Progress in Estonian Quaternary stratigraphy during the last decade

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Based on medium- and large-scale mapping and special scientific projects, rather well-grounded stratigraphical schemes of the Pleistocene, Holocene and Late-glacial deposits were compiled and published in Estonia in the mid-nineties. As the number of new drillings is very scanty, not a single new interglacial or interstadial has been recognised in Estonia during the last decade. Therefore, much attention has been paid to methodical problems and improvement of dating methods (ESR, OSL, varvochronology, etc.). In the official stratigraphical scheme of the Quaternary deposits in Estonia lithostratigraphic terms are used as basic units. Formation, as a fundamental unit, is used in the sense of glacial and interglacial episodes in event stratigraphy. Big stadial episodes in the sense of event stratigraphy are comparable with subformations. Although interglacial sediments are differentiated on the basis of spore and pollen and other fossil evidence, and pollen assemblage zones underlie their description, for the unity of the scheme even here lithostratigraphical terms Prangli (=Eemian Interglacial) and Karuküala (=Holsteinian Interglacial) formations were preferred. All stratigraphical units (formations and subformations) are based on well-investigated 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. In Holocene stratigraphy we have adopted the chronozone boundaries of the Nordic countries and differentiated eleven pollen assamblage zones which are time-transgressive. Stratotype sections for the Holocene deposits have not yet been officially accepted. This work is still in progress.

Keywords: lithostratigraphy, interglacial, interstadial, stratotype, formation and subformation, dating methods, pollen assemblage zones

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INTRODUCTION

Estonia belongs to the zone of glacial erosion or moderate accumulation, and, therefore, the Quaternary cover is thinner here than in the neighbouring countries Latvia and Lithuania. The cover is at its thickest in the Haanja and Otepää Heights in SE Estonia (often more than 100 m) and in the buried valleys of southern Estonia (207 m at Keskküla). Most of the Pleistocene cover is formed of glacial and aqueoglacial deposits. Glacial sediments, 70 per cent by volume and 47 per cent by surface area, dominate (Raukas, 1978). Five till beds, often of great thickness, are to be noted more or less distinctly. Only in a few cases they are separated from one another by deposits containing spores and pollen of interglacial or interstadial origin which considerably aggravates the correlation and dating of the glacial strata.

Stratigraphic studies aimed at compiling regional legends for geological mapping and different applied investigations have always been of high priority in Estonia. Based on several tens of thousands drillcores and medium- and large-scale mapping, rather well-grounded stratigraphical schemes of the Quaternary (Raukas, Kajak, 1995), Late-glacial (Pirrus, Raukas, 1996) and Holocene (Raukas et al., 1995) were compiled and published. These schemes were accepted on May 6, 1993 by the Estonian Stratigraphic Commission. However, in fact there were not very many new scientific ideas in the field of the Quaternary stratigraphy after the First Baltic Stratigraphic Conference in Vilnius in 1976, when the main outlines of the current stratigraphic schemes were accepted. Not a single new interglacial or interstadial has been recognized in Estonia during the last decade. Also the number of new drillings is scanty and, therefore, there is little hope to find intermorainic sections, which could alter the existing stratigraphic charts.

As there is little hope to get new sections due to limited drilling possibilities, in the last decade we have paid much attention to methodical problems and improvement of dating methods. In the Quaternary stratigraphy the age of tills is of special interest, because it enables to correlate lithologically similar formations over a vast area (Raukas, 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 the advancing glacier during the succeeding glaciations, and they are often embedded as erratics in younger sediments. Some researchers (Liivrand, 1991) believe that practically all continental interglacial deposits have been displaced not only horizontally, but occasionally also a considerable up-thrusting and/or folding has occurred. Therefore, older blocks are found standing in a position of tens or even more than a hundred metres (as in the Karuküla section) above their normal stratigraphical position. As, compared to E. Liivrand (1991), principally different opinions have been expressed on the bedding conditions of interglacial deposits in Estonia (Kajak, 1995), new methods of dating are needed for solving the problem. Some of them will be discussed below.

PLEISTOCENE STRATIGRAPHY

During all glaciations Estonia was affected by the Baltic and Peribaltic ice streams which moved at different rates during different glaciations and stadials of glaciations. The lithology of till beds and the orientation of clasts in tills suggest that the ice flow direction during the Late Ugandi and Valgjärve glaciations was mainly from NW to SE and during the Early Ugandi and Late Sangaste glaciations from N to S.

The areas of accumulation and erosion remained relatively stable through time. Ancient valleys, interlobate massifs, lee-side areas of bedrock elevations, as well as escarpments oriented transverse to the ice movement, acted as areas of accumulation (Tavast, Raukas, 1982). Intensive erosion took place on bedrock elevations and in ice lobe depressions where the Quaternary cover is correspondingly very thin. Quaternary sections in buried valleys and interlobate massifs are hardly correlatable due to very different accumulation conditions.

Interlobate massifs or so-called "accumulative insular uplands" are characterized by a hummocky topography and by a considerable thickness of Quaternary deposits. Representative outcrops on uplands have served as the main areas of stratigraphic investigations for over a century. The heights have formed between ice lobes as a result of frequent redeposition of older deposits and have a mosaic pattern of sediments. As a result of redeposition of interglacial and interstadial sediments, the number of supposed interglacials could be erroneously increased. This, in turn, may result in an older age assigned to the tills between them and misleading palaeogeographical conclusions. Deep ancient river valleys, which were further eroded by glaciers and their meltwaters, vary in morphology and sediment facies infill. They may be filled with different deposits. The deposits of radial and marginal valleys have certain areal differences. The deposits of radial valleys have been to a large extent reworked by glaciers and contain less older deposits. The deposits of ancient valleys, especially in marginal valleys, are the most suitable objects for stratigraphical studies because they contain fewer erratics than uplands.

Several local and stratigraphical schemes have been compiled for Estonia (in 1956, 1957, 1961, 1963, 1970, 1976). In the scheme compiled in 1976 (Kajak et al., 1976) local geographical names were for the first time used to denote the stratigraphic units. Over a period of more than 15 years, the scheme served as a basis for large-scale geological mapping and applied works in the Republic.

On May 6, 1993, a new official stratigraphical scheme of Quaternary deposits of Estonia was accepted by the Estonian Stratigraphic Commission (Raukas, Kajak, 1995). The scheme was approved as a correlative part of the stratigraphical chart of the Baltic States at the 2nd stratigraphical Conference in Vilnius (May 9–14, 1993). In this scheme (Table) lithostratigraphic terms have been used as basic units. As a fundamental unit, formation is used in the sense of glacial and interglacial episodes in event stratigraphy. Formations are three-dimensional sedimentary bodies which have been formed by a specific geological process in a time span as a result of one clear geological event. Big stadial episodes in the sense of event stratigraphy are comparable with subformations. Using close in the meaning but not synonymous chronostratigraphical (*e.g.*, Prangli Stage), climatostratigraphical (Prangli Interglacial), lithostratigraphical (Prangli Formation) and event stratigraphical (Prangli Interglacial Episode) terms has been avoided. Although interglacial sediments are differentiated on the basis of spore and pollen and other evidence, and pollen assemblage zones underlie their description, for the unity of the scheme even here lithostratigraphical terms (Prangli = Eemian and Karuküla = Holsteinian) were preferred.

Table. **Stratigraphic scheme of quaternary deposits in Estonia (accepted on May 6, 1993)**
Lentelė. **Estijos kvartero nuogulų stratigrafinė schema (patvirtinta 1993 05 06)**

General units: System	General units: Division		Local units: Subdivision	Local units: Formation	Paleontological and lithological characterization	Most important sites
	Holocene	Separate stratigraphic scheme of Holocene (Flandrian) deposits has been accepted			Variegated continental and marine deposits, 10 assemblage zones	Continental deposits all over Estonia, marine deposits in Low-Estonia
Quaternary	Pleistocene	Upper Pleistocene	Järva III_{jr}	Võrtsjärv 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)
				Valgjärv III_{vl}	Grey till in North Estonia, purplish-grey till in South Estonia, aqueoglacial deposits	Valgjärv, Kaagjärve, Prangli
				Kelnase III_{kl}	Cryo- and hydrophilous vegetation	Prangli
			Prangli (Rõngu) 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_{ug3}	Brown till in North Estonia, grey till in South Estonia, aqueoglacial deposits	Prangli, Rõngu, Juminda, Saadjärv, Suur-Munamägi
				Middle Ugandi II_{ug2}	Periglacial vegetation	Prangli, Keskküla, Valguta
				Lower Ugandi II_{ug1}	Brown till both in North and South Estonia, aqueological deposits	Prangli, Naissaar, Keskküla, Mägiste, Lanksaare
			Karuküla II_{kr}		Forest vegetation, pollen zones K_I-K_{IV}	Karuküla, Kõrveküla
			Sangaste II_{sn}	Upper Sangaste II_{sn3}	Shaly brownish till in Central and South Estonia	Saadjärv, Keskküla

The stratigraphical scheme of the Pleistocene deposits is based on the well studied stratotypes. For the interglacials, there are composite stratotypes, *i.e.* localities where both boundary and unite stratotypes are recognized. For the tills, areal stratotypes are used (Figure). The deposits of the Eemian (Prangli) interglacial, both continental (Rõngu) and marine (Prangli), serve as key sediments in the stratigraphic subdivision and correlation of the Pleistocene cover. The spore and pollen spectrum in many intermorainic sections is not clear, as these sediments often contain reworked pollen (Liivrand, 1991).

Unfortunately, there are practically no methods for direct dating of tills. Out of all types of Quaternary deposits, tills have proved the most complicated objects for luminescence dating. The obtained data, as a whole, are in bad correlation with supposable geological ages of tills, because the basic prerequisite of the method – sufficient daylight exposure – is not normally fulfilled for such kind of deposits.

The occurrence of *Portlandia arctica* shells in glacigenic sediments of Central Latvia allowed to use effectively the electron-spin-resonance (ESR) method for dating of glacially transported raft (Molodkov et al., 1998) in a disputable section. Unfortunately, in Estonia we have not found Pleistocene sections with datable shells. The radiocarbon method is limited by the last 40,000 years and only a few of the radiocarbon dates for the Late Weichselian chronology are reliable.

A good potential to distinguish the main Middle-Late Pleistocene warm-climate/high sea-level events and correlate marine and terrestrial deposits over wide areas is offered by an integ-

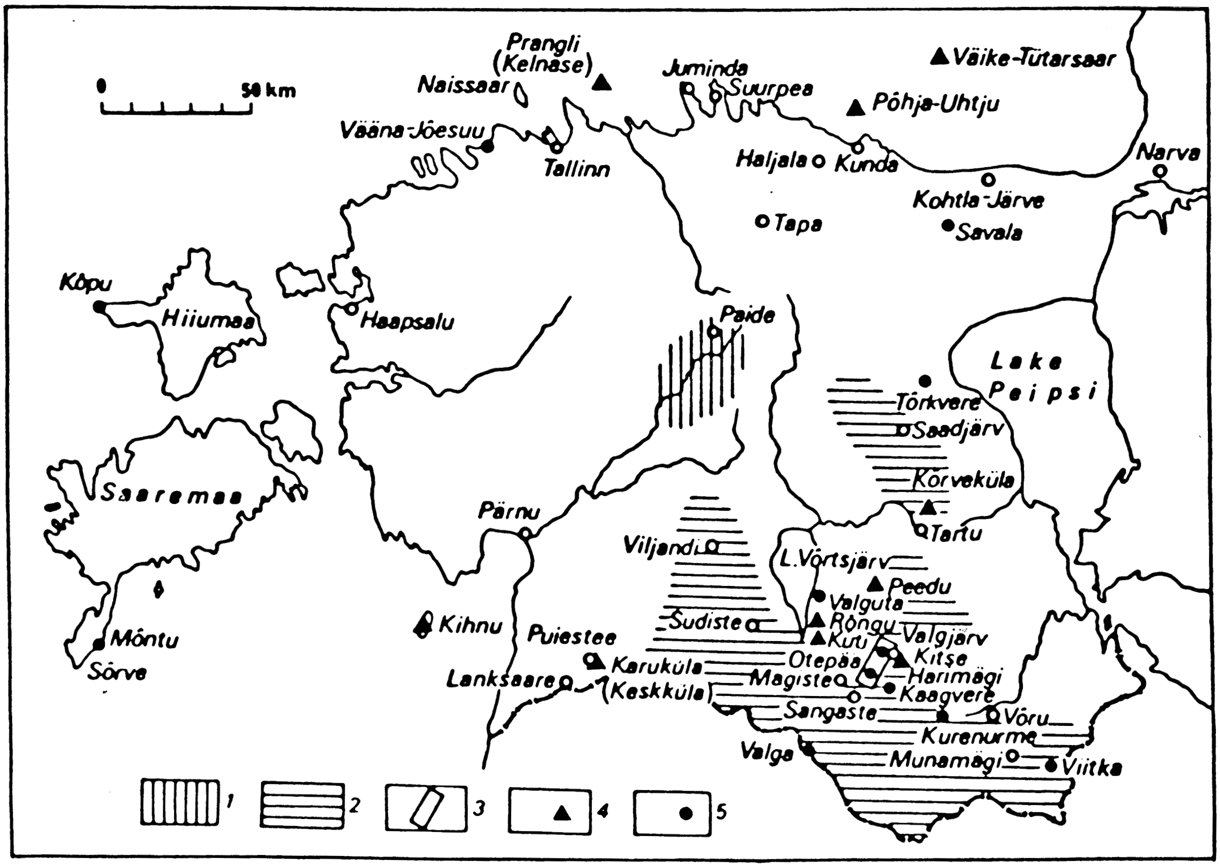

Figure. Areal stratotypes of the Järva (*1*), Ugandi (*2*) and Sangaste (*3*) glacial formations and location of main interglacial (*4*) and interstadial (*5*) deposits (after Raukas et al., 1993 with complements)
Pav. Jarvos (*1*), Ugandės (*2*) ir Sangastės (*3*) ledyninių svitų arealiniai stratotipai ir pagrindinių tarpledynmečių (*4*) bei tarpstadialų nuogulų pjūvių radimvietės (pagal Rauką ir kt., 1993 su papildymais)

rated approach based on two independent methods and sources of climato-stratigraphical information – the electron-spin-resonance (ESR) chronology of warm-climate related deposits and the palynological record of vegetation response to climatic variability and palaeoenvironmental events (Molodkov, Bolikhovskaya, 2002). This integrated approach allows establishing the number and stratigraphic position of the palaeoenvironmental events (stratigraphic units) existing in deep ocean sediments or ice cores but missing up to now in the stratigraphic schemes of the Baltic countries. We don't know exactly the number of Järva (Weichselian) subformations (glaciations, big stadials) in Estonia. In the Estonian Weichselian section, there are two clear till beds (Valgjärv and Võrtsjärv subformations). However, it is not yet clear whether the Valgjärv till belongs to the Lower or Middle Weichselian. We hope to solve this problem by OSL dating of intermorainic glacioaquatic deposits.

STRATIGRAPHY OF LATE-GLACIAL DEPOSITS

The Upper Järva (Upper Weichselian) late-glacial deposits in Estonia are divided into Arctic (Bølling, Older Dryas) and Subarctic (Allerød, Younger Dryas) chronozones and based on regional type sections. According to the decision of the INQUA Congress in Paris in 1969, the Holocene/Pleistocene boundary is accepted as 10,000 ^{14}C years. As to the chronology, we have to point out in every single case which is the time scale we are speaking about: conventional radiocarbon years, dendrochronologically calibrated radiocarbon years, dendroyears, TL-years, varve years or the so-called "calendar" or "absolute" years. All these scales are based on different phenomena, contain technical and geological errors, and transitions from one scale to another are scientifically insufficiently grounded. The mechanical use of different time scales has already resulted in a lot of misunderstandings and the situation will worsen in coming years.

In mainland Estonia and on the islands of the Gulf of Finland, Eemian (Prangli) deposits or pre-Pleistocene tills are in some places (*e.g.*, Prangli Island) (Kajak, 1961) overlain by four younger till beds, the exact age of which is uncertain. The upper till beds are regarded as stadial deposits of Late Weichselian age representing secondary oscillations of the ice sheet. It is also possible that two- or three-layered till beds consist of contemporaneous basal and ablation till from a single glacial event (Raukas, 1963). Locally, in some places, Haanja, Otepää, Pandivere and Palivere tills are separated by terrigenous layers containing subfossil molluscs (Kameri, in Orviku, 1939) and pollen assemblages of a cool character. Tills of the Haanja, Otepää, Pandivere and Palivere stages have a specific colour and lithological composition (Raukas, 1963, 1978) and can be regarded as lithostratigraphical units of the lowest taxonomical rank (beds). In some places, intermorainic layers have been dated by the ^{14}C method, but the results are contradictory.

Palynological studies of pre-Allerød deposits above the till beds in Estonia give evidence of severe climatic conditions throughout the Arctic period. They do not permit the layers related to the Bølling amelioration to be distinguished. Such deposits may be present in southern but hardly in northern Estonia. In the section of Haljala east of Tallinn (Männil, Pirrus, 1963) a pollen assemblage suggesting a brief interval of warming, possibly Bølling, has been reported.

Deposits of Older Dryas age occur both in northern and southern Estonia. The lower boundary of the Older Dryas is undefined in Estonia (Kajak et al., 1976), but probably it is the boundary between Otepää and Kurenurme beds.

In the light of the pollen evidence, the retreat of the ice margin from the Haanja position started during the transition from the Oldest Dryas to Bølling. The deglaciation of the Estonian territory was completed during the second half of the Allerød (Pirrus, Raukas, 1969).

The *Artemisia*–Cenopodiaceae palynozone in the Older Dryas chronozone is characterized by a high herb pollen percentage (*Artemisia, Chenopodiaceae, Helianthemum, Cyperaceae, Gramineae,* and several other species of primary vegetation) along with *Betula nana* L.

The Allerød Chronozone is subdivided into two pollen zones (Pirrus, Raukas, 1996): a) *Pinus-Betula* zone (ALa), b) *Pinus* zone (ALb). The lower boundary of AL Chronozone is fixed by a rather distinct increase in AP pollen and a decrease in herbs (*Artemisia, Chenopodiaceae*) and *Betula nana* L.

Characteristic of AL Chronozone is the prevalence of tree pollen. *Betula* shows a rapid increase and towards the uppermost part of the zone *Pinus* increases distinctly and has its Late-glacial culmination. At the same time, herb pollen is at its minimum. *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*.

The zone boundary AL/DR$_3$ is placed at a strong and rapid increase in the content of herb pollen (particularly *Artemisia*) and *Betula nana* L. The *Artemisia–Betula nana* palynozone of the Younger Dryas Chronozone is characterized by a remarkably high frequency of herb pollen ranging from 40–60%. The maximum values of *Betula nana* L. pollen in different profiles range from 20 to 25%. The Late-glacial culmination of *Picea* is either in the lowermost or uppermost part of the pollen zone.

The boundary DR$_3$/PB is placed at a rapid increase in tree pollen, prevailingly *Betula* (about 80%, in SE Estonia up to 90%) and *Pinus* (about 20%).

Traditionally, the beginning of the Late-glacial interval in Estonia is placed at the time the deposits of the Raunis Interstadial started to accumulate in Central Latvia (dated by different laboratories as 13390 ± 500 (Mo–196), 13250 ± 160 (TA–177), 13320 ± 250 (Ri–39) conventional ^{14}C ages (Punning et al., 1968). Based on the results obtained through new excavations, drillings, and complex palynological and malacological investigations (V. Zelčs a.o.), the organic sediments in the Raunis section seem to be of Early Holocene age and are covered with pseudotill, probably with colluvial sediments. As the majority of dates obtained from submorainic and intermorainic sequences with organic remains in Estonia (Petruse, Viitka, etc.) are younger than one would expect on the basis of the conventional radiocarbon method and, at the same time, due to the hard-water effect some organic layers above the uppermost till are dated at 13000–14000 yr BP (Pirrus, Raukas, 1996), new dating possibilities should be found.

Some promising results have been obtained through varve countings and palaeomagnetic studies of glaciolacustrine varved clays. The varve chronology produced for the Peipsi Basin (Hang, 2001) was extended to north-western Russia into the Luga and Neva basins (Hang et al., 2000) and via floating Finnish chronology to the Swedish time scale (Cato, 1987). However, there are too many gaps between Lake Peipsi and Sweden, and the accuracy of the estimated rate of ice recession during those gaps is extremely disputable. Tentative age assignment for Lake Peipsi suggests that accumulation of varved clays in Peipsi Ice Lake took place between 13,500 and 13,100 varve years BP (Hang, 2001). This is comparable with the age of the Pandivere (Neva) ice marginal formations (13,300 “calendar” years BP) from the Lake Onega area by Saarnisto and Saarinen (2001) and agrees with the traditional opinion (Raukas et al., 1969) that the southeastern part of

Estonia and the central part of the Haanja Heights emerged from under the ice sheet some 13,000 conventional radiocarbon years ago.

In the last years we have taken sand samples from surficial glacioaquatic deposits. Unfortunately, alongside reliable dates between 11,000–15,000 TL years BP, entirely unreliable dates from 8000 ± 3000 to 96 000 ± 12 000 BP (in one case even 114,000 ± 8000 TL years BP) have been obtained. This limits the use of the TL and OSL methods in solving the problems of deglaciation history. Also the ^{10}Be method shows little promise in this respect.

HOLOCENE STRATIGRAPHY

The Holocene deposits, at several sites rather thick, occur practically everywhere above the Pleistocene deposits. Unfortunately, the marine offshore and nearshore deposits are characterized by numerous unconformities and rapid facies changes; in many sequences gaps cover longer time spans than the preserved strata. The main stages in the Baltic Sea history are genetically known from the very beginning of the century, but they have never been properly defined as stratigraphical units (Hyvärinen, Raukas, 1992). Therefore, the stratigraphical scheme of the Holocene deposits is mainly based on continental deposits.

In the Holocene stratigraphy we have adopted the chronozone boundaries of the Nordic countries (Mangerud et al., 1974), and differentiated eleven pollen assemblage zones, which are time-transgressive (Raukas et al., 1995).

Unfortunately, for Holocene deposits the stratotype sections have not been officially accepted so far. It has been established that each site with its own local pollen assemblage biozones is effective in its own stratotype, but no stratotype can exist for the regional assemblage biozones, which are an artificial synthesis (Turner, 1989). Of the same type of artificial synthesis is the proposed local stratigraphical scheme of Holocene deposits, based on the multiple sections throughout the Republic, all having their own characteristics. As the pollen zones are time-transgressive, the boundaries between the palynological chronozones have not been drawn, and this makes the chart useful and applicable in the whole of Estonia.

In Estonia, there are 9836 peat bogs and about 1150 lakes greater than 1 ha in area (Orru et al., 1992; Mäemets, 1976). The peat is at its thickest (16.7 m) in the small Vällamäe kettle hole (Punning et al., 1985). The greatest thickness of organic lacustrine deposits is 18 m (Väimela-Alajärv), lake marl 6–7 m (Tapa, Kulina), travertine 5–6 m (Loosi, Rõuge), alluvial deposits 15 m (Väike Emajõgi) and aeolian deposits 15–20 m (Sininõmme, Kõpu). Already in the first half of the century the palynological approach (Thomson, 1925) was applied to the stratigraphical studies in Estonia, and at the end of the fifties physical dating methods were taken into use (Ilves et al., 1974). Therefore, the official scheme of the Holocene deposits in Estonia (Raukas et al., 1995) is better grounded than in neighbouring countries and a lot of local schemes were introduced. Several years ago investigations of laminated lake sediments in some lakes of South-East Estonia started, and this holds out some hope for the improvement of local chronology.

CONCLUSIONS

Based on the above, we can say that in Estonia we have all stratigraphic schemes of Quaternary deposits needed for large-scale geological mapping and for different applied works. Compared with the Southern Baltic area, the stratigraphical scheme of the Quaternary deposits in Estonia is much simpler, because the unclearest part of the section, the Lower Pleistocene, is absent here.

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Anto Raukas

ESTIJOS KVARTERO STRATIGRAFIJOS PASIEKIMAI PER PASTARĄJĮ DEŠIMTMETĮ

S a n t r a u k a

1993 m. gegužės mėnesį Respublikos stratigrafijos komisijos posėdyje buvo patvirtinta oficiali kvartero nuogulų stratigrafinė schema (lentelė) (Raukas, Kajak, 1995). Šioje schemoje svitos yra pagrindiniai stratigrafiniai vienetai, kuriems priskiriamos pagrindinių ledynmečių ir tarpledynmečių nuogulos: Jarvos (Vyslos, Valdajaus), Ugandės (Zalio, Vidurio Rusijos), Sangastės (Elsterio, Okos), Pranglio (Emio, Mikulio) ir Karakiulės (Holšteino, Lichvino). Posvitėms priskirtos stadijų (viršutinės Sangastės, apatinės Ugandės, viršutinės Ugandės, Valgjarvos, Vyrtsjarvos) ir tarpstadijų (Kelnases, Savalos) nuogulos. Visoms svitoms ir posvitėms patvirtinti stratotipai. Emio tarpledynmečiui šalia stratotipo Pranglio saloje, kurio nuosėdos yra jūrinės kilmės, nurodomas žemyninių ežerinių-pelkinių nuogulų parastratotipas – Ryngu pjūvis.

Atskira stratigrafinė schema buvo sudaryta vėlyvojo pleistoceno nuoguloms (Pirrus, Raukas, 1996), kurioje išskirta arktinė ir subarktinė chronozona su atitinkamomis palinozonomis. Chronozonų ribų amžius sugretintas su Skandinavijos šalių atitinkamų ribų amžiumi (Mangerud et al., 1974).

Pastarąjį dešimtmetį sumažėjus gręžimo darbams sumažėjo galimybė surasti naujų tarpledynmečių ir tarpstadijų nuogulų bei nuosėdų. Dabar, atliekant stratigrafinius tyrimus, pagrindinis dėmesys skiriamas metodinėms ir nomenklatūrinėms problemoms spręsti bei tobulinti nuogulų datavimo metodus.

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ПРОГРЕСС В СТРАТИГРАФИИ ЧЕТВЕРТИЧНЫХ ОТЛОЖЕНИЙ В ПОСЛЕДНЕМ ДЕСЯТИЛЕТИИ

Резюме

Последняя официальная стратиграфическая схема четвертичных отложений Эстонии (табл.) была утверждена на заседании Республиканской стратиграфической комиссии в мае 1993 г. (Raukas, Kajak, 1995). Основными стратиграфическими единицами в схеме являются свиты, которым соответствуют отложения общепринятых оледенений и межледниковий: ярваская (вейксельская, валдайская), угандиская (заальская, среднерусская), сангастеская (эльстерская, окская), пранглиская (эмская, микулинская) и карукюлаская (гольштейнская, лихвинская). В качестве подсвит рассматриваются стадиальные (верхнесангастеская, нижнеугандиская, верхнеугандиская, валгъярвская, выртсъярвская) и межстадиальные (келнасеская, савалаская) отложения. Для всех свит и подсвит утверждены стратотипы. Для эмского межледниковая, кроме стратотипа на острове Прангли, представленного морскими отложениями, установлен парастратотип в континентальных озерно-болотных отложениях разреза Рынгу.

Отдельная схема составлена для верхнеплейстоценовых позднеледниковых отложений (Pirrus, Raukas, 1996), где выделены арктическая и субарктическая хронозоны с соответствующими палинозонами.

Стратиграфическая схема голоценовых отложений Эстонии (Raukas et al., 1995) имеет параллельные подразделения для континентальных и морских фаций. Возрастные границы хронозон скоррелированы с соответствующими границами в Скандинавских странах (Mangerud et al., 1974).

В последнем десятилетии существенно уменьшились объемы бурения и в связи с этим сократились возможности для выявления новых межледниковых и межстадиальных отложений. Основное внимание в нынешних стратиграфических исследованиях уделяется методическим и номенклатурным проблемам, а также усовершенствованию методов датирования.