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QUATERNARY STRATIGRAPHY IN ESTONIA

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Abstract. In 1993 a new official stratigraphical chart of Quaternary deposits of Estonia was accepted. Glacial and aqueoglacial deposits make up about 95% of the Quaternary cover in Estonia. Five tills, often of a great thickness, are more or less distinctly traceable. In several places they are separated from each other with Prangli (Eemian, Mikulinan) and Karuküla (Holsteinian, Likhvinan) interglacial deposits or interstadial beds. All stratigraphical units have local geographical names and are based on stratotype sections.

Key words: Estonia, stratigraphical chart, Quaternary deposits, stratotypes.

INTRODUCTION

Estonia has a long history of stratigraphical investigations of Quaternary deposits. The first scheme was compiled by Schrenk (1854). Basing on the then prevailing drift theory he, like Schmidt (1854) and Grewingk (1861) some years later, divided all Quaternary sediments into the diluvial and alluvial ones with several lithological varieties. Estonia was among the first regions where the theory of continental glaciation was applied. Eichwald (1853) was the first in the Baltic provinces to consider the possibility that at least northern Estonia had once been covered by an ancient active glacier, which not only shaped the topography, but also carried boulders across its shores and left behind boulder clays. Already in 1865, Schmidt (1865) clearly spoke about glacial sediments. A bit later he described glacial and postglacial formations (Schmidt, 1869) and differentiated four stages in the development of the territory, including the time of the invasion of big glaciers, the time of the melting of the glaciers, and the time of the final melting of the ice with a wide distribution of fresh-water lakes. Ten years later the glacial theory was acknowledged by Grewingk (1879) who, by the way, was the first to state that Estonia's territory had experienced several glaciations. He reached the conclusion after he had identified two tills of different colour and lithological composition in the buried valleys at Tartu.

However, only half a century later Grewingk's statement was confirmed by palaeontological data. In 1939, Orviku performed the first detailed studies on interglacial organogenous deposits at Rõngu (Orviku, 1939), which according to pollen zones (Thomson, 1939, 1941) were correlated with the typical Riss-Würmian (Eemian) interglacial deposits in western Europe. By now tills of five glaciations or big stadials have been identified in Estonia (Раукас, 1978). The deposits of Eemian and Holsteinian interglacials (Liivrand, 1991) are spread to a lesser extent.

Stratigraphical chart of Quaternary deposits in Estonia (accepted on 6 May 1993)

General units			Local units		Palaeontological and lithological characterization	Most important sites
System	Division	Subdivision	Formation	Subformation		
Quaternary	Holocene		Separate stratigraphical scheme of Holocene (Flandrian) deposits has been accepted		Variegated continental and marine deposits, 10 pollen assemblage zones	Continental deposits all over Estonia, marine deposits in Low-Estonia
Quaternary	Pleistocene	Upper Pleistocene	Järva III_{jr}	Võrtsjärve III_{vr}	Grey till in North Estonia, reddish-brown till in South Estonia, aqueoglacial deposits	All over Estonia
				Savala III_{sv}	Dry periglacial vegetation	Savala, Vääna-Jõesuu, Tõravere (Peedu)
				Valgjärve III_{vl}	Grey till in North Estonia, purplish-grey till in South Estonia, aqueoglacial deposits	Valgjärve, Kaagjärve, Prangli
				Kelnase III_{kl}	Cryo- and hydrophilous vegetation	Prangli
			Prangli III_{pr}		Forest vegetation, pollen zones P_2—P_8, marine and continental deposits	Prangli, Rõngu, Küti, Kitse
		Middle Pleistocene	Ugandi II_{ug}	Upper Ugandi II_{ug_3}	Brown till in North Estonia, grey till in South Estonia, aqueoglacial deposits	Prangli, Rõngu, Juminda, Saadjärv, Suur-Munamägi
				Middle Ugandi II_{ug_2}	Periglacial vegetation	Prangli, Keskküla, Valguta
				Lower Ugandi II_{ug_1}	Brown till both in North and South Estonia, aqueoglacial deposits	Prangli, Naissaar, Keskküla, Mägiste, Lanksaare
			Karuküla II_{kr}		Forest vegetation, pollen zones KI—KIV	Karuküla, Kõrveküla
			Sangaste II_{sn}	Upper Sangaste II_{sn_3}	Shaly reddish till in Central and South Estonia	Saadjärv, Keskküla

In the 1930s, Piipenberg (1935) and Orviku (1939) established also intermorainic interstadial and interphasial deposits, summarized by Raukas (Раукас, 1963a, 1978). This enabled one to compile a rather detailed stratigraphical chart for late-glacial deposits (Каяк et al., 1976) and to evaluate deglaciation of the area at a new level, i.e. to speak already about the oscillatory character of the ice margin retreat.

Several local and regional stratigraphical schemes have been compiled for Estonia (in 1956, 1957, 1961, 1963, 1970, 1976). These were mainly correlative parts of the schemes of the European portion of the former Soviet Union or the Baltic States and Belarus (Orviku, 1960a; Орвику, 1956, 1960; Раукас, 1978 a. o.). Of those richest in the factual material was the scheme compiled by Kajak et al. (Каяк et al., 1976) under the leadership of Raukas. In this scheme local geographical names were for the first time used for stratigraphical units. Over a period of more than 15 years the scheme served as a basis for medium- and large-scale geological mapping and applied works in the republic.

On 6 May 1993, a new official stratigraphical scheme of Quaternary deposits of Estonia (Table) was accepted by the Estonian Stratigraphic Commission. The scheme was approved as a correlative part of the stratigraphical scheme of the Baltic States at the Second Stratigraphic Conference in Vilnius (9—14 May 1993). The scheme was compiled by Kajak, Liivrand and Raukas, but afterwards Liivrand resigned from her authorship.

LOCATION OF THE AREA AND THE THICKNESS OF THE QUATERNARY COVER

Estonia is located in the northwestern part of the East European Platfrom. Structurally, it lies within the boundaries of the southern slope of the Fennoscandian Shield or Estonian monocline with only its extreme southwestern and southeastern parts serving as the northern wings of the Baltic syneclise and Mõniste uplift, respectively. More or less rugged and weathered rocks of the crystalline basement are overlain by Vendian and Cambrian sandstones, siltstones and clays (in the fore-klint area), Ordovician and Silurian limestones, marls and dolomites (in northern Estonia) and reddish-brown or yellowish Devonian sand- and siltstones prevailingly (in southern Estonia). In the southeastern part of the republic, light-coloured Upper Devonian carbonate rocks crop out in a small area.

Quaternary deposits are of uneven distribution (Каяк, 1966). In northern Estonia, on the outcrops of the Ordovician and Silurian carbonate rocks, their thickness does not usually exceed 5 m, in places (on alvars) they are even lacking. The Quaternary cover is at its thickest in the Haanja and Otepää Heights (often more than 100 m) and in the buried valleys of South Estonia (in the Abja valley 207 m). The formation of the Quaternary cover was controlled by the bedrock topography (Таваст & Раукас, 1982).

STRUCTURE OF THE QUATERNARY COVER

About 95% of the Quaternary cover is formed of glacial and aqueoglacial deposits. Five till formations, often of a considerable thickness, are distinctly traceable. Only in a few cases they are separated from each other by deposits containing spores and pollen of interglacial or interstadial origin, which considerably aggravates the correlation and dating of glacial strata. The deposits of the Prangli (Eemian, Mikulinan) interglacial are represented by both continental (Rõngu) and marine (Prangli) sediments. The Karuküla (Holsteinian, Likhvinan) deposits are most complete in the Karuküla section. The spore and pollen spectrum of all other intermorainic sections is not clear, as these sediments often contain reworked pollen.

METHODICAL PROBLEMS AND STRATIGRAPHICAL PROCEDURES

In the Quaternary cover the normal bedding of deposits is often disturbed. In many cases, especially in the insular accumulative uplands (Haanja, Otepää), blocks of older deposits have been displaced not only horizontally, but occasionally also a considerable up-thrusting and/or folding has occurred. Older blocks are found standing in a position of tens or even more than a hundred metres (in the Karuküla section) above their normal stratigraphical position. As a result of redeposition of interglacial and interstadial deposits, the number of supposed interglacials and interstadials could be erroneously increased (Liivrand, 1991).

In the Quaternary stratigraphy the age of tills is of special interest as it enables one to correlate lithologically similar formations over a vast area (Раукас, 1978). The age of tills is generally determined by bedding conditions, by their position with respect to interglacial or interstadial deposits. Unfortunately, the latter are rather uncommon. Besides, most of unconsolidated intermorainic organic deposits were strongly crushed by advancing glaciers during the succeeding glaciations, and they are often embedded as erratics in younger sediments.

Unfortunately, there are practically no methods for the direct dating of tills. Out of all types of Quaternary deposits, tills have proved the most complicated objects for TL and OSL dating. The obtained data, as a whole, are in bad correlation with supposable geological ages of tills (Каяк et al., 1981). The dates of aqueoglacial sediments (Punning & Raukas, 1982; Liivrand, 1991) are more reasonable.

The study of redeposited pollen (Liivrand, 1991; Лийвранд, 1990) shows some promise. More reliable results have been obtained through the compilation of variograms, proposed by Grichuk and introduced into practice by Liivrand (Лийвранд, 1969). Variograms represent a graphical description of quantitative ratios of the most typical interglacial components, e. g. alder, hazel and broad-leaved species. However, in spite of the seemingly high theoretical motivation and some rather good results (Раукас & Лийвранд, 1971), the above method is not very trustworthy either. Until now the exact number of interglacials and their palynological characteristics have not yet been unambiguously elucidated. In addition, the content of pollen comprised in tills is also influenced by local peculiarities and abundant interstadial deposits, palynologic characteristics of which have not yet been sufficiently studied.

Over the course of various glaciations, the movement of ice has been different (Таваст & Раукас, 1982). This allows of the correlation of till beds on the basis of lithological and mineralogical data (Раукас, 1978). But, unfortunately, all the correlations grounded on lithological data should be performed only in areas with a similar geological structure and after careful determination of possible facial and local fluctuations in the composition of deposits. Of lithological methods most promising in solving the problems of the Pleistocene stratigraphy has proved the study of crystalline indicator (index) boulders (Раукас, 1963б), since their content in deposits has only slightly been influenced by differences of the local bedrock and it has remained almost stable over vast areas (Раукас, 1978).

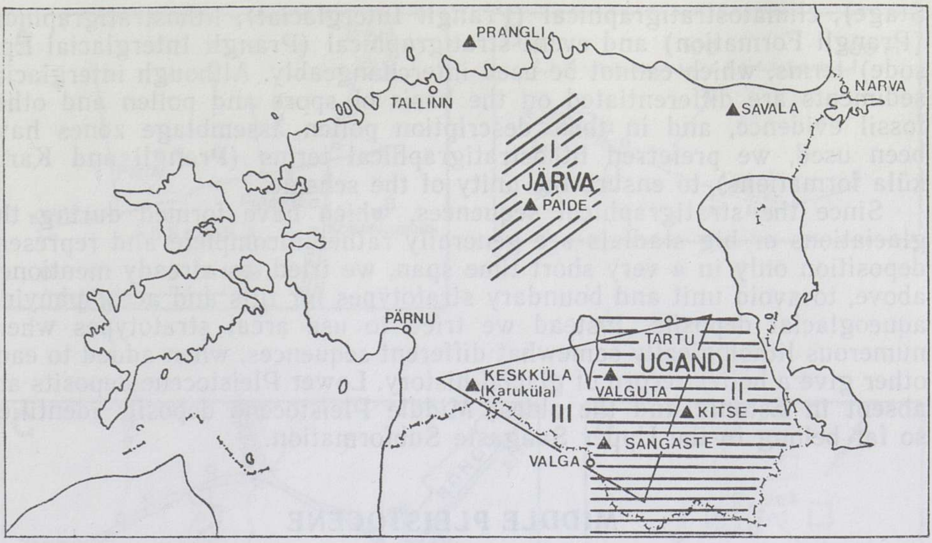

Fig. 1. Areal stratotypes of the Järva (I), Ugandi (II) and Sangaste (III) formations and some most important sections, mentioned in the text (after Раукас et al., 1993).

The International Stratigraphic Guide (Hedberg, 1976) states that all stratigraphical units, including the chronostratigraphical (stages, substages, and chronozones), biostratigraphical (biozones) and lithostratigraphical (formations, members, and beds) ones, should be firmly based and specifically defined on actual stratotypes and type localities. The stratotype serves as a reference example of a particular unit or feature, and therefore it provides a locality at which the unit or feature is firmly established. In the new stratigraphical scheme of the Quaternary deposits of Estonia, all stratigraphical units are based on stratotypes.

For the interglacials there are composite stratotypes, i. e. the localities where both boundary and unit stratotypes are recognized, for the tills areal stratotypes are used (Fig. 1), as recommended in the Stratigraphic Code of the former USSR (Стратиграфический кодекс, 1992). All proposed units are mappable.

SHORT DESCRIPTION OF STRATIGRAPHICAL UNITS

Quaternary chronostratigraphical subdivisions are closely linked with climatostratigraphical units. It seems that the major climatic changes during the Quaternary, recorded in the deep ocean oxygen isotope curves are globally more or less synchronous. However, the scale of individual events varies considerably and therefore the boundaries of the stages and substages all over the Baltic States are time transgressive. Therefore, traditionally, in the national or so-called local schemes lithostratigraphical terms have been used as basic units (Каяк et al., 1976). As a fundamental unit, formation is used in a meaning of glacial and interglacial episodes in event stratigraphy. Formations are three-dimensional sedimentary bodies, which have been formed by a specific geological process in the time span of one clear geological event.

Big stadial episodes in a meaning of event stratigraphy are comparable with subformations (Table). In the new scheme we tried to avoid using close in the meaning but not synonymous chronostratigraphical (Prangli

Stage), climatostratigraphical (Prangli Interglacial), lithostratigraphical (Prangli Formation) and event stratigraphical (Prangli Interglacial Episode) terms, which cannot be used interchangeably. Although interglacial sediments are differentiated on the basis of spore and pollen and other fossil evidence, and in their description pollen assemblage zones have been used, we preferred lithostratigraphical terms (Prangli and Karuküla formations) to ensure the unity of the scheme.

Since the stratigraphical sequences, which have formed during the glaciations or big stadials are generally rather incomplete and represent deposition only in a very short time span, we tried, as already mentioned above, to avoid unit and boundary stratotypes for tills and accompanying aqueoglacial deposits. Instead we tried to use areal stratotypes where numerous lithologically somewhat different sequences, when added to each other give a better record of glacial history. Lower Pleistocene deposits are absent in Estonia and the oldest Middle Pleistocene deposits identified so far belong to the Upper Sangaste Subformation.

MIDDLE PLEISTOCENE

Sangaste Formation

Upper Sangaste Subformation

The Sangaste Formation is correlated with the Dainava Stage in the southern Baltic, the Oka Stage in the European part of Russia and with the Elsterian Stage in western Europe.

The lowest diamicton unit in Estonia termed as the Upper Sangaste till, is very compact, greyish-yellow, occasionally greenish in colour with indications of shearing. It rests directly upon the bedrock and is found only in the bottommost part of ancient valleys. The thickness of the till bed is small: 8 m at Puiestee, 10.7 m at Sudiste and 5.4 m at Mägiste. Figure 1 shows the areal stratotype, named after the Sangaste Commune NE of the town of Valga (Каяк et al., 1976). Borehole 177 (Puiestee) at a depth of 169.0—207.0 m was chosen for the stratotype section (Раукас et al., 1993), and borehole 528 (Kõrveküla) at a depth of 7.8—21.5 m, where the till rests below the organic interglacial sediments, for a parastratotype. The clast composition is different: in SW Estonia crystalline rocks are clearly prevailing (up to 95%), in SE Estonia their amount is only 25—60%. The content of local carbonate rocks ranges from 5—10% in SW to 60—75% in SE Estonia. Locally, they contain Devonian sand- and siltstones (up to 5%). A high content of Vyborg Rapakivi and Suursaari quartz porphyries in SE Estonia and absence or a very low content of rapakivi from SW Finland suggest that the deposition of till was due to the southward flowing ice. The poorly sorted diamicton is richer in clay particles than the uppermost till units. The latter abound in kaolinite (up to 30—45%) derived from the weathered bedrock. Due to the influence of Devonian sand- and siltstones, the sand and silt fractions of till are richer in quartz and contain less feldspars and carbonates than other till units (Раукас, 1978).

Karuküla Formation

The Karuküla Formation (interglacial) is palynologically correlated with the Butėnai Stage (interglacial) in the southern Baltic, the Likhvinan Stage in the European part of Russia and the Holsteinian of western Europe.

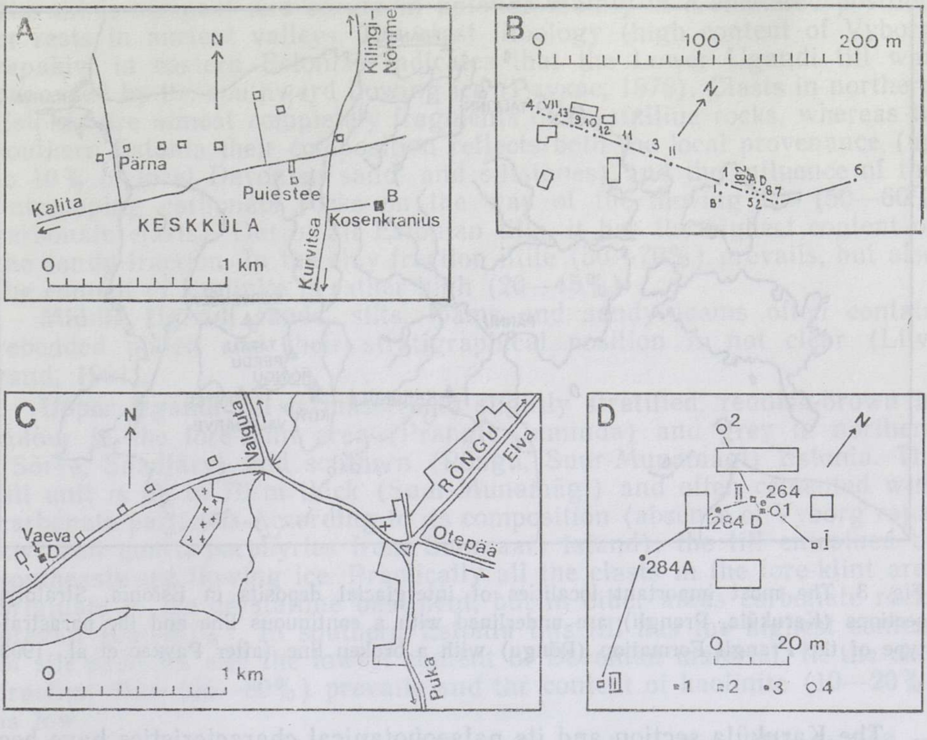

Fig. 2. Location of the stratotype section of the Karuküla Formation on the lands of the Kosenkranius farm (*A*) with the most important boreholes and excavations (*B*), location of the parastratotype Rõngu section of the Prangli Formation on the lands of the Vaeva farm (*C*) with the most important boreholes and excavations (*D*). From Раукас et al., 1993. Legend for 2*D*: *1*, draw-well; *2*, excavations of Orviku; *3*, boreholes of Kajak; *4*, boreholes of Liivrand.

The type site is situated in SW Estonia, in the Pärnu County, 7 km south of the town of Kilingi-Nõmme (Figs. 1, 2) on the lands of the Kosenkranius farm (Fig. 2). It displays continental deposits and was first described by Orviku (1944). The name of the stratotype proposed by Kajak et al. (Каяк et al., 1976) is inaccurate because the section is actually not in the Karuküla but Keskküla village. Due to a rather long history of investigations and wide recognition of the site, the changing of the stratotype's name was considered unpurposeful.

Great difficulties arose with the dating of the organic deposits in the Karuküla sequence, which for a long time were considered Upper Pleistocene, as the sediments of the second climatic optimum of the Riss-Würmian Interglacial (Orviku, 1960a, b; Орвику, 1960), the Brørup Interstadial (Орвику & Пиррус, 1965), the second Late Pleistocene or the Karuküla Interglacial (Пуннинг et al., 1967, 1969).

The Middle Pleistocene (Likhvinan, Holsteinian) age of the section was first suggested by Danilans (Даниланс, 1966) and Vozhnyachuk (Вознячук, 1966), and later established by Liivrand (Liivrand, 1984; Величкевич & Лийвранд, 1976, 1984).

The present information about the Karuküla site is based on about 70 boreholes and open excavation pits. The interglacial deposits are probably of allochthonous bedding (Левков & Лийвранд, 1988). There seem to be three large and two small erratics and two lumps of Holsteinian deposits within one stratigraphical level measuring 105 m horizontally and 3.25 m vertically (Liivrand, 1991).

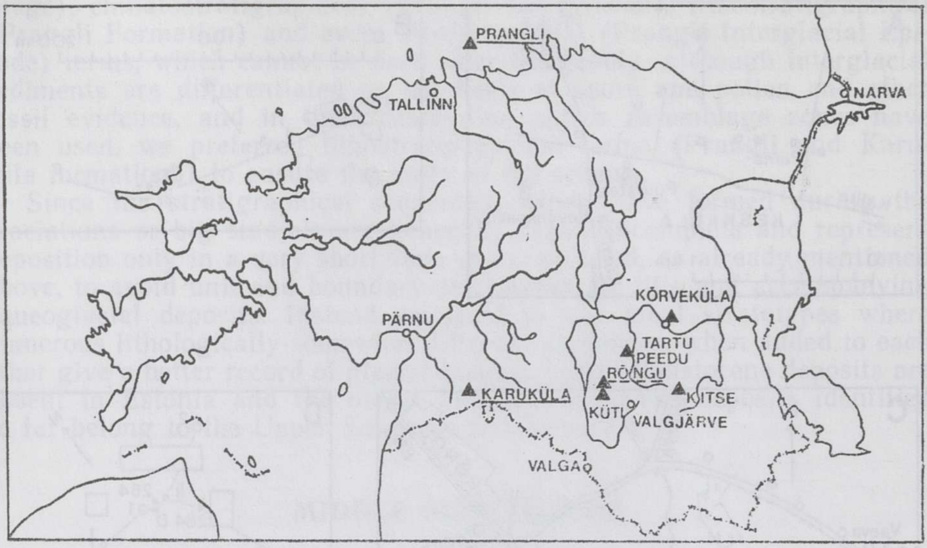

Fig. 3. The most important localities of interglacial deposits in Estonia. Stratotype sections (Karuküla, Prangli) are underlined with a continuous line and the parastratotype of the Prangli Formation (Rõngu) with a broken line (after Раукас et al., 1993).

The Karuküla section and its palaeobotanical characteristics have been described in detail in several publications (Лийвранд, 1972, 1990; Liivrand, 1984, 1991). The unit stratotype of the formation is presented in borehole *2* (Fig. 2) and in the closelying excavations *A* and *B* (Раукас et al., 1993).

Another well investigated site of the Karuküla Formation is at Kõrveküla (Fig. 3) near Tartu (Лийвранд & Саарсе, 1983).

Ugandi Formation

The Ugandi Formation is correlated with the Žeiminiai Formation in Lithuania, Kurzeme Formation in Latvia, Middle Russian deposits in Russia and Saale deposits in western Europe. In Lithuania, the Ugandi Formation is divided by the problematic Snaigupėlė Interglacial (Кондратене et al., 1993), whose pollen spectra greatly resemble the Eemian ones. The analogous Middle Pleistocene interglacial, established in Russia (Odintsovo, Roslavl) and Belarus (Shklov) is also highly disputed. In Estonia this interglacial is unknown, in some places Middle Ugandi interstadial beds have been described. The areal stratotype of the Ugandi Formation is shown in Fig. 1. Kajak et al. (Каяк et al., 1976) proposed to name it after an ancient South Estonian and North Latvian area Ugandi (Ugandimaa), where those deposits are most widely distributed. Borehole 6 on Prangli Island (depth 78.2—123.0 m) and borehole 268 at Valguta (13.1—35.0 m) have been established as the unit and boundary stratotypes for North and South Estonia, respectively (Раукас et al., 1993).

The Ugandi Formation is mainly represented by glacial and related aqueoglacial deposits (Раукас, 1978).

The till of the **Lower Ugandi Subformation**, which is correlated with the Dniepr till in Russia and the Žemaitia till in Lithuania, is reddish-brown in colour both in North (Prangli, Naissaar, Suurpea) and South Estonia (Mägiste, Lanksaare, Sudiste) and up to 50 m thick (Mägiste).

The till is compact and occurs in uplands mainly in a sheltered position or rests in ancient valleys. The clast lithology (high content of Vyborg rapakivi in eastern Estonia) indicates that the Lower Ugandi till was deposited by the southward flowing ice (Раукас, 1978). Clasts in northern Estonia are almost completely fragments of crystalline rocks, whereas in southern Estonia their composition reflects both the local provenance (up to 10% of local Devonian sand- and siltstones) and the influence of the outcropping carbonate rocks on the way of the moving ice (50—60% carbonate clasts). Out of all Estonian tills, it has the highest content of the sandy fraction. In the clay fraction illite (50—70%) prevails, but also the content of kaolinite is rather high (20—45%).

Middle Ugandi sands, silts, loams and sandy loams often contain rebedded pollen and their stratigraphical position is not clear (Liivrand, 1991).

Upper Ugandi till is massive to slightly stratified, reddish-brown in colour in the fore-klint area (Prangli, Juminda) and grey in northern (Sõrve, Saadjärv) and southern (Rõngu, Suur-Munamägi) Estonia. The till unit is up to 70 m thick (Suur-Munamägi) and often cemented with carbonate particles. According to its composition (absence of Vyborg rapakivi and quartz-porphyries from Suursaari Island), the till entrained by southeastward flowing ice. Practically all the clasts in the fore-klint area originate in the crystalline basement, but in other areas carbonate rocks prevail (65—80%). In southern Estonia this till has the highest content of silt particles and the lowest content of Devonian material. In the clay fraction illite (65—80%) prevails and the content of kaolinite (10—20%) is low.

The thickness of aqueoglacial deposits of the Lower (Rõuge 125 m, Puiestee 60 m) and Upper (Vääna-Jõesuu 60 m) Ugandi subformations is rather big and their composition is variable (Раукас, 1978).

UPPER PLEISTOCENE

Prangli Formation

The Upper Pleistocene in Estonia begins with the well-known Eemian interglacial deposits in western Europe and Mikulinan interglacial deposits in eastern Europe. In the Regional Scheme of the Baltic Area this interglacial is called the Merkinė Interglacial after a town in SE Lithuania. The Eemian (Mikulinan) deposits, both continental (Rõngu) and marine (Prangli), correlated on the basis of the pollen assemblage zones, are in good stratigraphical agreement (Liivrand, 1991).

The continental Eemian deposits at Rõngu were investigated in particular detail about half a century ago (Orviku, 1939; Thomson, 1939, 1941). Later complementary investigations were carried out in several other sections (Küti, Kitse, Peedu, Fig. 3) by Liivrand (Лийвранд, 1977).

In 1961, marine Eemian deposits were found on Prangli Island in the Gulf of Finland (Kajak, 1961) and subject to palynological (Лийвранд & Вальт, 1966; Liivrand, 1974, 1991; Лийвранд, 1987, 1990) and diatom (Черемисинова, 1961) studies.

A stratotype section at a depth of 67.6—75.5 m in borehole 6 on Prangli Island (Fig. 4) and a parastratotype for the continental deposits in borehole 264 (2.3—7.8 m) and excavation II (2.0—5.8 m) on the lands of the Vaeva farm (2 km to the west from the settlement of Rõngu, Fig. 2) were established for the Prangli Formation (Раукас et al., 1993). The name for the formation was proposed by Kajak et al. (Каяк et al., 1976).

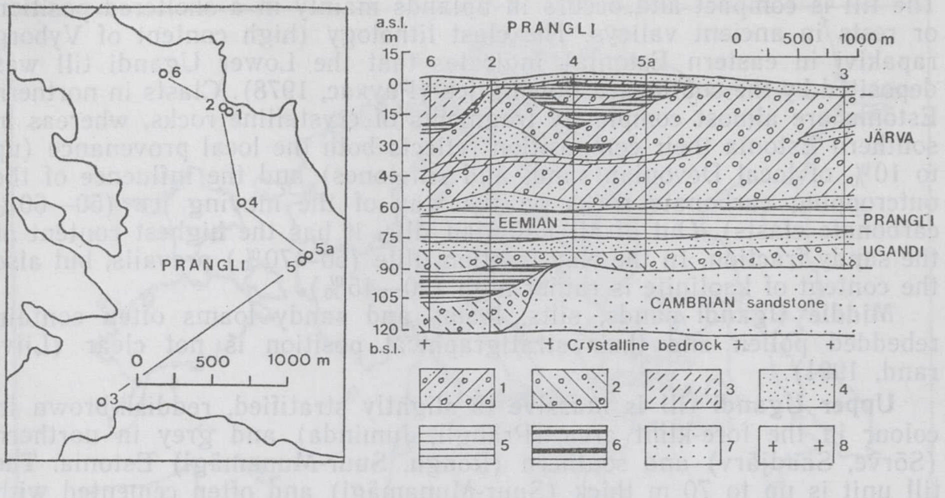

Fig. 4. Location of boreholes on Prangli Island and the stratotype section of the Prangli Formation: *1*, Upper Pleistocene (Järva) till; *2*, Middle Pleistocene (Ugandi) till; *3*, sandy loam; *4*, sand; *5*, marine loam and clay; *6*, varved clay; *7*, Cambrian sandstone; *8*, Proterozoic bedrock (after Раукас et al., 1993).

Järva Formation

The name of the formation was proposed by Kajak et al. in 1976 (Каяк et al., 1976) after the Järva County in Central Estonia (Fig. 1), where a typical grey till of the last glaciation is widespread in the drumlins and lowland near the town of Paide. The Järva Formation is correlated with the Nemunas Formation in Lithuania, the Baltia group in Latvia, the Valdaian Stage in Russia and the Weichselian glaciation in western Europe. The Vääna-Jõesuu (7.0—13.4 m) and Kitse boreholes (0—31.1 m) were chosen for stratotype sections in North and South Estonia, respectively (Раукас et al., 1993).

The **Kelnase Subformation** has derived its name from a village on Prangli Island. In the Prangli section it is represented by clayey silts with the pollen spectra characterized by an increasing quantity of *Betula nana* (40—80%) and herbs (tundra species). *Gramineae* and *Cyperaceae* are common. *Selaginella selaginoides*, *Lycopodium alpinum* and *Artemisia arctica* are present. A cryophilous and hydrophilous vegetation refers to the approaching glacial advance (Каяк et al., 1976; Liivrand, 1991).

The **Valgjärv Subformation**, named after a lake in South Estonia, is represented by grey till in North and purplish-grey till and related aqueoglacial deposits in South Estonia. The purplish-grey till was proposed for a specific stratigraphical unit by Orviku (1939) and described lithologically by Orviku (Орвику, 1958) and Raukas (Раукас, 1963a, 1978). The age of the purplish-grey till in South Estonia is likely to differ with areas and sections (Раукас, 1963a).

The **Savala Subformation** is named after a village in NE Estonia. The type section (borehole 7854, depth 25.8—30.2 m) is situated in the Purtse ancient valley about 120 km east of Tallinn. It is mainly filled with glaciolacustrine and glaciofluvial sediments (Таваст & Раукас, 1982). The pollen and spore composition of the intermorainic layer is indicative of dry periglacial conditions (Лийвранд, 1986; Liivrand, 1991). The Savala interstadial warming was not accompanied by any substantial development of forests.

The **Võrtsjärv Subformation**, named after Lake Võrtsjärv, is mainly represented by tills of different colour of the last glaciation and aqueoglacial deposits above and beneath the till. In several places some till layers with thin intermorainic interstadial or interphasial sediments occur (Orviku, 1939; Раукас, 1963a). Tills of the last glaciation, lying on the Cambrian blue clays, sand- and siltstones in the fore-klint area, are bluish-grey, mostly clayey and contain mainly clasts from Finland and the bottom of the Gulf of Finland. Stony tills on the Ordovician and Silurian bedrock are enriched with the local carbonate material. The constituent clasts are mainly angular. Tills on the Devonian sand- and siltstones are reddish-brown and rich in sand and silt fractions. Rather well-rounded local carbonate and erratic crystalline material in tills occurs in various ratios in the cobble and pebble fractions (Орвику, 1958; Раукас, 1978). In the stratotype area, the Lake Võrtsjärv basin, both grey limy (Valma) and reddish-brown (Tamme) tills are widely distributed.

The Upper Järva late-glacial deposits are divided into Arctic (Bølling, Older Dryas) and Subarctic (Allerød, Younger Dryas) chronozones. According to the decision of the INQUA Congress in Paris in 1969, the Holocene/Pleistocene boundary is accepted as 10 000 ^{14}C years.

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EESTI KVATERNAARI STRATIGRAAFIA

Anto RAUKAS, Kalju KAJAK

6. mail 1993 kinnitas Eesti Stratigraafia Komisjon Eesti kvaternaari uue stratigraafilise skeemi, mis nädal hiljem aktsepteeriti II Baltimaade stratigraafia konverentsil Vilniuses (9.—14. maini 1993) Balti korrelatsiooniskeemi koostisosana. Skeemi põhiüksusteks on kihistud, millel kõigil on kohalikud geograafilised nimed ja stratotüübid. Eraldi skeemid kinnitati Holotseeni ja hilisglatsiaali setete stratigraafiliseks liigestamiseks.

СТРАТИГРАФИЯ ЧЕТВЕРТИЧНЫХ ОТЛОЖЕНИЙ ЭСТОНИИ

Анто РАУКАС, Калью КАЯК

6 мая 1993 г. на заседании Республиканской стратиграфической комиссии была утверждена новая стратиграфическая схема четвертичных отложений Эстонии (см. таблицу), составленная А. Раукасом, К. Каяком и Э. Лийвранд (которая потом отказалась от соавторства). Схема была одобрена на 2-й стратиграфической конференции Прибалтики (Вильнюс, 9—14 мая 1993 г.) как часть корреляционной схемы четвертичных отложений Прибалтики.

Основными стратиграфическими единицами в новой схеме, как и в схеме 1976 г. (Каяк и др., 1976), являются свиты, которым соответствуют отложения общепринятых оледенений и межледниковий: ярваская (валдайская), угандиская (среднерусская), сангастеская (окская), пранглиская (микулинская) и карукюлаская (лихвинская). В качестве подсвит рассматриваются стадиальные (верхнесангастеская, нижнеугандиская, верхнеугандиская, нижнеярваская и верхнеярваская) и межстадиальные (среднеугандиская, среднеярваская) отложения. В верхнем плейстоцене выделяются подсвиты, носящие географические названия (келнасеская, валгъярвская, савалаская, выртсъярвская).

Впервые для всех свит и подсвит предложены и утверждены стратотипы (Раукас и др., 1993). Для микулинского межледниковья, кроме стратотипа на о-ве Прангли, представленного морскими отложениями, установлен парастратотип в континентальных озерно-болотных отложениях разреза Рынгу.