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LATE-GLACIAL STRATIGRAPHY IN ESTONIA

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Abstract. The Late-Glacial interval in Estonia starts from the accumulation of Raunis Interstadial deposits in central Latvia about 13 500 yr BP and ends 10 000 ^{14}C years ago. In 1993, a new official stratigraphical chart of Estonian Late-Glacial deposits, described in the paper, was accepted. In the light of the evidence provided by complex investigations, the ice cover started to retreat from the Haanja belt in the Bølling about 13 000 years ago. Estonia became free of ice during the second half of the Allerød.

Key words: Late-Glacial, stratigraphical chart, marine and continental deposits, stratotypes, stadials and interstadials, pollen assemblage zone, Estonia.

INTRODUCTION

On 6 May 1993 a new official stratigraphical chart of Estonian Late-Glacial deposits was accepted at the session of the Estonian Commission of Stratigraphy (Table 1). A week later it was approved by the 2nd Baltic Stratigraphic Conference in Vilnius (9—14 May). The chart was compiled by the authors of this paper and it is mainly based on the long-term palynological investigations by Reet Pirrus. In Estonia the Late-Glacial deposits above till beds are represented by different clays, silts, and sands comprising plant remains or interlayers, which can be, at least partly, redeposited. This hampers their ^{14}C dating. As those deposits often rest upon the carbonaceous bedrock or limy till, the dating results are significantly affected by the hard water and reservoir effect. Most of the stadials are almost entirely based on lithostratigraphy; biostratigraphical evidence has been considered to a lesser degree.

Marine nearshore sections abound in hiatuses. Pollen grains and spores in these sediments are often repeatedly redeposited. Glacial varved clays have a poor record of the palaeomagnetic field and sedimentological factors produce spurious variations of comparable amplitude to palaeosecular variations. Owing to the above problems the establishment of boundary stratotypes for Late-Glacial sediments is extremely difficult, unit stratotypes, however, will not cover the full time span of chronozones.

Traditionally, the Late-Glacial interval in Estonia starts from the accumulation of Raunis Interstadial deposits in central Latvia (Каяк et al., 1976) and ends 10 000 ^{14}C years ago. With the decision of the INQUA Congress in Paris (1969) it was acknowledged as the Pleistocene/Holocene boundary. In the Raunis section interstadial sands with alternating layers of silt and clay, containing peat and plant remains, are embedded between two till layers on the right bank of the Raunis River southeast of the town of Cēsis. Organic remains from the Raunis section have been dated in several laboratories (13 390±500:

Mo-196; 13 250±160: TA-177; 13 320±250: Ri-39). The results obtained are in good agreement (Пуннинг et al., 1968b). Nevertheless, recent investigations of Latvian researchers have shown that the layers of the Raunis Interstadial are highly contaminated with younger organic matter and their real age can be much older than hitherto supposed. However, on the other hand, several new intermorainic interstadial sections with rather similar ^{14}C ages recently discovered in Latvia (Raukas et al., 1993, 1995): Lidumnieku (13 080±60: Лу-668A; 12 780±100: Лу-668; 12 830±90: Лу-695) and Savaini (13 840±350: Ri-A-1; 13 970±370: Ri-A-2) allow us to place the lower boundary of the Late-Glacial in Estonia at approximately 13 500 yr BP as before.

Table 1

Stratigraphical chart of Estonian Late-Glacial deposits

Chronological scale, yr BP	Stage	Substage	Chronozone		Index	Definition of boundaries, yr BP	Palynozone	Index	Baltic Sea stage	Ice marginal formations
	Holocene	Lower Holocene	Pre-Boreal	PB	PB₂		*Betula*	B	Anc. L.	
						9 500				
					PB₁		*Betula—Pinus*	B—P	Yoldia "Sea"	
10 000						10 000				
10 500	Pleistocene	Upper-Järva (Võrtsjärve)	Subarctic	Younger Dryas	DR₃		*Artemisia—Betula nana*	Ar—Bn	Baltic Ice Lake	
11 000						10 800				Palivere zone (11 200+430* yr BP)
				Allerød AL	AL$_b$		*Pinus*	P		
						11 300				
11 500					AL$_a$		*Pinus—Betula*	P—B		
						11 800				
12 000				Older Dryas	DR₂		*Artemisia*—Chenopodiaceae	Ar—Ch		Pandivere zone (12 050+430* yr BP) Sakala zone (12 250+430* yr BP)
						12 200				
12 500			Arctic	Bølling	BØ		*Betula*—Cyperaceae	B—Cy	Local ice lakes	Otepää zone (12 600+430* yr BP)
13 000						13 200				
13 500				Oldest Dryas	DR₁					Haanja zone (13 000–13 200+ +430* yr BP)

* Swedish varve-chronology correction (Cato, 1985).

DEGLACIATION HISTORY

The Estonian territory was freed from the continental ice in the Gotiglacial time about 13 500 to 11 000 years ago (Raukas, 1986). Against the background of a gradual climatic warming there probably occurred remarkable cooling periods which caused halts or even new advances (Palivere Stadial) of the degrading ice cover marked in the nature by distinct ice marginal formations: Haanja, Otepää, Sakala, Pandivere, and Palivere. It was believed (Raukas et al., 1969) that the ice cover began to retreat from the maximum distribution area of the Haanja belt about 13 200—13 000 years ago, from the Otepää—Karula belt about 12 600 years ago, from the Sakala belt about 12 250 years ago, and from the Pandivere belt about 12 050 years ago. According to the traditional approach, the Estonian territory finally cleared of ice about 11 000 years ago, but before that the glaciers temporarily reinvaded the West Estonian Archipelago and northwestern Estonia. The Palivere belt is well marked with marginal eskers and glaciofluvial deltas and can be traced by the distribution of indicator boulders (Raukas, 1992).

However, in the light of the revised Swedish varve chronology (Cato, 1985; Lundqvist, 1986) the dates obtained earlier need some readjustment. We suggested that the ice cover began to retreat from the Estonian ice marginal zones some half a thousand years earlier than hitherto assumed (Donner & Raukas, 1989; Карукяпп et al., 1992). Nevertheless the data available do not allow of any definite revision of the old deglaciation chronology (Raukas, 1986).

HISTORY OF THE BALTIC SEA

Immediately after the retreat of the ice sheet, vast areas were covered with big ice-dammed lakes (Раукас et al., 1971). The Baltic Sea was formed about 12 000 years ago after the retreat of the ice margin from the northern slope of the Pandivere Upland, as a result of which the isolated big ice-dammed basins west and east of the elevation joined up to form the Baltic Ice Lake (Квасов & Раукас, 1970). The drainage of the Baltic Ice Lake about 10 300 yr BP (Svensson, 1989) is considered as the beginning of the Yoldia Sea stage. In several recent papers the history of the Baltic Ice Lake (Donner & Raukas, 1989; Доннер & Раукас, 1992) and the Yoldia Sea (Raukas, 1994, 1995) with related deposits has been described in rather detail.

CHRONOSTRATIGRAPHY

The boundaries of chronozones are marked according to North and West European standards. Deglaciation history has been dated with conventional varve chronology, radiocarbon chronology, ESR, and TL (OSL) methods. All these methods are prone to errors and none of them can, therefore, be assigned universal validity. Only few of the radiocarbon dates for the deglaciation chronology in Estonia are reliable. The majority of dates of intermorainic or submorainic sequences are younger than one would expect on the basis of the conventional methods. As an example serve the submorainic sections at Petruse (12 670±200, 12 080±120) and Viitka (10 950±80) in the hilly area of southeastern Estonia, which was freed from the ice at least 13 000 years ago. This may result from redeposition caused by glaciokarst processes (Raukas & Karukäpp, 1994). At the same time, due to hard water effect some organic layers above the uppermost till are dated at 13 000—14 000 BP. For instance, in the Loobu section in the northernmost part of Estonia (Fig. 1) two samples have

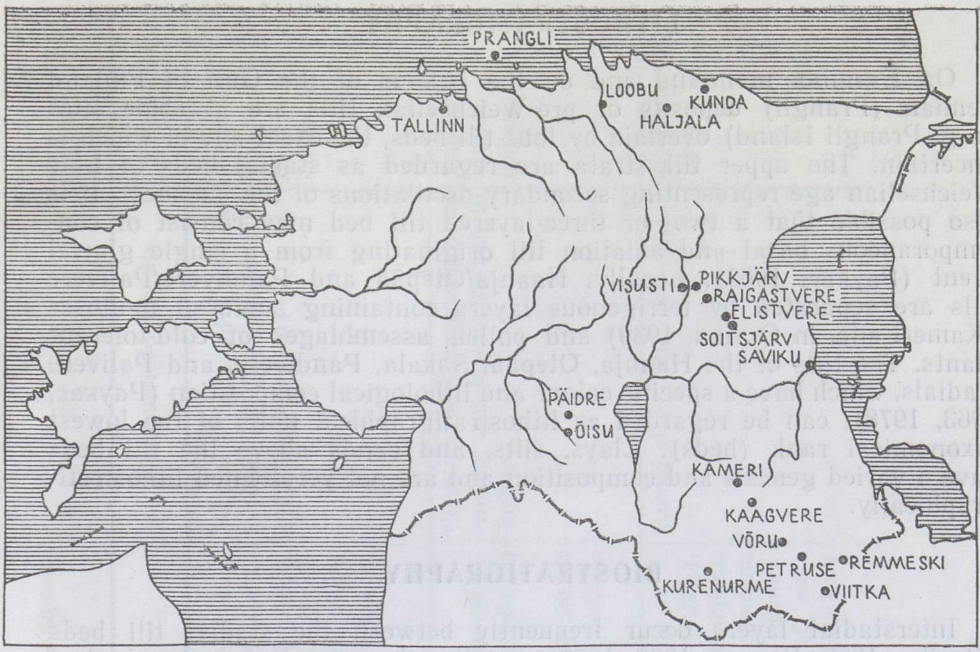

Fig. 1. Location of sections mentioned in the text.

yielded the ages 13 970+115: TA-137 and 14 725+260: TA-138, respectively (Пуннинг et al., 1968a), which are undoubtedly too old (Raukas, 1986).

In the Kurenurme section, SE Estonia, remains of *Salix* wood were taken from sandy loam overlying Haanja till. Quite reliable radiocarbon dates on the wood (12 650±520: TA-57) and organic detritus (12 420±100: Tln-35) suggest that these deposits accumulated at the beginning of the Bølling Interstadial. Unfortunately, the application of the section in till stratigraphy is hampered since the process of the deposition of the organic material is not clear (Raukas & Karukäpp, 1994). In the Kaagvere section, SE of the town of Otepää, the dates (15 150±575: TA-50, >30 000: TA-36) obtained below the reddish-brown till indicate redeposition of the older interglacial material (Каяк et al., 1976).

Plant remains (*Bryales*) from clayey silt under the lake marl correlated to the Younger Dryas in the Kunda section (North Estonia) were dated at 11 690±150 (TA-194) yr BP, which does not agree with the palynological evidence either.

Somewhat better results have been obtained through varve chronology. In northeastern Estonia, Rähni (Ряхни, 1963) recognized the prospect of varved clays in geochronology. He assumed (Raukas et al., 1969) that the ice-dammed lakes of Luga-Peipsi and Neva joined up for the first time 12 080—12 083 years ago and for the second time 12 049 years ago, when a thick (up to 80 cm) drainage or overflow varve was formed. Karukäpp (Карукяпп et al., 1992) has obtained some promising results with the floating chronology for the duration of the glacial lake in the area of the Gulf of Finland.

Glaciolacustrine varved clays provide suitable material for palaeomagnetic studies. The Late-Glacial palaeomagnetic scale compiled by Ekman et al. (Экман et al., 1987) for the Leningrad district and Karelia covers about 6000 years, but unfortunately, its correlation with the palaeomagnetic curves of Estonia is not yet clear (Бахмутов et al., 1987).

LITHOSTRATIGRAPHY

On Estonian mainland and on the islands of the Gulf of Finland Eemian (Prangli) deposits or pre-Weichselian tills are at some sites (e. g. Prangli Island) overlain by four till beds, the exact age of which is uncertain. The upper till strata are regarded as stadial beds of Late Weichselian age representing secondary oscillations of the ice sheet. It is also possible that a two- or three-layered till bed may consist of contemporaneous basal and ablation till originating from a single glacial event (Раукас, 1963). Locally, Haanja/Otepää and Pandivere/Palivere tills are separated by terrigenous layers containing subfossil molluscs (Kameri site, in Orviku, 1939) and pollen assemblages of cold-tolerant plants. The tills of the Haanja, Otepää, Sakala, Pandivere, and Palivere stadials, which have a specific colour and lithological composition (Раукас, 1963, 1978), can be regarded as lithostratigraphical units of the lowest taxonomical rank (beds). Clays, silts, and sands above the till beds have a varied genesis and composition and are not yet defined lithostratigraphically.

BIOSTRATIGRAPHY

Interstadial layers occur frequently between the stadial till beds (Orviku, 1939; Раукас, 1963, 1978), but they have no clear palynological characteristics and probably contain a lot of material redeposited from the older interglacials (Liivrand, 1991). For instance, the interstadial deposits of the Prangli section at a depth of 4—15 m are intercalated between the two uppermost grey tills (Kajak, 1961). They consist of varved glaciolacustrine sediments occasionally containing plant detritus, vivianite, and redeposited pollen grains.

The spore and pollen in Preallerød deposits above the till beds in Estonia suggest severe climatic conditions throughout the Arctic period. In the Bølling, there was only a short-term climatic warming, and even in the southern part of Estonia the environmental conditions were almost glacial with fast accumulation of sediments. Local vegetation just set in to develop and the concentration of redeposited pollen in sediments was high. That is why the Bølling sediments in this region do not reveal any clear palynological characteristics. However, the lower parts of some sections (Remmeski, Võru) are much richer in *Cyperacea* pollen and poorer in *Betula nana* L. than the upper parts of the same sections. Occasionally, *Ericales* pollen and *Sphagnum* spores are encountered. At the same time, the Bølling sediments in southern Estonia comprise remains of tundra shrubs, and leaves and stalks of *Bryales* moss which are not found in the lower parts of sections in northern Estonia. Moreover, although there is indirect evidence of the lower parts of sections being Bølling, we have no reliable palynological grounds to state it with conviction, and the lower boundary of the Older Dryas cannot be palynologically defined in our region (Кессел & Пиррус, 1983). Deposits of Older Dryas age occur both in northern and southern Estonia.

In the light of the pollen evidence, the retreat of the ice margin from the Haanja belt started in the Bølling. The territory of Estonia was finally cleared of the ice in the second half of the Allerød (Пиррус & Раукас, 1969).

The below-described chronozones and pollen assemblage zones reflect the most important trends in the evolution of Late-Glacial vegetation in Estonia (Table 2). The palynologically described sections, which serve as a basis for the stratigraphical subdivision and stratigraphical chart, are as follows (Figs. 1—3):

Table 2

Pollen stratigraphy of Estonian Late-Glacial deposits (compiled by R. Pirrus)

Substage	Chronozone		Pollen Zone	Index		Palynological characterization	Characteristic deposits	Type sections
Upper Järva (Võrtsjärve)	Subarctic	Younger Dryas	*Artemisia*—*Betula nana*	DR$_3$		Herbs dominate (40—60%). *Artemisia* content in S Estonia is more than 50%, in N Estonia 70% (up to 170%), Chenopodiaceae amount to 19 and 25%, respectively. *Betula nana* L. reaches 25%. *Betula* dominates in S Estonia, *Pinus* in N Estonia. Slight culmination of *Picea* occurs either in the lower or upper part of the zone.	Silts and clays, often with interlayers of fine-grained sand and *Bryales* remains.	Remmeski Visusti Haljala Kunda
		Allerød	*Pinus*	b	AL	Trees (*Pinus*, *Betula*, less *Picea*) dominate. b) *Pinus* has Late-Glacial culmination (80—90%). Herbs amount to 1—5%, in N Estonia to 15%, *Betula nana* L., some %.	Clays and silts comprising plant remains and interlayers rich in troilite	Remmeski Visusti Haljala
			Pinus—*Betula*	a		a) *Betula* frequency is increased and it may prevail over *Pinus*. Herbs form 18—20%, *Artemisia* 7—23%, *Betula nana* L. 4—7%.		
	Arctic	Older Dryas	*Artemisia*—Chenopodiaceae	DR$_2$		High values of herbs (20—30%). In S Estonia up to 37—43%. Chenopodiaceae form 5—10% (up to 29%), *Artemisia* amounts to 44%. Xerophilous, halophilous, and tundra species of pioneer plants are common. Among trees *Pinus* dominates, in lower part — *Betula*. High values of pollen (*Alnus*, *Corylus*, *Picea*, *Q. mix.*, partly *Betula* and *Pinus*) rebedded from till, have been identified.	Varved clays, silts, and sands	Remmeski Visusti

(a) Potential stratotype sections: Remmeski (Пиррус, 1969), Visusti (Пиррус, 1969, 1971), and Haljala (Мянниль & Пиррус, 1963; Raukas, 1986).

(b) Complete or rather complete sections of Late-Glacial sediments: Võru (Мянниль & Пиррус, 1963; Пиррус, 1969), Päidre (Пиррус, 1969), Õisu (Lõokene & Pirrus, 1979), Pikkjärv, Kuremaa, Elistvere, Raigastvere (Pirrus & Rõuk, 1988), Soitsjärv (Pirrus & Rõuk, 1979), Kunda (Пиррус, 1976), and the sections in Tallinn (Кессел & Пиррус, 1983).

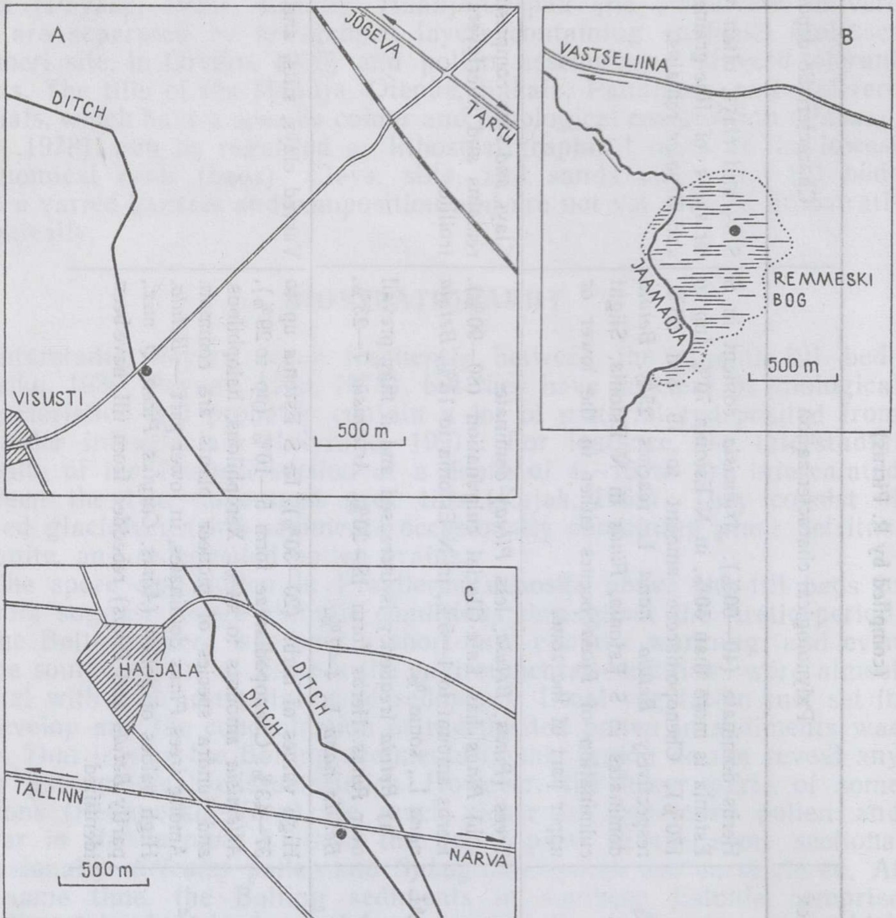

Fig. 2. Location of type sections: *A*, Visusti; *B*, Haljala; *C*, Remmeski.

Older Dryas Chronozone (DR_2)

Artemisia—Chenopodiaceae Palynozone

The Older Dryas Chronozone is represented by varved clays or rhythmically laminated silts and sands overlain by lacustrine silts and clays. In the southern part of Estonia minerogenic lacustrine sediments may contain minor amounts of plant remains. The thickness of deposits ranges from 1.3 to 11.3 m.

This zone is characterized by high herb pollen percentages (*Artemisia*, Chenopodiaceae, *Helianthemum*, Cyperaceae, Gramineae, and several other species of primary vegetation) along with *Betula nana* L. (Table 3).

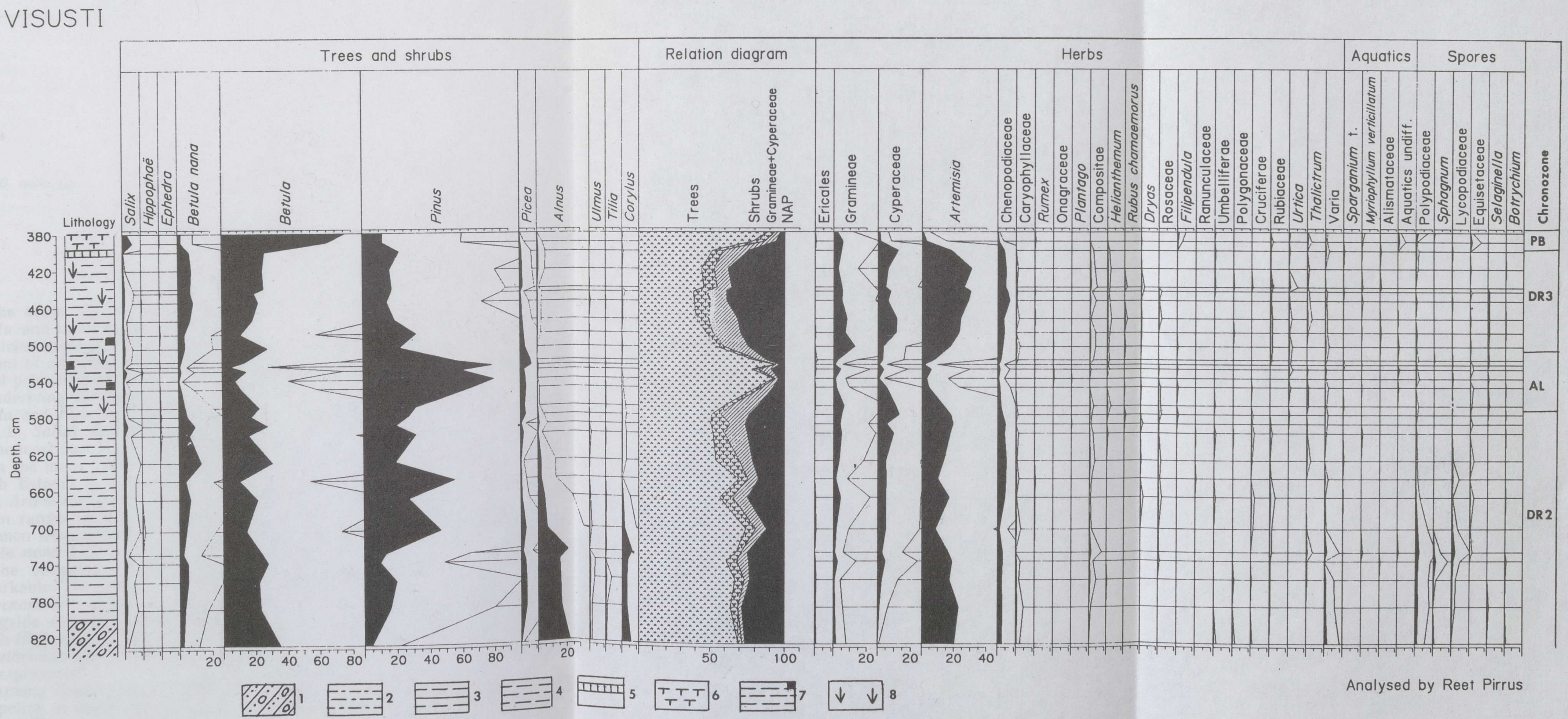

Fig. 3. Pollen diagram of the Visusti section. *1*, till; *2*, silty sand; *3*, rhythmically laminated clayey silt; *4*, clayey silt and silty clay with rare fine-grained sand interlayers; *5*, gyttja; *6*, lacustrine lime; *7*, clay and silt with some content of hydrotroilite; *8*, plant remains.

Table 3

The content of pollen in the lower and upper parts of the *Artemisia*—Chenopodiacea Palynozone, %

Trees	Lower part	Upper part
Alnus	up to 42 common 20	about 10
Picea	up to 35 common 2—17	0—6
Corylus	2—11	0—2
Betula (excl. *B. nana* L.)	34—80 common 50	10—47
Pinus	6—40	about 70
Herbs	4—28 common 20	up to 43 common 20—30

The lower part of the palynozone contains both spores and pollen *in situ* and those rebedded from till with clayey-silty fraction. In glaciolacustrine sediments the latter ones often prevail. In lake sediments the amount of rebedded pollen is considerably lower or insignificant and pollen of primary rare pioneer vegetation dominates. The pollen composition of underlying till suggests that *Alnus*, *Corylus*, *Q. mixtum*, *Picea*, partly *Betula* and *Pinus* are redeposited. In all probability herbs, shrubs (*Betula nana* L., *Salix*), spores of *Bryales*, tundra species of *Lycopodium* et al. are for the most part bedded *in situ*.

In the main part of the zone herb pollen ranges from 20 to 30%. In South Estonia it reaches 37—43%, in North Estonia (Loobu, Haljala) 29%. *Artemisia* dominates (up to 44%, generally *c.* 30%). Chenopodiaceae pollen ranges from 5 to 10% (up to 29%), Cyperacea forms 10—20%. Common frequency of Gramineae does not exceed 5%. The percentage of *Betula nana* L. is usually high (10%, max. 29%).

The occurrence of xerophilous and halophilous species pollen is remarkable. The pollen of xerophytes, e. g. *Eurotia ceratoides* (L.) C.A.M., *Polycnemum* sp., *Chenopodium glaucum* L., *Ch. botrys* L., is present alongside with the pollen of *Artemisia*, *Ephedra*, and the mesoxerophilous shrub *Hippophae rhamnoides* L. Of halophytes *Salsola kali* L., *S. foliosa* L., *S. ruthenica* Iljin, *Salicornia europaea* L., *Kochia prostrata* (L.) Schrad are represented.

Among tundra species *Betula nana* L. has a high percentage. Besides, the pollen of *Dryas octopetala* L., *Rubus chamaemorus* L., and spores of *Selaginella selaginoides* (L.) Link, *Botrychium boreale* (Fr.) Milde have also been found. In the constituent of trees the pollen of *Pinus* dominates over *Betula*.

Allerød Chronozone (AL)

The Allerød Chronozone is represented by lacustrine clays and silts with blackish-grey interlayers. Scattered plant remains, mostly leaves and stalks of *Bryales* moss, are common. The thickness of sediments is 0.15—1.85 m.

The Allerød Chronozone is subdivided into two parts: (a) *Pinus—Betula* Zone (AL_a), (b) *Pinus* Zone (AL_b).

The lower boundary of the AL Chronozone is fixed with a rather distinct increase of AP pollen and decrease of herbs (*Artemisia*, Chenopodiaceae) and *Betula nana* L.

Characteristic of the AL Chronozone is the prevalence of tree pollen. *Betula* shows a rapid growth and towards the uppermost part of the zone *Pinus* increases distinctly having its Late-Glacial culmination. At the same time herb pollen is at its lowest. *Betula nana* L. is constantly present in low percentages. The variety of bog and meadow species of terrestrial herbs and water plants has increased. Xerophytes, halophytes, heliophytes, and tundra plants are continuously present but in low values. Fine preservation and abundance of pollen as well as the regularity of pollen curves indicate their bedding *in situ*.

Pinus—Betula Zone (AL_a)

The lower boundary coincides with the boundary DR_2/AL. It is placed at the simultaneous decrease of herbs (*Artemisia*, Chenopodiaceae, Cyperaceae), *Betula nana* L. and increase of trees, particularly *Betula*.

In this zone the frequency of *Betula* increases reaching 50—60%, *Pinus* pollen forms 46—70%. Thus, *Betula* is dominant or its content increases and it continues to prevail over *Pinus*. The amount of herbs is relatively low (18—20%). *Artemisia* pollen ranges from 7 to 23%, Chenopodiaceae make up about 5%, and *Betula nana* L. 4—7%.

Occasional grains of *Filipendula ulmaria* L., *Valeriana officinalis* L., *Myriophyllum* sp. are found. The frequency of *Equisetum* spore is usually regular.

Pinus Zone (AL_b)

The boundary AL_a/AL_b is fixed with a distinct increase of *Pinus* and continuous decrease of herbs and *Betula nana* L. In this zone *Pinus* has its expressive maximum. The pollen content of *Pinus* reaches 80—91%, corresponding to the decrease of *Betula*. *Picea* is constantly present in low values: Remmeski 2—6%, Võru 1—4%, Visusti 4—9%, Loobu 5—7%, Haljala 4—15%. The herb pollen frequency is usually 1—3%, but in some profiles it reaches 15%. *Betula nana* L. pollen percentage is low. *Artemisia* pollen forms commonly 1—8%, Chenopodiaceae 1—3%, *Hippophae rhamnoides* L., *Helianthemum* sp., *Eurotia ceratoides* (L.) C.A.M., *Salsola kali* L., *Ephedra* sp., and various halophytes are present sporadically.

The variety of species of mesophilous bog and meadow terrestrial herbs is remarkable: *Valeriana officinalis* L., *Menyanthes trifoliata* L., *Polygonum persicaria* L., *P. hydropiper* L., *Filipendula ulmaria* L., *Geum rivale* L., *Epilobium* sp., *Plantago* sp. Water plants are represented by mesophilous species: *Myriophyllum verticillatum* L., *M. celterniflorum* L., *Sparganium* sp., *Alisma* sp., *Nuphar* sp., a.o. *Equisetum* spores are found regularly. *Selaginella selaginoides* (L.) Link is rare. Finds of *Lycopodium* species (*Lycopodium clavatum* L., *L. complanatum*, *Huperzia* selago (L.) Bernh. ex Schrank et. Mart.) are occasional.

Younger Dryas Chronozone (DR_3)

Artemisia—Betula nana Zone

The Younger Dryas Chronozone is represented by lacustrine silts and clays, often containing fine-grained sand interlayers. *Bryales* remains are scattered or occur as thin layers, occasionally abounding in hydrotroilite. The thickness of deposits ranges from 0.2 to 4.0 m.

The zone boundary AL_b/DR_3 is placed at the strong and rapid increase of the content of herb pollen (particularly *Artemisia*) and *Betula nana* L. This zone is characterized by remarkably high frequency of herb pollen ranging from 40 to 60%. *Artemisia* is dominant. In South Estonia *Artemisia* pollen makes up 50% (27—78%), in North Estonia it is usually over 70%, reaching 142% in the Loobu section, 170% at Haljala, and 135% at Kunda.

The representation of Chenopodiaceae is frequent: South Estonia — 6—19%, North Estonia — 9—25%. Throughout the zone the amount of Cyperaceae pollen ranges from 30 to 45%, Gramineae reaches 20%. Maximum values of *Betula nana* L. pollen in different profiles range from 20 to 25%.

Among the pollen and spores of xerophilous herbs and tundra plants the species occurring already in the Older Dryas are found in considerably increased contents (Пиррус, 1971). The representation of the pollen of bog, meadow, and aquatic plants occurring in the Allerød has slightly decreased. Different amounts of the pollen of mesoxerophilous (*Chenopodium album* L., *Ch. glaucum* L.) and xerophilous (*Eurotia ceratoides* (L.) C.A.M., *Polycnemum*, *Salsola ruthenica* Iljin) species are present along with *Ephedra*, *Hippophae rhamnoides* L., *Helianthemum*. The occurrence of halophilous species (*Salsola kali* L., *Salicornia europaea* L., *Salsola foliosa*, *Kochia prostrata* (L.) Schrad, *Chenopodium chenopodioides* L.) is common. The representation of the pollen and spores of tundra plants (*Dryas octopetala* L., *Selaginella selaginoides* (L.) Link, *Ledum palustre* L., *Rubus chamaemorus* L., *Botrychium boreale* (Fr.) Milde, *Lycopodium pungens* La Pyl., *Lyc. alpinum* L.) may be frequent. Among the trees *Betula* dominates in South Estonia and *Pinus* in North Estonia. Rather high and regular frequency of *Picea* can be established in the sections: Kunda — up to 26%, Loobu — up to 20%, and Remmeski — 26%. The Late-Glacial culmination of *Picea* is either in the lowermost (Võru, Visusti, Haljala) or the uppermost (Remmeski, Loobu) part of the pollen zone.

The accumulation of organic sediments in SE Estonian lakes started 10 300—10 200 yr BP, replacing the accumulation of sand, silt, and clay, clearly prevailing during the Late-Glacial. The oldest organic sediments are dated in the Saviku section 10 200±90: TA-328 (Сарв & Ильвес, 1975). The boundary DR_3/PB is placed at the rapid increase of tree pollen, prevailingly *Betula* (about 80%, in SE Estonia up to 90%) and *Pinus* (about 20%). Among birches *Betula* sect. *Albae* prevails. The *Betula nana* content is rather low (5—10%).

According to international rules, all stratigraphical charts should be based on the unit and boundary stratotypes. Unfortunately in Estonia stratotype sections have not been officially accepted for the Late-Glacial deposits. The location of most important type sections is shown in Fig. 2.

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EESTI HILISJÄÄAJA SETETE STRATIGRAAFIA

Reet PIRRUS, Anto RAUKAS

On esitatud 6. mail 1993 Eesti Stratigraafia Komisjoni poolt kinnitatud hilisjääaja setete stratigraafiline skeem (tab. 1) ja selle palünoloogiline põhjendus (tab. 2).

СТРАТИГРАФИЯ ПОЗДНЕЛЕДНИКОВЫХ ОТЛОЖЕНИЙ ЭСТОНИИ

Рээт ПИРРУС, Анто РАУКАС

Представлены утвержденная 6 мая 1993 г. на заседании Республиканской стратиграфической комиссии новая стратиграфическая схема позднеледниковых отложений Эстонии и ее палинологическое обоснование.