miller (1964). The concentrated material was mounted in Aroclor with a refraction index of 1.67. At most levels analysed over 400 diatom frustules were counted.

The results are illustrated as separate curves for the different salt-ecological groups: marine (M-MB), brackish-marine (BM), brackish (B), brackish lagoonal (BL), halophilous (BF) and freshwater (FB-F) (cf. Miller & Robertsson 1979, Miller *et al.* 1979). Percentages for each group were calculated on the total sum of diatoms counted. The marine-brackish *Cocconeis scutellum*, the slightly halophilous (FB) genera *Fragilaria* spp. and the brackish water plankton *Melosira westii* var. *parva* occur with high frequencies and are presented as separate curves in the diagrams.

DESCRIPTION OF LOCALITIES

KRAPELÅSMOSSEN

The mire is situated at Lat. 59° 14', Long. 18° 00' about 7 km northeast of Österbybruk and 3 km NNW of Gubbo. It is partly a bog, partly a fen located in a depression surrounded by till-covered areas. The outlet is towards the south and the threshold was levelled at 48.4 m above sea level. The bog is ditched. The vegetation of the bog mainly consists of *Sphagnum* spp., *Calluna vulgaris, Ledum palustre* and *Eriophorum angustifolium.*

The geology of the area is shown in Fig. 2. The bedrock is dominated by leptite. A section through the bog (Fig. 3) shows that in the depression the till is covered by a thin layer of sand, gyttja clay, clayey gyttja and gyttja, together 0.6-1.0 m thick. In the upper part the gyttja is a red-coloured algal gyttja, which is overlain by *Phragmites* peat. The uppermost part of the organic strata consists of *Carex-Sphagnum* and

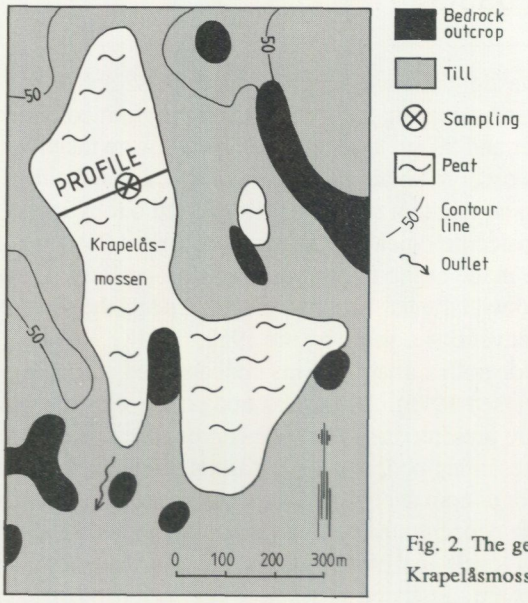

Fig. 2. The geology around Krapelåsmossen.

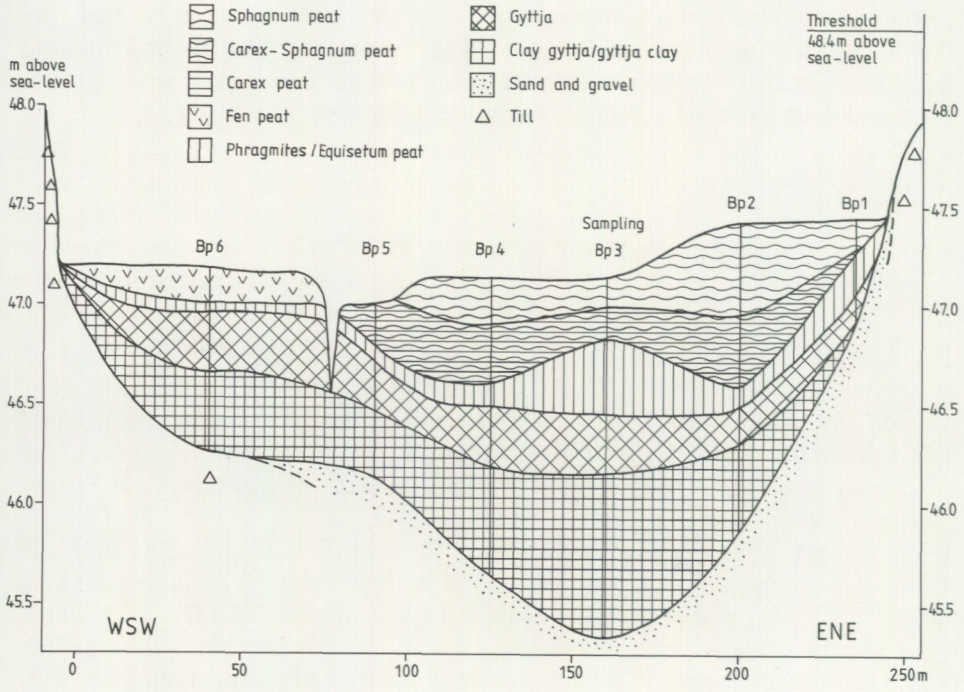

Fig. 3. Section through Krapelåsmossen.

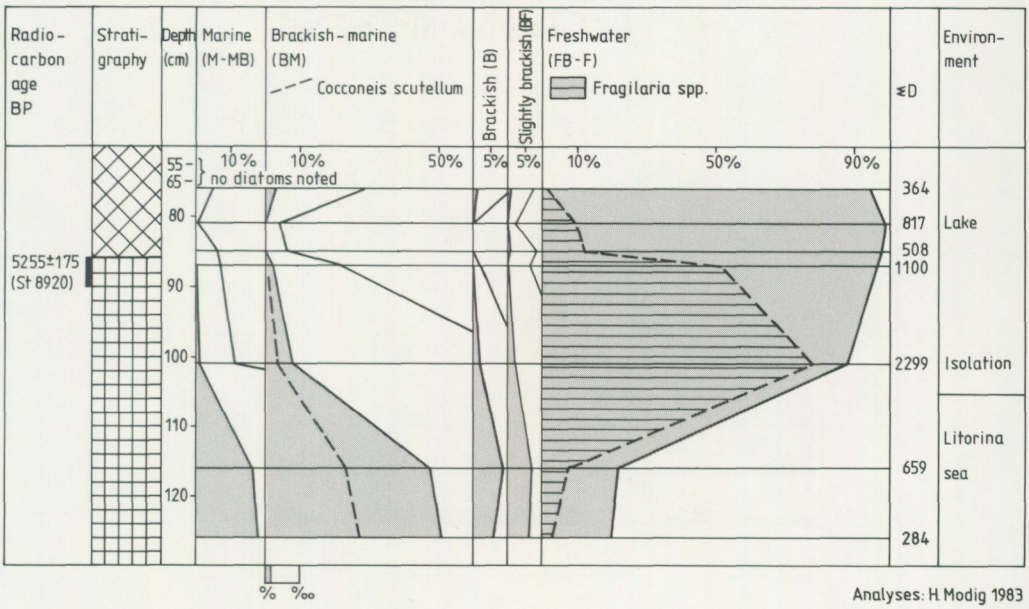

Fig. 4. Diatom diagram from Krapelåsmossen.

Sphagnum peat in the eastern part and of fen peat in the western part of the investigated mire.

Diatom analyses were carried out between 127.5 and 75 cm below surface (Fig. 4). At 65 and 55 cm no diatom frustules were noted. A marine and brackish-marine flora was found in the laminated gyttja clay and clay gyttja between 127.5 cm and 117.5 cm. Dominating species are *Cocconeis scutellum, Hyalodiscus scoticus, Grammatophora marina, G. oceanica* and *Rhabdonema arcuatum*. At 102.5-100 cm the marked increase of *Fragilaria* spp. represents the isolation of the basin from the Litorina Sea. The fresh water flora in the gyttja between 85 and 75 cm is predominated by *Navicula radiosa, N. oblonga, Cymbella cymbiformis, C. aequalis, C.* spp. and *Anomoeoneis exilis*.

According to the stratigraphy and the composition of the diatom flora the isolation took place during the deposition of the upper part of the clayey gyttja. The transition between clayey gyttja and gyttja indicates the end of the isolation process, c. 5300 B.P. according to a 14C-dating of the clayey gyttja between 90 and 86 cm below surface.

The pollen-analytical results are shown in Fig. 5. *Pinus* and *Betula* dominate with 30-50% each, *Alnus* and *Corylus* reach c. 10 and 5% respectively throughout the sequence. Pollen of QM are represented by *Quercus* and *Ulmus* (1-5%), *Tilia* and *Fraxinus* do not exceed 3%. In the *Phragmites*-peat at 58-52 cm there is a minimum for QM dated at 4000±115 B.P. At the top of the sequence the immigration of *Picea* is reflected.

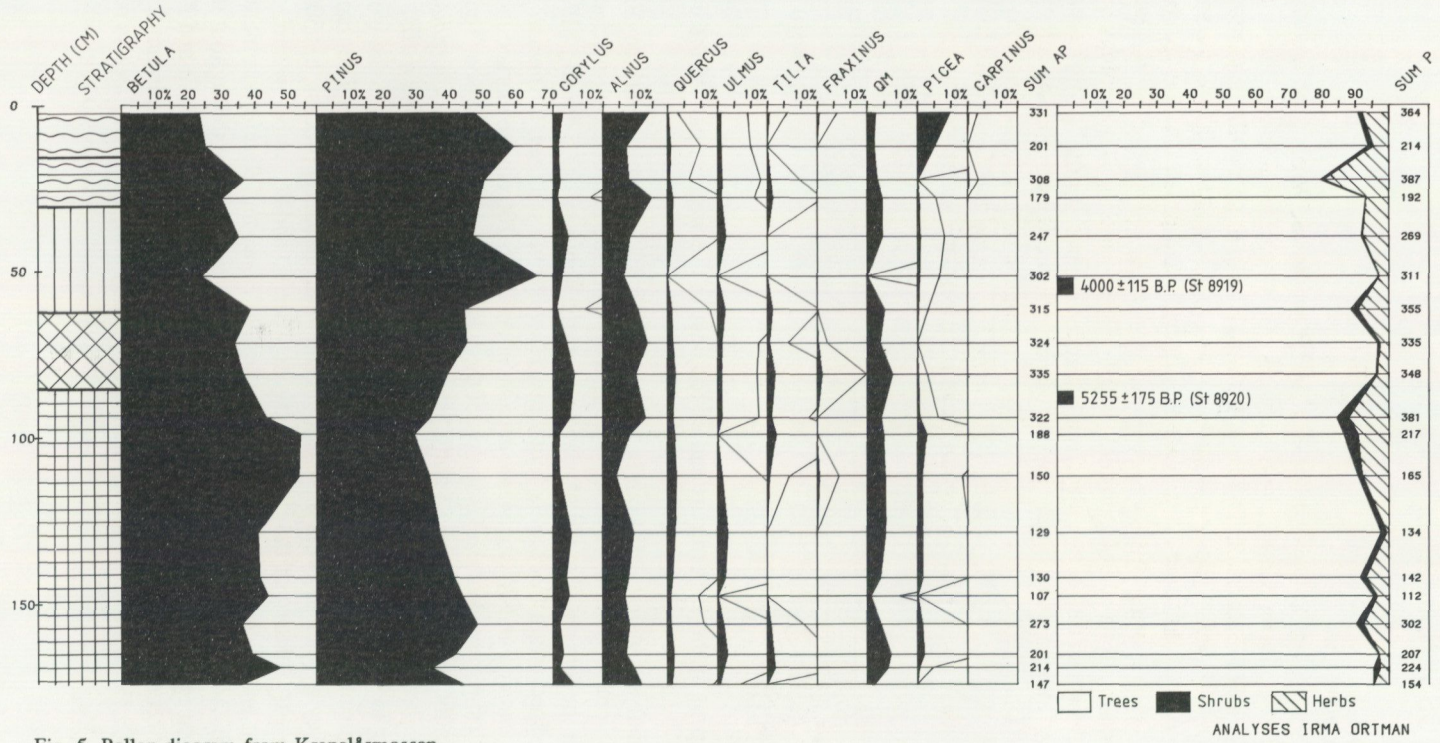

Fig. 5. Pollen diagram from Krapelåsmossen.

EXARBYMOSSEN

The mire is situated at Lat. 59° 13', Long. 17° 39' 4 km SSW of Tobo and 1.7 km SSE of Exarby in a basin between two branches of a glaciofluvial esker. The outlet is towards NNW and the threshold is a very distinct ridge built up by till. It was levelled at 42.0 m above sea level. The bog is ditched. The surface is rather flat and the vegetation is dominated by different ericaceous dwarf shrubs and pines. The western part of the mire is a fen dominated by *Carex*, but also covered by spruce and birch. The bedrock in the area consists of old granitoids more or less gneissose. The geology around the basin is shown in Fig. 6 and a section through the mire in Fig. 7. The lowermost sediment is a fine-grained glacial clay, 1 to nearly 5 m thick covered by rather thin layers of sand and gravel and postglacial clay. The organic part of the stratigraphy starts with a thin layer of clay gyttja covered by *Carex-Sphagnum* and *Carex* peat less than 1 m thick. In the eastern part *Sphagnum* peat, c. 0.5 m thick forms the top layer.

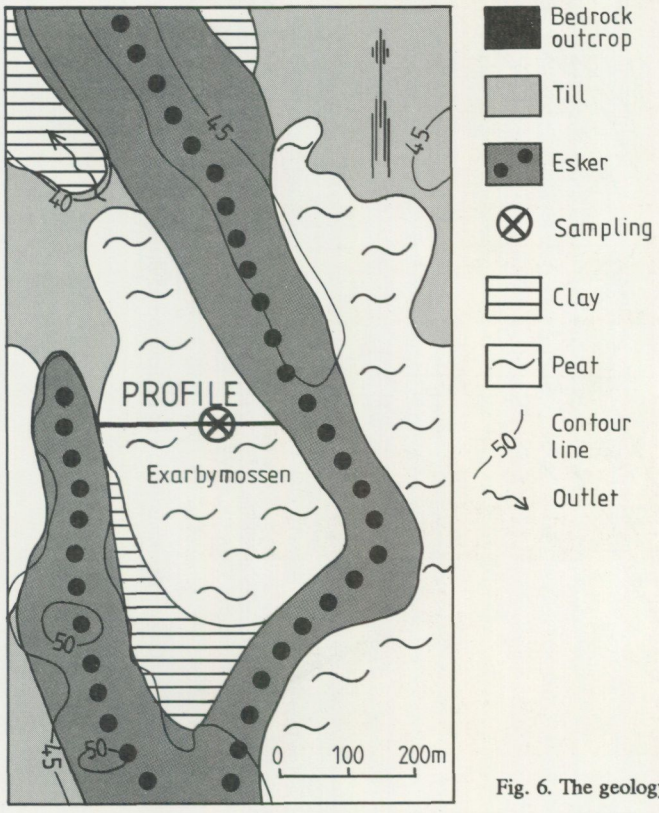

Fig. 6. The geology around Exarbymossen.

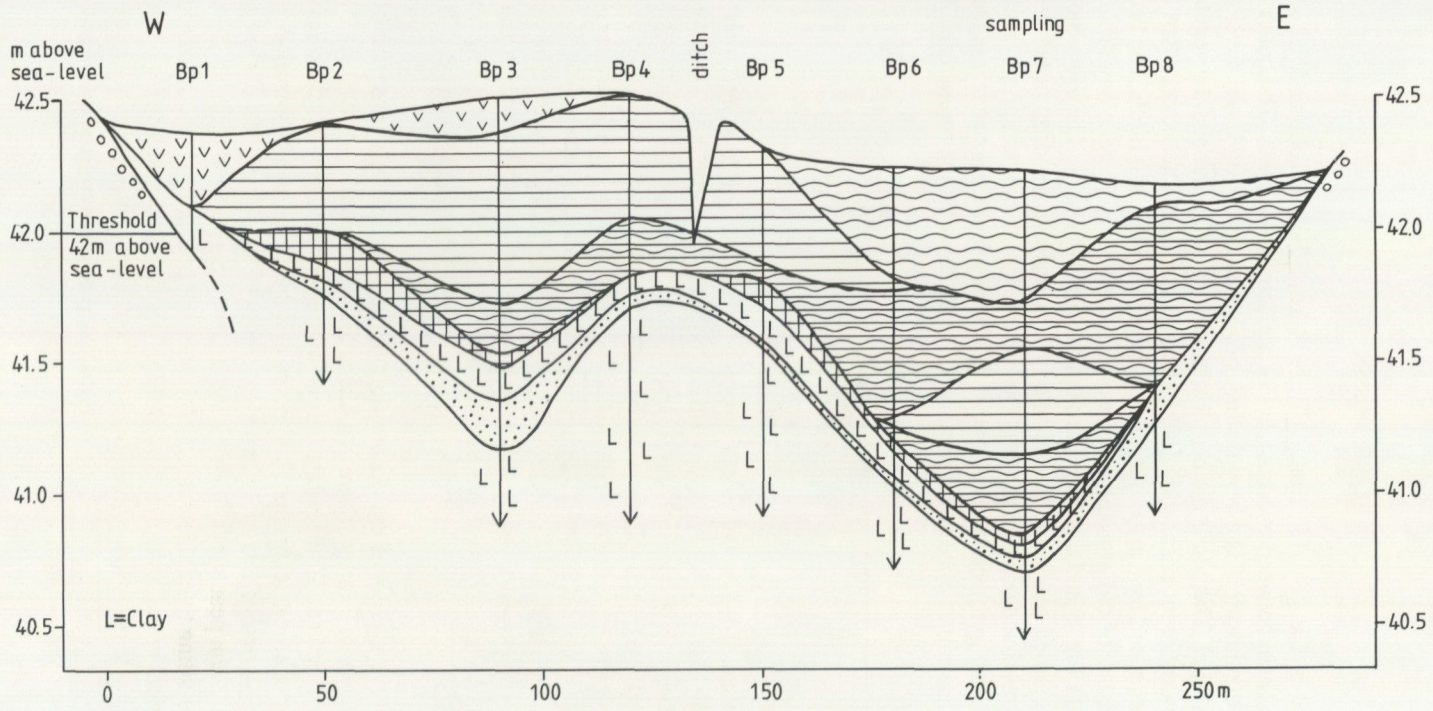

Fig. 7. Section through Exarbymossen. For explanation of the symbols, see Fig. 3.

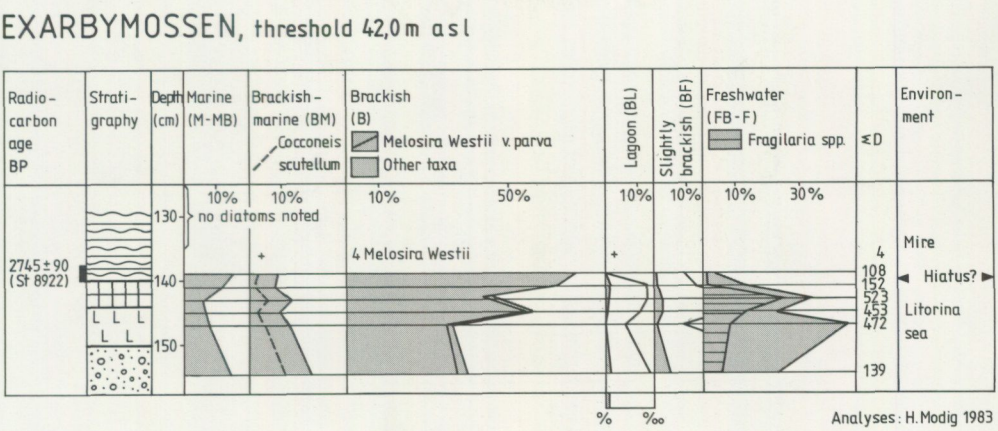

Fig. 8. Diatom diagram from Exarbymossen.

Diatom analyses were made on the sequence between 168 and 127.5 cm below surface. At 168–160 and 137.5–127.5 cm no diatoms were noted. The results of the quantitative analyses between 154 and 139 cm are shown in Fig. 8. The marine group is mainly represented by the coastal plankton *Melosira sulcata* occurring with low frequencies. Brackish-marine taxa dominated by *Grammatophora* spp., *Achnanthes brevipes, Cocconeis scutellum* and *Hyalodiscus scoticus* reach moderate values. The four uppermost diatom spectra at 145–139 cm are dominated by the brackish water plankton *Melosira westii* var. *parva*, which reaches over 70% at 139 cm. Diatoms living in a lagoonal and slightly brackish environment (halophilous) are represented by very low frequencies in all samples analysed. *Fragilaria* has a maximum at 143 cm, indicating the start of an isolation.

According to the composition of the diatom flora no distinct isolation phase can be traced in the stratigraphy at Exarby. There is a hiatus between the thin layer of clayey gyttja and the overlaying peat. The absence of isolation sediments may be caused by erosion in connection with the regression. The permeable esker sediments surrounding the basin may have contributed to a rapid drainage, followed by a drying up of the basin. The *Carex-Sphagnum* peat superimposing the brackish clay gyttja began to form after c. 2800 B.P. according to the radiocarbon dating of the peat at 140–135 cm depth.

The pollen analytical results are presented in Fig. 9. The pollen frequencies in the samples below 130 cm depth, were so low that no quantitative analyses could be performed. The tree pollen spectra in the organic layers show high values for *Picea, Pinus* and *Betula*. The organic part of the sequence was deposited during the Sub-Atlantic per-

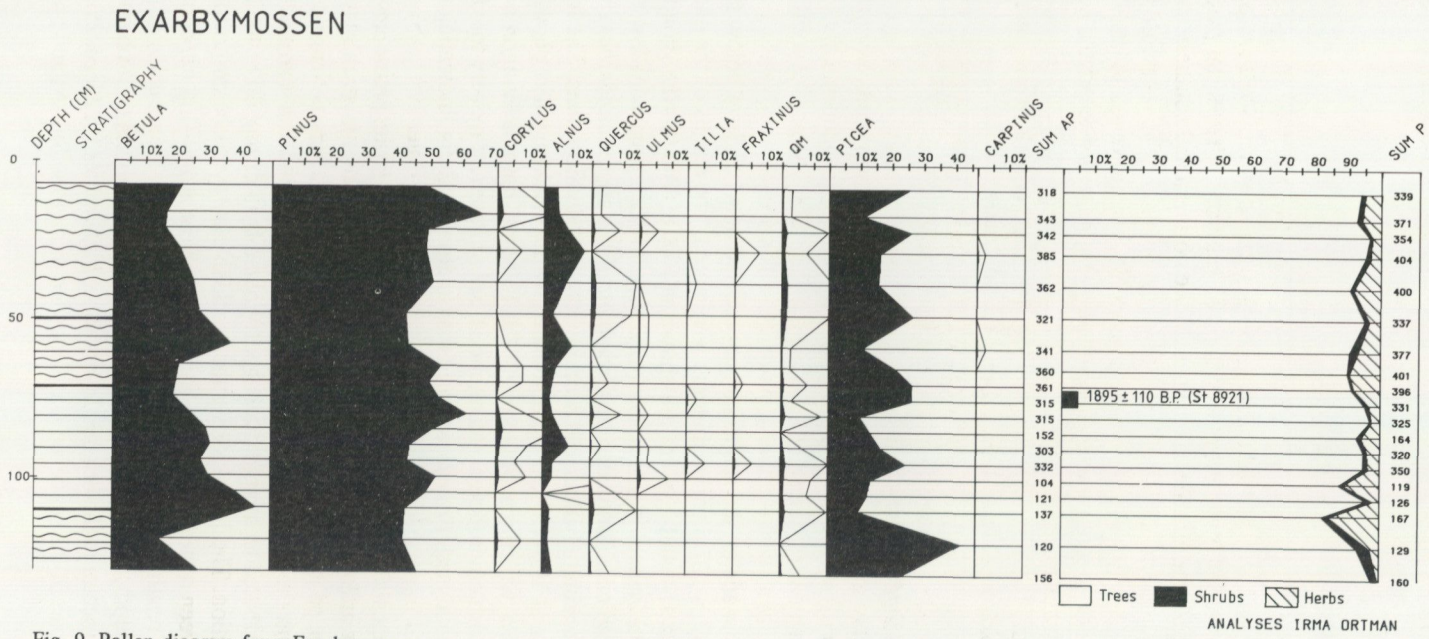

Fig. 9. Pollen diagram from Exarbymossen.

iod after the immigration of *Picea*. A radiocarbon dating of the *Carex-Sphagnum* peat at 140–135 cm gave 2745±90 B.P.

RALBOMOSSEN

The mire is located at Lat. 60° 21', Long. 17° 39' about 10 km NNW of Tobo and 500 m northwest of Ralbo. The small lake Trusksjön is situated in the southern part of the mire, which is surrounded by till areas with bedrock outcrops. The central part of the mire is covered by Sphagna, Ericales and pines. In the northern and southern parts the bog is surrounded by a fen area. The outlet is towards the south. The threshold for the investigated southern part of the mire was levelled at 36.3 m above sea level. The northern part of the mire is drained towards the southwest. The mire is ditched and peat pits are found in the southwestern part.

The geology around the basin is illustrated in Fig. 10. The bedrock in the area is dominated by old granitoids more or less gneissose.

Fig. 11 shows the stratigraphy in the southern part of the mire. In the northern part only two borings were made. The sediments in the lowermost part of the basin consists of glacial and postglacial clay, overlain by 5–10 cm sand and gravel. This layer is covered by gyttja clay, clay gyttja and gyttja. The peat strata are from the bottom and upwards composed of *Phragmites* and *Equisetum, Carex, Carex-Sphagnum* and *Sphagnum*. Different layers of wood were observed in the peat (Fig. 11). The boring points 6 and 11 were sampled for analyses. At boring point 9 there is a narrowing of the mire and decreased thickness of organic layers marking a threshold between the southern and northern part of the mire.

The different peat layers in Ralbomossen have been specially studied regarding the quantity of uranium and radio-activity (Fredriksson *et al.* 1984a) as well as sulphur, nitrogen and trace elements (Fredriksson *et al.* 1984b).

The composition of the diatom flora in the sediments between 300 and 270 cm at bp 6 is illustrated in Fig. 12. The clay gyttja and the lower part of the gyttja were deposited in the Litorina Sea. The marine diatoms (M-MB) are represented i.a. by *Melosira sulcata, Navicula flanatica*, and *N. ammophila*. At 284–276 cm *Navicula scopulorum* v. *belgica* f. *suecica* was noted. The ecology of this taxon is hardly known. It has been observed in the fossil flora of Åland and Valdemarsvik (Cleve-Euler 1951–55) but not among living diatoms in the Baltic (Tynni 1975). In the brackish-marine group *Cocconeis scutellum* dominates, as does *Melosira westii* v. *parva* among brackish water diatoms. The isolation of the basin is indicated by high frequencies of *Fragilaria* spp. The dating of the algal gyttja at 284–280 cm shows that the isolation had started 4070±190 B.P. The gyttja at 274–270 cm dated at 3335±190 B.P. was deposited in freshwater after the isolation. The lengthy isolation may have been caused by retarded shore displacement between c. 4000 and c. 3400 B.P. or by erosion of the threshold area.

After 4000 B.P. the Litorina Sea had a transgressive phase in southern Sweden as described from eastern Svealand (Miller 1973, Brunnberg *et al.* 1985) and Blekinge (Berglund 1971).

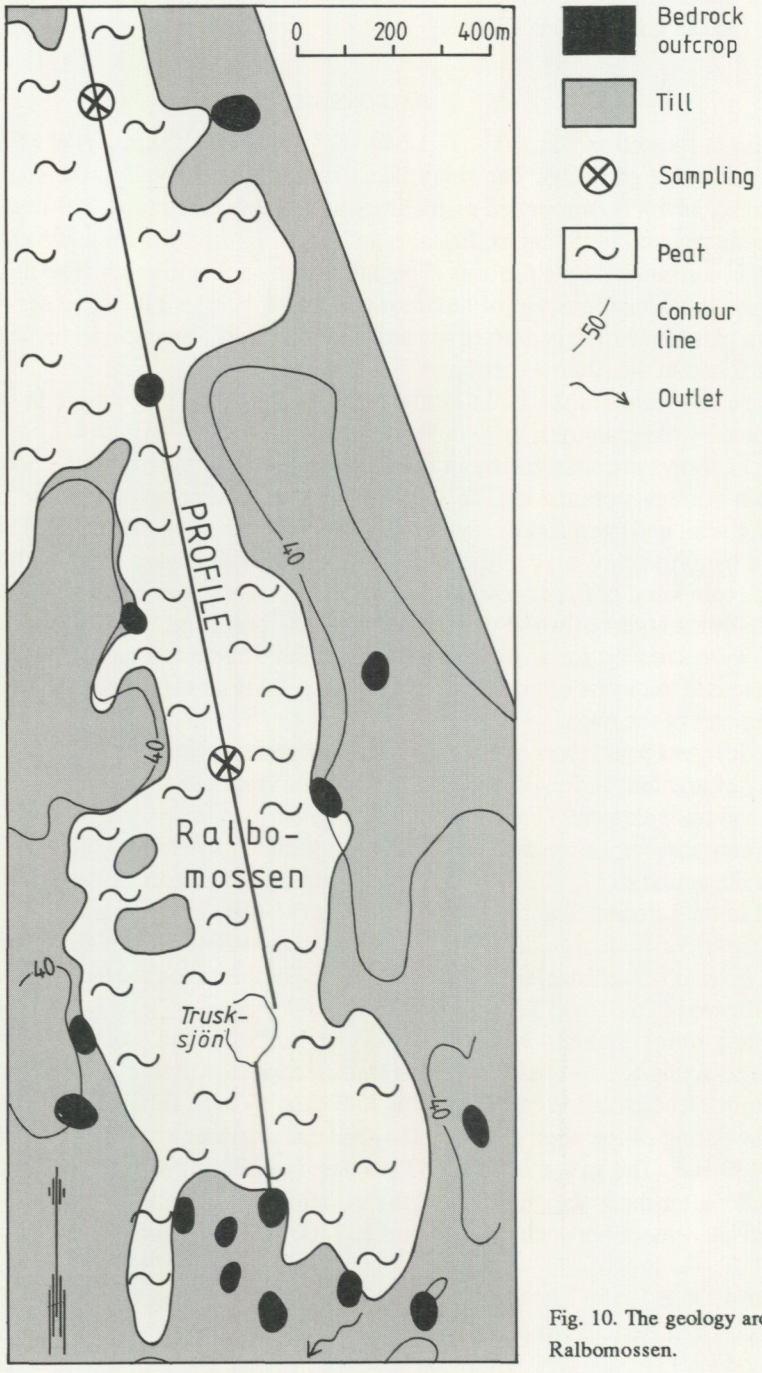

Fig. 10. The geology around Ralbomossen.

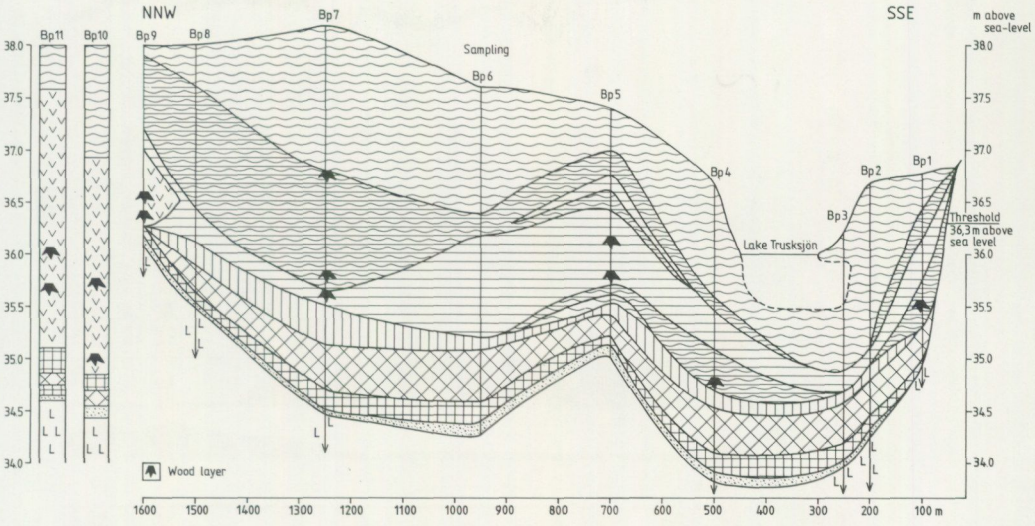

Fig. 11. Section through Ralbomossen. For explanation of the symbols, see Fig. 3.

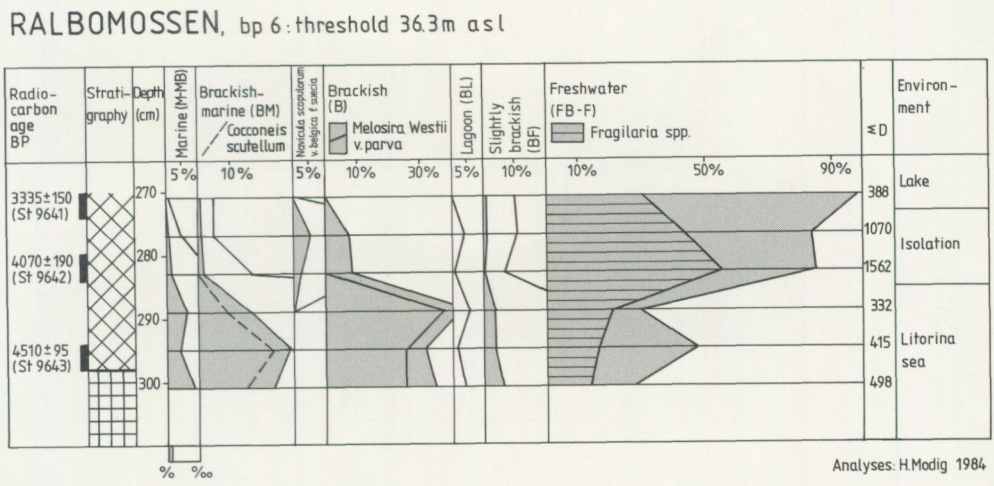

Fig. 12. Diatom diagram from Ralbomossen.

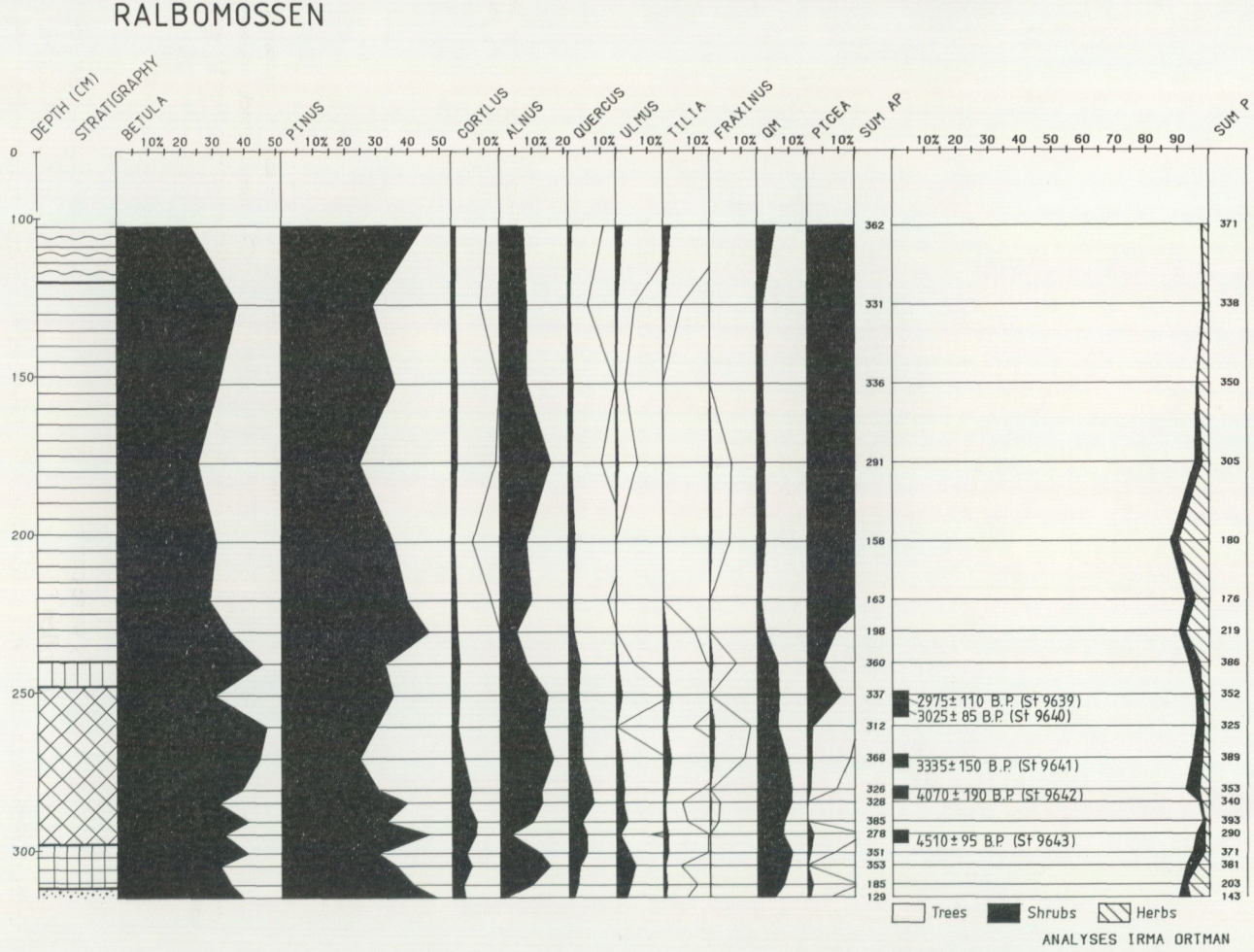

Fig. 13. Pollen diagram from Ralbomossen.

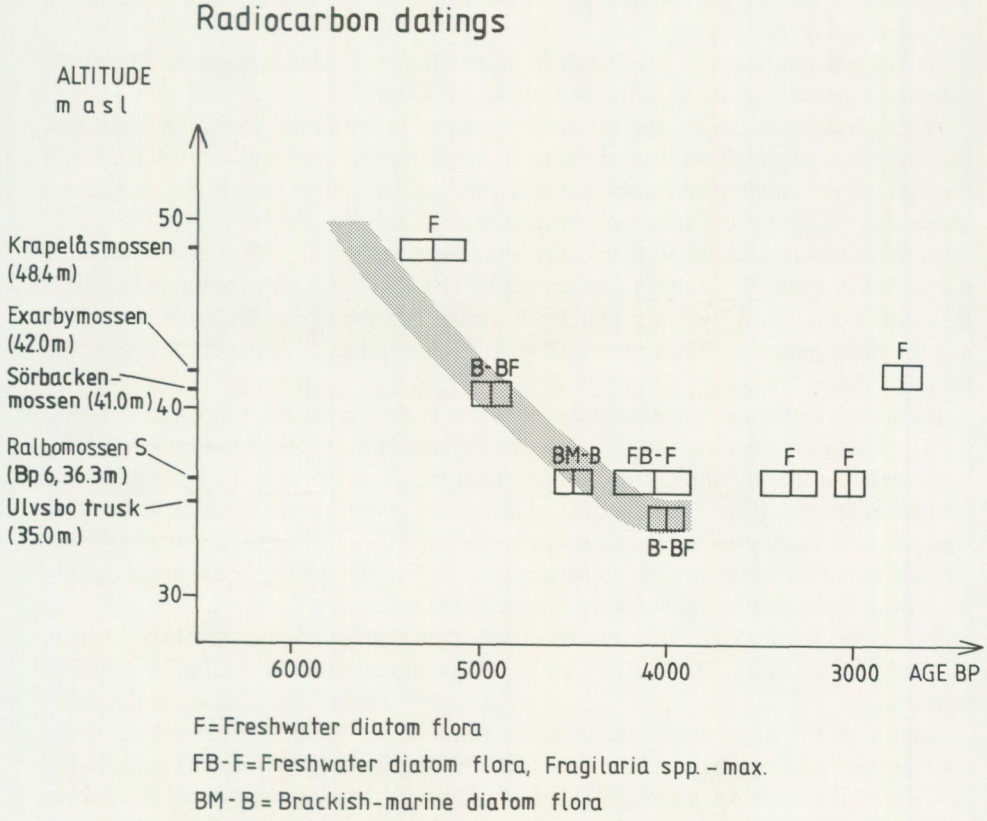

Fig. 14. Radiocarbon datings of samples from the three mires studied. A tentative shore displacement curve (shaded area) for the interval c. 5500–3500 B.P. has been established. The mires Sörbackenmossen (altitude 41.0 m) and Ulvsbo trusk (altitude 35.0 m) in the Florarna area studied by Ingmar (unpublished) and dated by Olsson (Olsson & Piyanuj 1965) are included.

At bp 6 pollen analyses were carried out on samples from 315 to 100 cm below surface (Fig. 13). The tree pollen flora in the lower part is composed of *Betula*, *Pinus* and *Alnus*. Among thermophilous trees *Corylus*, *Quercus* and *Ulmus* occur with c. 5% each. There is a marked decrease of *Ulmus* just above 300 cm dated at 4510±90 B.P. The immigration of *Picea* took place at c. 3000 B.P. according to the dating of the gyttja at 258–254 cm, 3025±85 B.P.

CONCLUSIONS

The results of the radiocarbon datings and the diatom analyses of the samples dated are compiled in Fig. 14.

In Krapelåsmossen with the threshold at an altitude of 48.4 m above sea level the isolation process from the Litorina Sea ended *c.* 5300 B.P.

In Exarbymossen the isolation is not represented in the strata. This is caused either by erosion or rapid shore displacement in combination with drainage of the basin through the surrounding permeable esker sediments. The pollen flora in Exarbymossen shows that the spread of *Picea* took place after *c.* 2700 B.P.

In the southern basin of Ralbomossen with the threshold at 36.3 m above sea level the isolation from the Litorina Sea started c. 4100 B.P. and was completed c. 3500 B.P. Pollen-analytical levels dated in Ralbomossen are the *Ulmus* decline c. 4500 B.P. and the immigration of *Picea* after c. 3000 B.P. The spread of *Picea* in the region has been dated at c. 2900 B.P. (Olsson & Piyanuj 1965).

Radiocarbon datings of the isolation of basins in the mire district Florarna in northern Uppland have been made by Olsson and Piyanuj (1965). The isolation levels have been determined by means of diatom analyses carried out by T. Ingmar. In Sörbackenmossen (Fig. 1) situated 41 m above sea level the transition from brackish water to freshwater environment was dated 4990±90 B.P. (U 451). This locality is situated at about the same altitude above sea level as Exarby, which should consequently have been isolated at about the same time, c. 5000 B.P.

In Ulvsbo trusk (Fig. 1) 35 m above sea level the isolation phase was dated at 4030±90 B.P. (U 225). This is in very good agreement with the results from Ralbomossen.

Studies of the shore displacement of the Litorina Sea have been carried out in the southern part of Uppland by Granlund (1928, 1931), Florin (1944), Åse (1970), Miller (1973), Miller & Robertsson (1981), Miller (1982), Brunnberg, Miller & Risberg (1985). The highest level of the Litorina Sea, the so called Litorina Limit is supposed to be situated 50–55 m above sea level in southern Uppland. Detailed studies on the Åland Islands by Glückert (1978) show that the Litorina Limit is found at an altitude of c. 50 m in the southeastern part and at c. 60 m in the northwestern part of the islands. In the northern part of Uppland including the area studied, the Litorina Limit probably is situated around c. 70 m (Agrell 1979). This altitude is however uncertain as very small areas reached above the sea level when the Litorina Limit was formed.

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