Baltica
www.geo.lt/Baltica/baltica.htm

since 1961

BALTICA Volume 20 Number 1-2 December 2007 : 35-45

Reconstructed late glacial shore displacement in Estonia

Leili Saarse, Jüri Vassiljev, Alar Rosentau, Avo Miidel

Saarse, L., Vassiljev, J., Rosentau A., Miidel, A. 2007. Reconstruction of late glacial shore displacement in Estonia. *Baltica, Vol. 20 (1-2), 35-45*. Vilnius. ISSN 3067-3064.

Abstract A shore displacement database of the Baltic Ice Lake (BIL) in Estonia, NW Latvia and NW Russia, including more than 700 sites, was compiled. The data were interpolated to the surfaces using the point kriging approach. The highest shoreline of the Baltic Ice Lake (A_1 in Estonia) was formed concurrently with or before the formation of the Pandivere ice marginal zone ca 13,300 cal BP. The age of A_2 is not ultimately defined (13,000 or 12,700 cal BP). Digital reconstruction of palaeoshorelines shows that during stages A_1 and A_2 the Baltic Ice Lake extended as far as the basins of lakes Võrtsjärv and Peipsi, which isolated from the Baltic Ice Lake between 12,800–12,300 cal BP. Tentative shore displacement curves at Tallinn and Pärnu isobases were constructed. The low water level prior to the BIL I stage was discarded and the earlier opinion, which ties up the elevation of the sandy flat plain surfaces near Tallinn with the low water level, is questioned.

Keywords *Proglacial lakes, Baltic Ice Lake, palaeogeographical maps, Estonia.*

Leili Saarse [saarse@gi.ee], Jüri Vassiljev [vassilje@gi.ee], Avo Miidel [miidel@gi.ee], Institute of Geology at Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia; Alar Rosentau [alar.rosentau@ut.ee], Department of Geology, University of Tartu, Vanemuise 46, 51014 Tartu, Estonia. *Manuscript submitted 13 September 2007; accepted 15 November 2007.*

INTRODUCTION

In spite of the long tradition of the shore displacement studies around the Baltic Sea, there are still many issues, such as the number of transgressions and regressions, timing of different stages and their spatial distribution, which are still awaiting elaboration and revision. Estonia is situated in an uplifting area and serves as an excellent object for such studies, because its coastal formations are located at different altitudes and the land uplift is ongoing at a maximum rate of 2.8 mm yr^{-1} (Vallner et al. 1988). Recently the Geographic Information System (GIS) technologies opened up an opportunity to reconstruct more precise palaeogeographical maps of the spatial distribution of the Baltic Ice Lake. As for such reconstruction a large set of proxies is needed, a local shoreline database was compiled. K.Pärna (1960, 1962) and H.Kessel (1972, 1975) were the first to undertake archiving of shoreline data but this work was interrupted by their death. After about a twenty-year standstill the creation of Estonian shoreline database became topical once again in the light of new technical approaches and improved knowledge on the development of the Baltic Sea history (Svensson 1989, 1991; Björck 1995; Uścinowicz 1999, 2006; Andrén et al. 2002; Jakobsson et al. 2007).

In this paper we present initial data on the Baltic Ice Lake shore displacement in Estonia, discuss the late glacial development and distribution of the proglacial lakes and revise some earlier proposed opinions. The shoreline database of proglacial lakes A_1 and A_2 is published earlier (Vassiljev et al. 2005) and, therefore, not repeated here. The aim of the current study was to enhance the Baltic Ice Lake database, to elaborate palaeogeographical maps on its spatial distribution in Estonia and neighbouring areas using point kriging interpolation and complex of terrain modelling operations, and to specify the water-level stand during different stages of the BIL.

REGIONAL BACKGROUND

During the ice retreat from Estonia five ice marginal zones have been distinguished (Fig. 1) supplemented by several proglacial lakes, which area, depth and extent changed concurrently with the retreating ice margin (Raukas et al. 1971). Isostatic land uplift determined the shore displacement of proglacial lakes at various elevations.

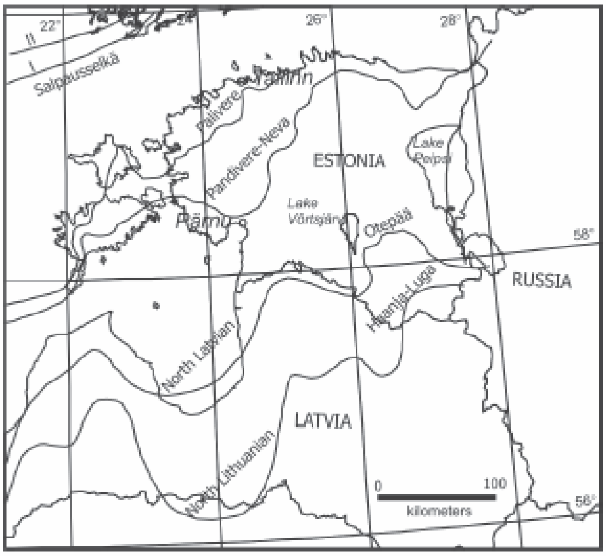

Fig. 1. Map of the study area with indication the main ice marginal positions.

During the first stages of the Baltic Sea almost half of Estonian territory was inundated by water. The largest proglacial lakes A_1 and A_2 were developed between 13,300–12,700 cal BP west of the Pandivere and Sakala uplands and in the Peipsi and Võrtsjärv basins. They left several benches, beach ridges, boulder fields and dunes on the upland slopes, now positioned at different elevations (Ramsay 1929; Parts 1933; Lõokene 1959; Pärna 1960, 1962; Kessel & Raukas 1979; Vassiljev et al. 2005; Rosentau 2006). After the retreat of the ice margin from the northern slope of the Pandivere Upland water level in the proglacial lake lowered and about 13,000 cal BP the ice margin reached close to the southern coast of Finland(Lunkka et al. 2004).

Due to the ice re-advance at about 12,700–12,800 cal BP the Palivere-Nõmme proglacial lake (A_3) was formed, which created near Tallinn Männiku and Nõmme glaciofluvial deltas at an elevation of 52–48 m a.s.l. (Künnapuu 1962; Pärna 1962). The ice distribution limit during this stage is marked by marginal formations in western and by glaciofluvial plains and ice COntact slopes (up to 20 m high) in northern Estonia. In several places glaciofluvial deposits cover varved clays (Raukas et al. 1971; Karukäpp & Mikalauskas 1972) that together with the landform orientation towards the ice advance, affirm the oscillation of the retreating ice. Five OSL dates from Männiku sandy deposits do not offer a reliable age of their formation, varying between 80,500 and 10,000 years (Raukas 2004; Raukas & Stankowski 2005). These low lying plateau-like marginal formations in Finland and Estonia (Männiku, Nõmme) were earlier interpreted as glaciofluvial deltas that represent the proglacial lake "g" (A_3 in Estonia) level ca 25 m lower of the Baltic Ice Lake (BIL I) level (Sauramo 1958; Pärna 1962; Donner 1982; Kessel & Raukas 1982; Glückert 1995).

The detailed sedimentological studies at Salpausselkä I by Fyfe (1990) showed that actually these low lying glaciofluvial plateau-like plains are overlapping fans formed below the water surface, which means that their surface did not indicate the proglacial lake water level position. Most likely, the above-mentioned plateau-like marginal formations in Estonia were also deposited below the water surface. Linkrus (1976, 1981) suggested that the glaciofluvial deltas south of the Palivere ice marginal formations are not real deltas but limnoglacial terraces as glaciofluvial plains smoothly return to limnoglacial ones.

The wide distribution of subaquatic waterlain glacial diamictons formed during the Palivere stadial at a depth of 50–60 m below the Baltic Ice Lake water table (Kalm & Kadastik 2001) could also serve as an argument for the higher water level during deposition of Palivere and Nõmme marginal plains, than assumed earlier. In this case there was not necessarily a rise of water level before it stood at the BIL I level, as mentioned Donner (1995, p. 105). Hitherto, all earlier reconstructions have shown a drastic water level fall (25–30 m) from the proglacial lake A_2 level to the A_3 (Palivere-Nõmme) level (Pärna 1960; Kessel & Raukas 1979; Donner & Raukas 1989, 1992).

MATERIAL AND METHODS

Shore displacement data were derived from different published and unpublished sources of Estonia (see Appendix), Latvia (Grinbergs 1957; Veinbergs 1979), NW Russia (Shmaenok et al. 1962) and southern Finland (Donner 1978). Collected proxies served as basis for compiling palaeogeographic maps, shoreline isobases and diagrams. The age of different shorelines is grounded on biostratigraphical records, varve counts (Hang 1997) and correlation with icemarginal zones (Kalm 2006; Saarnisto & Saarinen 2001). ^{14}C dates from the coastal formation are absent due to lacking of suitable for dating material and the OSL dating has not yielded reliable results so far (Raukas 2004; Raukas & Stankowski 2005).

The creation of the Estonian shoreline database started once again five years ago (Saarse et al. 2003;

Vassiljev et al. 2005; Rosentau et al. 2007). At present the late glacial shoreline database covers in total more than 700 sites. Simulations showed that roughly half of the data could be directly used in statistical analyses. The other half of data does not match simulation requirements due to inaccurate coordinates, elevations or erroneous correlation of different shorelines. It means that all earlier published material was thoroughly checked before inclusion into a uniform database. A_1 coastal formations have been identified in 83 different sites, from which 40 sites were used in the simulation. The database of proglacial lake A_2 includes 66 sites, 42 of which meet the requirements of simulation (Vassiljev et al. 2005). Altogether 53 points from Estonia have been considered to characterise coastal formations of BIL I stage, 37 – BIL II and 82 – BIL III (Appendix). Of the total of 274 points finally 172 matched to the BIL characteristics (Appendix).

Point kriging interpolation with the linear trend approach was used to create interpolated surfaces of water levels for different stages of BIL. Kriging is advantageous because it interpolates accurate surfaces from irregularly spaced data and it is easy to identify outliers in the data set. Residuals for the whole database were calculated to check whether there was any potential site, which could match with BIL shoreline characteristics. Then the interpolated water level surfaces were smoothed using residuals (the difference between the actual site altitude and the interpolated surface).

A modern Digital Terrain Model (DTM) with a grid size of 200x200 m was generated from the Digital Base Map of Estonia on a scale of 1:50 000 (Estonian … 1996), Shuttle Radar Topography Mission (International … 2004) and Topography of the Baltic Sea (Seifert et al. 2001) elevation data. Reconstruction of BIL shorelines and bathymetry was based on GIS analysis, by which interpolated water-level surfaces and average thickness of Holocene peat deposits from Estonian territory were systematically removed from the modern DTM (for further explanation see Rosentau et al., 2007).

RESULTS AND DISCUSSION

During the deglaciation two main proglacial lake systems were developed: Peipsi-Pihkva in the east and A_1 and A_2 (Voose, Kemba) in the west (Lõokene 1959; Pärna 1960; Raukas & Rähni 1969; Raukas et al. 1971; Kessel & Raukas 1979; Hang 2001). The eastern proglacial system started to develop during the Haanja-Luga Stade about 15,700–14,700 cal BP (Fig. 1; Kalm 2006). As the ice retreated further north the area of the proglacial lake gradually enlarged but its water level lowered due to the shifting outlets and isostatic rebound.

During the Pandivere Stade (Fig. 1) large proglacial lake A_1 in western Estonia and Võrtsjärv basin emerged which left coastal formations on the slopes of the Pandivere and Sakala uplands between 41–93 m a.s.l. (Vassiljev et al. 2005). Modelled distribution of A_1 proglacial lake along the ice border at ca 13,300 cal BP is displayed in Fig. 2. The water depth reached 50 m in the West Estonian Lowland and 40 m in the Peipsi basin. This promoted sedimentation of varved clays, now widely distributed. Pollen records evidence that glaciolacustrine sediments of this proglacial lake started to accumulate during the Older Dryas and the sedimentation continued in the Allerød (Pirrus & Sarv 1968). A strait in the Emajõgi River valley formed the main link between the eastern and western glacial lake systems and ensured their comparable water level (Rosentau et al. 2007). A narrow strait could also exist in north Estonia directly in front of the ice margin. A_1 formed an elongated belt of the Baltic Ice Lake in which the Pandivere Upland together with Vooremaa formed a huge island (Fig. 2).

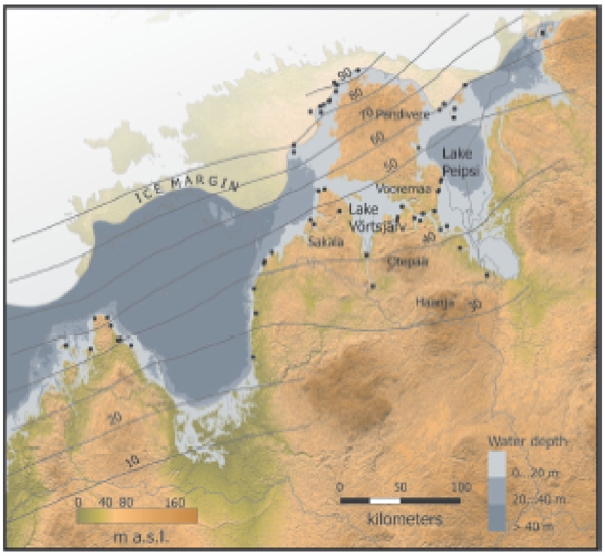

Fig. 2. Palaeogeographic reconstruction of the water level surface isobases, shoreline and bathymetry of the proglacial lake stage A_1 (Voose) in Estonia and neighbouring areas. Black dots are coastal landforms used in reconstruction

The proglacial lakes west and east of the Pandivere Upland joined up about 13,000 cal BP (Vassiljev et al. 2005) and the proglacial lake A_2 (known also as Kemba) was formed (Fig. 3). This event has been considered the beginning of the Baltic Ice Lake (Kvasov & Raukas 1970). Most recent studies have indicated that A_2 proglacial lake could have emerged later, about 12,700–12,800 cal BP during the Palivere Stade (Rosentau et al. 2007). This is supported by varve chronology, according to which it took at least 470 years for the ice margin to retreat from the Pandivere to the Palivere marginal zone (Hang 1997). The coastal landforms of proglacial lake A_2 are located at lower altitudes than those of A_1 (Appendix). The strait north of the Pandivere Upland formed now the main connection between A_2 and Peipsi proglacial lakes.

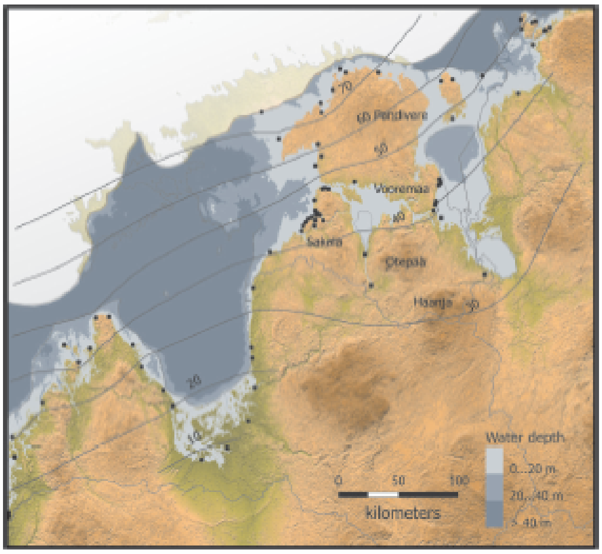

Fig. 3. Palaeogeographic reconstruction of the water level surface isobases, shoreline and bathymetry of the proglacial lake stage A_2 (Kemba) in Estonia and neighboring areas. Black dots are coastal landforms used in reconstruction shown in Appendix.

The former straits through Emajõgi and Navesti River valleys narrowed considerably. The proglacial lake A_2 covered a large area in western Estonia with its water depth reaching over 40 m. Glacial lake Peipsi was not so deep as the western one; its depth reached ca 25 m (Fig. 3). The biostratigraphy of proglacial lake sediments has been studied in several localities. The results show that these sediments started to accumulate in the Allerød (Pirrus & Sarv 1968; Kessel & Pirrus 1982).

The isobases of the proglacial lakes A_1 and A_2 show a relatively regular pattern of the uplift only in the NW part of the study area (Figs 2, 3). In the southern part isobases curve remarkably towards southeast, being up to 8 m higher than expected from the regional pattern. The main reason for that seems to be an anomalously low tilting gradient, which was revealed by correlation of over-deepened river mouths of the Emajõgi, Ahja and Obdekh rivers (Miidel et al. 1995) and the late glacial river terraces (Hang et al. 1964; Hang et al. 1995). This phenomenon can reflect the forebulge effect during the glaciation and its later collapse (Rosentau et al. 2007). Fig. 4 displays water level stand in the surroundings of Tallinn and Pärnu, which differ from the earlier reconstruction, where the drastic water level fall (ca 25 m) from the A_2 (Kemba) to A_3 (Palivere-Nõmme) proglacial lake was shown. In the present paper we have questioned the existence of the A_3 proglacial lake at all, but our suggestion needs to be controlled more precisely in the future.

During the ice retreat from the Palivere marginal zone to the Salpausselkä I ridges a considerable rearrangement of the proglacial lake drainage system occurred in Estonia. Connection of Võrtsjärv and Peipsi with the BIL was terminated via straits and were converged to the river valleys (Fig. 5). The above-named

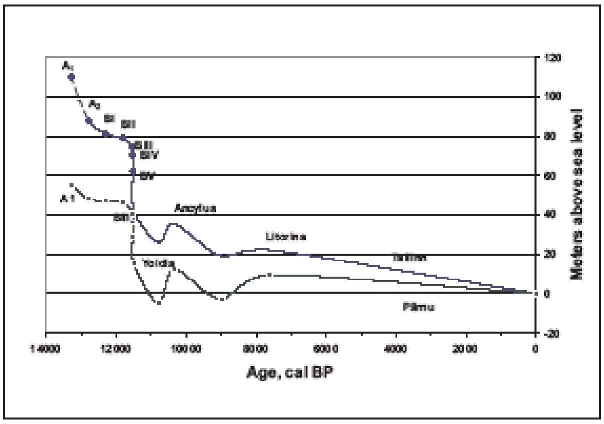

Fig. 4. Reconstructed water level curve for surroundings of Tallinn and Pärnu. The curve is derived from the interpolated water level surfaces (Saarse et al. 2003; Vassiljev et al. 2005 Saarse et al. current paper).

lakes started to develop as isolated shallow bodies of water. A remarkable number of BIL I sites (86) refers to the possibility that its shoreline was formed during a long standstill of the ice margin, obviously at Salpausselkä I position about 12,300–12,100 cal BP (Saarnisto & Saarinen 2001). A wide variety of coastal formations (beach ridges, scarps, dunes and boulder fields) have been recorded. At present coastal formations of BIL I fringe the northern and western slopes of the Pandivere and Sakala uplands between 70 and 36 m a.s.l. (Appendix). The shoreline of BIL I stage is morphologically well developed in the western slope of the Sakala Upland (Fig. 5).

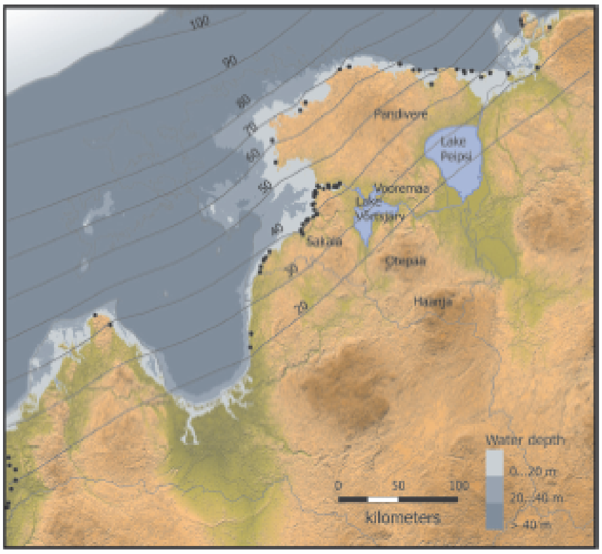

Fig. 5. Palaeogeographic reconstruction of the water level surface isobases, shoreline and bathymetry of the Baltic Ice Lake stage I (BIL I). Black dots are coastal landforms used in reconstruction shown in Appendix.

The coastal formations of BIL II stand quite close to those of BIL I dispersed commonly at 2–3 m lower

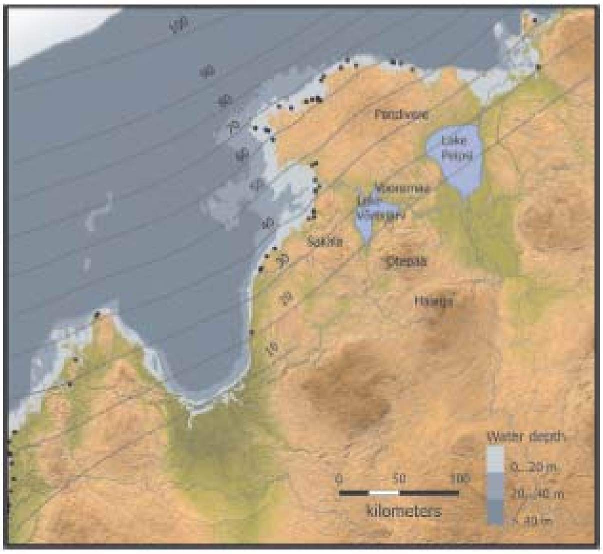

Fig. 6. Palaeogeographic reconstruction of the water level surface isobases, shoreline and bathymetry of the Baltic Ice Lake stage II (BIL II). Black dots are coastal landforms used in reconstruction shown in Appendix.

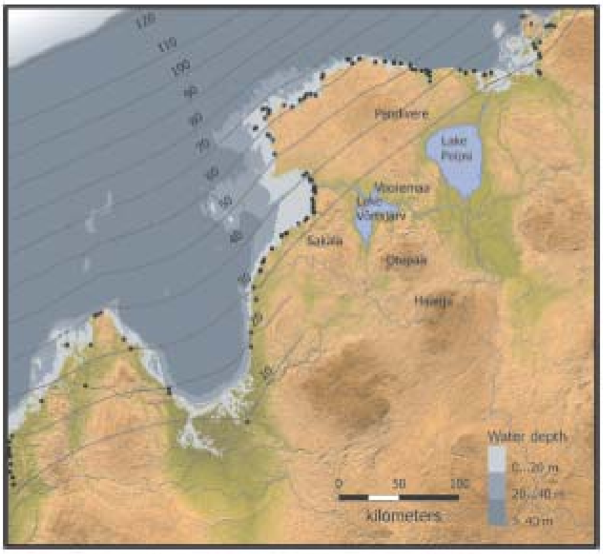

Fig. 7. Palaeogeographic reconstruction of the water level surface isobases, shoreline and bathymetry of the Baltic Ice Lake stage III (BIL III). Black dots are coastal landforms used in reconstruction shown in Appendix.

elevations, between 68 and 36 m a.s.l. (Fig. 6; Appendix). Of the total number of points (52) 15 have been singled out during the simulation. Lake Peipsi and Especially Lake Võrtsjärv were considerably shallow basins. Obviously, the beach formations of BIL II were formed during the retreat of ice margin behind the first Salpausselkä ridges at about 12,000 cal BP when the regression was slowed down (Glückert 1979).

During the ice margin standstill at the Second Salpausselkä ridges (Ss II) about 11, 800–11,600 cal BP (Saarnisto & Saarinen 2001) a well developed coastline of BIL III was formed. BIL III formations in Estonia have been registered in 124 points (42 are singled out from simulation) between 68 and 32 m a.s.l. (Appendix). Probably they were formed during the transgressive phase. The magnitude of transgression in the northwestern part of Estonia was estimated to be about 3–5 m. The basal sand of Younger Dryas age overlain by silt, intercalated with Bryales remains in the mire of central Estonia is considered as an evidence of this transgression (Kessel 1972). Glaciofluvial deposits on the coastal sediments at Kunda Hiiemägi (Kessel 1975; Moora & Moora 1996) also verify a transgression. Among landforms, marking the BIL III coastline on the western slope of the Sakala Upland, dunes are quite frequent. The openness of the area to the westerly winds and lithology of the Quaternary and Palaeozoic deposits determined their development. In northern Estonia terraces are more frequent.

The spatial distribution of BIL III is visualised in the map (Fig. 7) showing a rather intended coastline with several bays, especially on the northern and northwestern slopes of the Pandivere Upland, in the river mouths and klint bays. In the Peipsi depression a small water body was left. This is in good accord with the earlier palaeogeographic reconstruction and water level curve (Orviku 1960; Hang et al. 1995). The Võrtsjärv basin was very shallow or dry during most of season (Moora & Raukas 2004). At the end of the Younger Dryas about 11,590–11,690 cal BP BIL water level lowered (Strönberg 1992; Björck 1995; Andrén et al. 2002; Rasmussen et al. 2006) and left few scattered beach formations between 58 and 45 m a.s.l. altogether in 51 sites. In Estonia these formations have been connected with the BIL IV and V phases. The pattern of the Baltic Ice Lake isobases (Figs 5–7) is rather regular. Thus, our data do not display any changes in isobases, especially BIL III in middle Estonia, as Orviku (1960) and Pärna (1962) stated it.

CONCLUSIONS

A digital shoreline database of the Baltic Ice Lake coastal formation has been created and that for Estonia was made accessible for the public domain. The highest shoreline of the A_1 proglacial lake (Voose) was formed concurrently with or before the formation of the Pandivere ice marginal zone ca 13,300 cal BP. The age of the proglacial lake A_2 (Kemba) is not ultimately defined (13,000 or 12,800/12,700 cal BP). Digital reconstruction of shorelines shows that the proglacial lake A_1 formed an elongated bay of the Baltic Ice Lake and can be regarded as the first stage of the Baltic Ice Lake in Estonia.

A tentative shore displacement curves at the Tallinn and Pärnu isobase were reconstructed, where the low water level prior to the BIL I stage was discarded. The earlier opinion that ties up the elevation of the delta surfaces near Tallinn with the low water level prior to BIL I was questioned. Lakes Võrtsjärv and Peipsi isolated from the Baltic Ice Lake before the BIL I stage, between 12,800–12,300 cal BP.

Simulated isobases of A_1 and A_2 proglacial lakes show a relatively regular pattern of the land uplift along the Baltic coast, with a steeper tilt to northwest. Isobases in the southern part of the Peipsi depression are curving towards southeast being up to 8 m higher from the regional trend. This phenomenon can reflect the forebulge effect during the glaciation and its later collapse.

Acknowledgements

Authors wish to thank Prof. Anto Raukas for valuable comments and suggestions. Helle Kukk is acknowledged for improving English. The study was funded by Estonian target funding projects 0332626s03, 0182530s03 and Estonian Science Foundation Grant no 6736. Thank is given to Dr. Leonora Živilė Gelumbauskaitė and Prof. Jan Harff for their valuable review of the manuscript.

References

Andrén, T., Lindeberg, G., Andrén, E. 2002. Evidence of the final drainage of the Baltic Ice Lake and the brackish phase of the Yoldia Sea in glacial varves from the Baltic Sea. Boreas 31, 226–238.

Björck, S. 1995. A review of the history of the Baltic Sea, 13.0–8.0 ka BP. Quaternary International 27, 19–40.

Donner, J. 1978. The dating of the levels of the Baltic Ice Lake and the Salpausselkä moraines in Southern Finland. Commentationes Physico-Mathematicae 48, 11–38.

Donner, J. 1982. Fluctuations in water level of the Baltic Ice Lake. Annales Academiae Scientiarum Fennicae, Ser. A III, Geologica-Geographica 134, 13–28.

Donner, J. 1995. The Quaternary History of Scandinavia. World and Regional Geology 7. Cambridge University Press, Cambridge, 210 pp.

Donner, J., Raukas, A. 1989. On the geological history of the Baltic Ice Lake. Proceedings of the Estonian Academy of Sciences, Geology 38, 128–137.

Donner, J., Raukas, A. 1992. Baltic Ice Lake. In: A. Raukas, H. Hyvärinen (eds.), Geology of the Gulf of Finland, Estonian Academy Publishers, Tallinn, 262–276. In Russian.

Estonian Land Board 1996. Digital base map of Estonia in scale 1:50 000 on 112 sheets.

Fyfe, G.J. 1990. The effect of water depth on ice-proximal glaciolacustrine sedimentation: Salpausselkä I, southern Finland. Boreas 9, 147–164.

Glückert, G. 1979. Shore-level displacement and the history of vegetation in the Salpausselkä belt, western Uusimaa, south Finland. Publications Department Quaternary Geology, University of Turku 39, 77 pp. In Finish.

Glückert, G. 1995. The Baltic Ice Lake in south Finland and its outlets. Quaternary International 27, 47–51.

Grinbergs, E.F. 1957. Late- and postglacial history of the coast of the Latvian SSR. Academy of Sciences of the Latvian SSR, Institute of Geology and Mineral Resources. Riga, 127 pp. In Russian.

Hang, E., Liblik, T., Linkrus, E. 1964. On the relations between Estonian valley terraces and lake and sea levels in the Late-Glacial and Holocene periods. Tartu Riikliku Ülikooli Toimetised 156. Geograafia-alaseid töid IV, 29–42.

Hang, T.1997. Clay varve chronology in the Eastern Baltic area. GFF 119, 295–300.

Hang, T. 2001. Proglacial sedimentary environment, varve chronology and Late Weichselian development of Lake Peipsi, eastern Estonia. Ph. D. Thesis, Quaternaria A11, 44 pp. + 6 app.

Hang, T., Miidel, A., Pirrus, R. 1995. Late Weichselian and Holocene water-level changes of Lake Peipsi, eastern Estonia. PACT 50, 121–131.

International Centre for Tropical Agriculture 2004. Hole-filled seamless SRTM data V1. http://gisweb.ciat.cgiar.org/sig/90m_data_tropics.htm; http://srtm.usgs.gov/

Jakobsson, M., Björck, S., Alm, G., Andrén, T., Lindeberg, G., Svensson, N.-O. 2007. Reconstructing the Younger Dryas ice dammed lake in the Baltic basin: Bathymetry, area and volume. Global and Planetary Change 57, 355–370.

Kalm, V. 2006. Pleistocene chronostratigraphy in Estonia, southeastern sector of the Scandinavian glaciation. Quarternary Science Reviews 8, 960–975.

Kalm, V., Kadastik, E. 2001. Waterline glacial diamicton along the Palivere ice-marginal zone on the West Estonian Archipelago, Eastern Baltic Sea. Proceedings of the Estonian Academy of Sciences, Geology 50, 114–127.

Karukäpp, R., Mikalauskas, A. 1972. Põhja-Eesti fluvioglatsiaalsetest kruusa-liivaväljadest.Eesti Geograafia Seltsi aastaraamat 1970, Valgus, Tallinn, 38–49. In Estonian.

Kessel, H. 1972. Lateglacial geological history of the Baltic Sea on the Estonian territory. Eesti NSV Teaduste Akadeemia Geoloogia Instituut. Tallinn, 73 pp. Manuscript in the Institute of Geology at Tallinn University of Technology. In Estonian.

Kessel, H. 1975. Lateglacial and Holocene development of the Baltic Sea in Estonia. Eesti NSV Teaduste Akadeemia Geoloogia Instituut, Tallinn, 175 pp. Manuscript in the Institute of Geology at Tallinn University of Technology. In Estonian.

Kessel, H. 1980. On the palaeogeography of the Baltic Sea in Estonia. Eesti NSV Teaduste Akadeemia Geoloogia Instituut, Tallinn, 124 pp. Manuscript in State Archive of Estonia, R-2346, SÜ 850. In Estonian.

Kessel, H., Pirrus, R. 1982. Some problems concerning stratigraphic subdivision of Estonian late glacial sediments on the basis of palynologic data. In: T. Bartosh (Ed.), Palynologic researches in geologic studies of the Baltic region and the Baltic Sea, Zinatne, Riga, 14–17.In Russian.

Kessel, H., Raukas, A. 1979. The Quaternary history of the Baltic. Estonia. In: V. Gudelis, L.-K. Königsson (eds.), The Quaternary history of the Baltic, Acta Universitatis Upsaliensis, Uppsala, 127–146.

time on the basis of the east Baltic evidence. Peribaltic II, 131–143. In Russian.

Kvasov, D.D., Raukas, A. 1970. Postglacial history of the Gulf of Finland. Proceedings Geographical Society of Soviet Union 102, 432–438. In Russian.

Künnapuu, S. 1962. Die Rezession des Inlandeises in der Umgebung von Tallinn. Eesti Geograafia Seltsi Aastaraamat 1960/61, Eesti NSV Teaduste Akadeemia, Tallinn, 29–36. In Estonian.

Linkrus, E. 1976. The geomorphology and landscape regions of Lahemaa National Park. In: A. Raukas, L. Tulp (eds.), Estonia. Regional studies, Estonian Geographical Society, Tallinn, 114–126.

Linkrus, E. 1981. Geomorphology of the eastern part of the Lahemaa National Park. In: I. Etverk (Ed.), Lahemaa uurimused, Valgus, Tallinn, 28–44.In Estonian.

Lunkka,J.P., Johansson, P., Saarnisto M., Sallasmaa O. 2004. Glaciation of Finland. In:J. Ehlers, P. L. Gibbard (eds.), Quaternary Glaciations–Extent and Chronology. Part I: Europe, Elsevier, Amsterdam, 93–100.

Lõokene, E. 1959. Geomorphologie des nördlichen Teils des Höhengebiets von Sakala. Tartu Riikliku Ülikooli Toimetised 75. Geoloogia-alaseid Töid I, 119–154. In Russian.

Lõokene, E. 1960. Sakala kõrgustiku orgude geoloogiast. Eesti Loodus 2, 72–81.

Miidel, A., Hang, T., Pirrus, R., Liiva, A. 1995. On the development of the southern part of Lake Peipsi in the Holocene. Proceedings of the Estonian Academy of Sciences, Geology 44, 33–44.

Moora, T., Moora, H. 1996. The ridge of Hiiemägi as a precondition for the formation of the ancient Lake Kunda. PACT 51, 231–240.

Moora, T., Raukas, A. 2004. Evolution of the lake. In: J. Haberman, Pihu, E., Raukas, A. (eds.), Lake Võrtsjärv, Estonian Encyclopedia Publishers, Tallinn, 49–59.

Orviku, K. 1948. Über die Geologie des Kunda-Sees. In: Indreko, R., Die Mittlere Steinzeit in Estland, Almqvist & Wiksells AB, Uppsala, 17–39.

Orviku, K. 1960. Geological development of Estonia in Anthropogene. Eesti Loodus 1, 6–16. In Estonian.

Parts, A. 1933. Ancient beach formations at the northwestern slope of the Sakala Upland and their landscape meaning. Tartu Ülikooli Loodusuurijate Seltsi Aruanded 39, 108–120. In Estonian.

Pirrus, R., Sarv, A. 1968. Stratigraphy of Late glacial and Holocene deposits based on palynological key section of Estonia. Manuscript in the Institute of Geology at Tallinn University of Technology, 173 pp. In Estonian.

Pärna, K. 1960. Zur Geologie des Baltischen Eisstausees sowie der lokalen grossen Eisstauseen auf dem Territorium der Estnischen SSR. Eesti NSV Teaduste Akadeemia Geoloogia Instituudi uurimused V, 269–278. In Russian.

Pärna, K. 1962. On the geology of the Baltic Ice Lake and large proglacial lakes on the territory of Estonia. PhD Thesis, 163 pp. In Estonian.

Ramsay, W. 1929. Niveaurschiebungen, Eisgestaute Seen Und Rezession des Inlandeises in Estland. Fennia 52, 1–48.

Rasmussen, S.O., Andersen, K.K., Svensson, A.M., Steffenen, J.P., Vinther, B.M., Clausen, H.B., Siggaard-Andersen, M.-L., Johnsen, S.J., Larsen, L.B., Dahl-Jensen, D., Bigler, M., Röthlisberger, R., Fischer, H., Goto-Azuma, K., hansson, M.E., Ruth, U. 2006. A new Greenland ice core chronology for the last glacial termination. Journal of Geophysical Research 111, 1–16.

Raukas, A. 2004. Application of OSL and ^{10}Be techniques to the establishment of deglaciation chronology in Estonia. Proceedings of the Estonian Academy of Sciences, Geology 53, 267–287.

Raukas, A., Rähni, E. 1969. On the geological development of the Peipsi-Pihkva depression and the basins distributed in that region. Eesti NSV Teaduste Akadeemia Toimetised, Keemia, Geoloogia 18, 113–125. In Russian.

Raukas, A., Rähni, E., Miidel, A. 1971. Marginal glacial formations in North Estonia, Valgus, Tallinn, 226 pp. In Russian.

Raukas, A., Stankowski, W. 2005. Influence of sedimentological composition on OSL dating of glaciofluvial deposits: examples from Estonia. Geological Quarterly 49, 463–470.

Rosentau, A. 2006. Development of proglacial lakes in Estonia. Dissertationes Geologicae Universitatis Tartuensis 18. Tartu University Press. 48 pp. + 4 app.

Rosentau, A., Vassiljev, J., Saarse, L., Miidel, A. 2007. Palaeogeographic reconstruction of proglacial lakes in Estonia. Boreas 36, 211–221.

Saarnisto, M., Saarinen, T. 2001. Deglaciation chronology of the Scandinavian ice sheet from the east of Lake Onega basin to the Salpausselkä end moraines. Global and Planetary Change 31, 387–405.

Saarse, L., Vassiljev, J., Miidel, A. 2003. Simulation of the Baltic Sea shorelines in Estonia and neighbouring areas. Journal of Coastal Research 19, 261–268.

Sauramo, M. 1958. Die Geschichte der Ostsee. Annales Academiae Scientiarum Fennicae, Ser. A III, Geologica-Geographica 51, 1–522.

Seifert, T.T., Tauber, F., Kayser, B. 2001. A high resolution spherical grid topography of the Baltic Sea –2nd edition. In: Baltic Sea Science Congress 2001: past, present and future – a joint venture, Stockholm Marine Research Centre, Stockholm University, p. 298.

Shmaenok, A.I., Sammet, E.J., Belenetskaya, G.A., Verbova, I.M., Korneeva, T.L., Ronshin, N.I., Feigelson, M.M. 1962. Geology of the Narva, Luga and Sisty River lower courses. Complex geological mapping, scale 1:200 000. Manuscript in Northwest Geological Survey of Russia, St. Petersburg. In Russian.

Strönberg, B. 1992. The final stage of the Baltic Ice Lake. In: A. M. Robertson, Ringberg, B., Miller, U., Brunnberg, L. (eds.), Late Quaternary stratigraphy, glacial morpholohy and environmental changes, Sveriges Geologiska Undersökning, Ca 81, 347–354

Svensson, N.-O. 1989. Late Weichselian and Early Holocene shore displacement in the central Baltic, based on stratigraphical and morphological records from eastern Småland and Gotland, Sweden. LUNDQUA These 25, 195 pp.

Svensson, N.-O. 1991. Late Weichselian and Early Holocene shore displacement in the central Baltic Sea. Quaternary International 9, 7–26.

Tammekann, A. 1926. Die Oberflächengestaltung des Nordostestländischen Küstentafellandes. Acta Universitatis Tartuensis, Series A, IX, 1–152.

Uścinowicz, S. 1999. Southern Baltic area during the last deglaciation. Geological Quarterly 43, 137–148.

Uścinowicz, S. 2006. A relative sea-level curve for the Polish Southern Baltic Sea. Quaternary International 145–146, 86–105.

Vallner, L., Sildvee, H., Torim, A. 1988. Recent crustal movements in Estonia. Journal of Geodynamics 9, 215–233.

Vassiljev, J., Saarse, L., Miidel, A. 2005. Simulation of the proglacial lake shore displacement in Estonia. Geological Quarterly 49, 253– 262.

Veinbergs, I. 1979. The Quaternary history of the Baltic. Latvia. In: V. Gudelis, L.-K. Kõnigsson (eds.), The Quaternary history of the Baltic. Acta Universitatis Upsaliensis. Uppsala, 147–157.

Väärsi, A., Kajak, K., Kajak, H., Kozlova O., Liivrand, H. 1968. Report on the geological-hydrogeological mapping in scale 1: 200 000, sheet O-35XIV. Manuscript in 5th volumes in the library of Estonian Geological Centre. In Russian.

Appendix

Coastal formation database. In the simulations the lowest altitude values were used. Indexes according to authors cited.

Site name	Coordinates		Altitude	Type of landform	Index	References	Residual
	Latitude	Longitude	m a.s.l.				m
BIL I							
Aidunõmme	59°19´45´´	27°05´40´´	45-46	beach ridge	B	Tammekann 1926	-0.68
Auksaare	58°16´30´´	25°09´20´´	40	abraded coast	BII/III	Väärsi et al. 1968	-0.12
Iila	59°29´23´´	26°39´10´´	59	beach ridge	B	Tammekann 1926	0.04
Jälevere	58°36´00´´	25°24´05´´	44	beach ridge	BI	Väärsiet al. 1968	0.06
Järvakandi	58°46´40´´	24°48´20´´	54	beach ridge	BI	Kessel 1975	-0.26
Kanaküla	58°14´10´´	25°10´15´´	39	boulders	BI	Väärsi et al. 1968	0.04
Kangrusaare	58°36´45´´	25°43´10´´	43.6	scarp	BI	Pärna 1962	0.30
Karu	58°31´10´´	25°21´00´´	42	beach ridge	BI	Väärsi et al. 1968	-0.02
Kipsu	58°21´58´´	25°19´30´´	40	beach ridge	BI	Väärsi et al. 1968	0.07
Konju	59°23´55´´	27°35´45´´	44	beach ridge	B	Tammekann 1926	-0.13
Kose	59°09´325°10´20´´		68	beach formations	BI	Pärna 19620.51	
Kullamaa	58°36´15´´	25°32´50´´	43.5	beach ridge	BI	Väärsi et al. 1968	0.02
Kõrkküla	59°26´05´´	26°56´	54-55	beach ridge	B	Tammekann 1926	0.37
Laagna	59°23´20´´	27°58´	38	beach ridge	B	Tammekann 1926	0.14
Labida	58°32´38´´	25°21´15´´	42.5	dune	BI	Väärsi et al. 1968	-0.05
Labida	58°32´39´´	25°22´16´´	43	dune	BI	Väärsi et al. 1968	0.44
Laiksaare	58°06´30´´	24°41´50´´	38.5	scarp	BI/II	Pärna 1962	-0.23
Läätsi	58°34´47´´	25°33´41´´	42	abraded coast	BI	Väärsi et al. 1968	-0.48
Loobu	59°28´45´´	25°53´57´´	65	ridge	BI	Kessel 1980	-0.46
Maalaste	58°35´18´´	25°40´55´´	42	abraded coast	BI	Väärsi et al. 1968	-0.51
Maalaste	58°35´25´´	25°40´24´´	43	dunes	BI	Väärsi et al. 1968	0.33
Martsa	59°25´40´´	27°28´25´´	48-49	ridge	B	Tammekann 1926	0.20
Massiaru	57°59´55´´	24°34´50´´	36.7	beach formations	BI/II	Pärna 1962	0.29
Merinäki	58°02´40´´	24°36´40´´	37.2	beach formations	BI/II	Pärna 1962	-0.42
Merinäki N	58°03´10´´	24°37´25´´	38.5	beach formations	A_2	Pärna 1962	0.53
Mutioja	58°33´08´´	25°22´51´´	43	ridge	BI	Väärsi et al. 1968	0.30
Männiku	58°31´20´´	25°20´50´´	42	beach ridge	BII	Parts 1933	-0.07
Männiku	58°31´20´´	25°21´	43	beach ridge	BI	Väärsi et al. 1968	0.92
Nepste	58°03´ 30´´	24°38´	38.5	beach ridge	A_2	Pärna 1962	0.34
Nõmbra	59°13´12´´	25°15´	66	scarp	BI	Pärna 1962	-0.72

Nööripere	58°34´41´´25°29´12´´	43	scarp	BI	Parts 1933	0.17
Paelama	58°28´05´´25°20´30´´	42	boulders	BI	Väärsi et al. 1968	0.06
Paelama	58°27´32´´25°19´40´´	42	beach ridge	BI	Väärsi et al. 1968	-0.05
Poola	58°25´15´´ 25°20´53´´	42	beach ridge	BI	Väärsi et al. 1968	0.77
Päite	59°24´45´´27°42´07´´	43	ridge	B	Tammekann 1926	0.10
Raikküla	58°56“34““24°45“10““	61.1	scarp, beach ridge	BI	Pärna 1962	-0.27
Rannaküla	59°26“23““26°50“32““	54-55	ridge	B	Tammekann 1926	-0.19
Raudma	58°35“24““25°24“30““	43	boulders	BI	Väärsi et al. 1968	-0.58
Rehesaare	58°35“23““25°38“18““	43	dune	BI	Väärsi et al. 1968	-0.02
Rehesaare	58°35“32““25°38“08““	44	dunes, boulders	BI	Väärsi et al. 1968	0.84
Rääka	58°33“19““25°21“43““	42.5	beach ridge	BI/II	Lõokene 1959	-0.28
Saka	59°26“06““27°10“35““	52-53	ridge	B	Tammekann 1926	0.32
Sooba	58°04“27““24°39“06““	39	beach ridge	BI	Pärna 1962	0.45
Tagama	58°15“40““25°09“	40	beach ridge	BI	Väärsi et al. 1968	0.21
Teaste	57°57“37““24°33“37““	36.2	scarp	BIII	Kessel 1980	0.12
Teaste	57°57“40““24°33“38““	36	beach ridge	BII/III	Pärna 1962	-0.09
Torga-Erne	58°21“07““25°15“17““	40	beach ridge	BI	Väärsi et al. 1968	-0.55
Uia	58°20“16““25°13“41““	41	abraded coast	BI	Väärsi et al. 1968	0.21
Vaivara	59°21“44““27°50“20““	38-39	scarp	B	Tammekann 1926	-0.13
Valgejõe	59°27“40““25°45“56““	70	scarp	BI	Pärna 1962	0.33
Venisaare	58°18“38““25°11“02““	41	beach ridge	BI	Väärsi et al. 1968	0.25
Voka	59°24“37““27°34“32““	45-46	ridge	B	Tammekann 1926	-0.02
Väike-Kõpu	58°23“18““25°23“05““	39	abradedcoast	BI	Väärsi et al. 1968	-0.35

BIL II

Alavere	59°14“ 30““25°20“30““	62-63	scarp	BII	Pärna 1962	-0.39
Angerja	59°11“30““24°51“20““	67.5	beach formation	BII	Pärna 1962	-0.16
Arava	59°15“15““25°24“40““	63-64	beach dune	BII	Pärna 1962	0.47
Iila	59°29“25““26°39“10““	57,5	ridge	BII	Ramsay 1929	0.08
Jändja	58°45“05““25°19“	47	ridge	BII	Pärna 1962	-0.47
Kemba	59°28“11““25°45“42““	67	scarp	BII	Pärna 1962	0.22
Kolu	59°10“40““25°02“10““	66	scarp	BII	Pärna 1962	0.22
Koogu	59°26“25““26°49“	54-55	ridge	B	Tammekann 1926	0.00
Korismägi	59°30“05““26°30“55““	58.4	ridge	BII	Ramsay 1929	0.22
Kunda	59°29“49““26°33“	56-58	ridge	BIII	Orviku 1948	0.83
Kursi Aruk.	59°25“00““25°30“40““	67.1	boulders	BII	Pärna 1962	-0.64
Kõrve	59°23“25°28“30““	68	scarp	BII	Pärna 1962	0.55
Laidrema	59°14“24““25°24“34““	62.5	dune	BII	Pärna 1962	0.61
Laupa	58°45“30““25°22“	48.5	scarp	BI	Kessel 1975	0.55
Massiaru	57°58“09““24°33“39““	36.2-36.4	beach formation	BII/I	Pärna 1962	0.38
Massiaru	57°59“25““24°34“25““	35.8- 36	beach ridge	BII/III	Pärna 1962	-0.24
Mutioja	58°33“25““25°21“50““	41	ridge	BI	Väärsi et al. 1968	0.26
Nõmbra	59°13“40““25°14“58““	62-63	scarp	BII	Pärna 1962	-0.09
Palamulla	59°00“44““24°39“32““	62.8	beach formation	BII	Pärna 1962	-0.16
Raikküla	58°56“36““24°45“08““	58.5	beach formation	BII	Pärna 1962	-0.14
Rassi	58°38“10““25°21“30““	44	beach sand	BI	Väärsi et al. 1968	0.23
Raudsilla	59°14“25°27“	60	dune	BII	Pärna 1962	-0.44
Ruunaraipe	58°24“16““25°19“10““	38.5	dune	BII	Lõokene 1959	-0.02
Rääka N	58°33“28““25°21“28““	40	dune	BII	Pärna 1962	-0.72
Rääka	58°33“09““25°21“06““	40	dune	BII/III	Lõokene 1959	-0.48
Sakusaare	59°29“17““25°59“44““	62	scarp	BII	Kessel 1980	-0.25
Sauga	58°24“09““25°20“17““	38.5	dune	BI	Pärna 1962	0.31
Sooba	58°04“30““24°39“04““	36.5	scarp	BII/I	Pärna 1962	-0.01
Teaste	57°58“47““24°34“11““	36.2-36.4	beach ridge	BII/III	Pärna 1962	0.27
Torga-Erne	58°21“07““25°15“16““	39	beach ridge	BII	Lõokene 1959	0.40
Tõrma	59°00“27““24°41“30““	62.5	scarp	BII	Pärna 1962	0.13
Uusküla	59°31“26““25°52“11““	67	islet	BII	Kessel 1980	0.04

Valgejõe	59°28"06""25°46"09""	66.6	scarp	BII	Pärna 1962	0.03
Vanaveski	58°21"43""25°20"02""	37.1	terrace	BII	Lõokene 1960	-0.18
Vangu	58°08"24°45"58""	36	beach formation	BII	Pärna 1962	-0.13
Varbola	59°01"44""24°30"04""	66.5	beach formation	BII	Pärna 1962	-0.02
Voskejan	58°35"30""25°24"30""	42	beach ridge	BII	Väärsi et al. 1968	0.01

BIL III

Adila-Rabivere	59°06"30""24°39"10""	62	scarp	BIII	Ramsay 1929	-0.47
Aiduliiva	59°21"27°04"	42	beach sand	BIII	Kessel 1972	0.12
Esku	59°15"25°13"40""	60.2	beach ridge	BIII	Pärna 1962	-0.64
Hageri NW	59°10"40""24°40"15""	64-65	scarp	BIII	Ramsay 1929	-0.42
Hageri-2	59°08"10""24°42"	63	beach formation	B III	Kessel 1972	-0.02
Hermiste	58°03"24°36"55""	33	scarp	BIII	Pärna 1962	0.01
Iila	59°29"30""26°39"05""	52.9-54	terrace	BIII	Ramsay 1929	0.14
Ilmapõllu	58°21"30""25°14"	33	dune	BII/III	Väärsi et al. 1968	0.07
Ilumäe	59°31"53""25°53"24""	63	scarp	BIII	Ramsay 1929	-0.14
Juhkruõue	58°33"55""25°19"35""	36	beach ridge	BIII	Väärsi et al. 1968	-0.50
Jabara	59°25"27°03"50""	44	ridge, terrace	C	Tammekann 1926	0.09
Jämmi	58°59"05""24°41"17""	58.5	ridge	BIII	Pärna 1962	0.23
Kajaka	59°14"20""25°09"40""	63	scarp	BIII	Pärna 1962	0.64
Kalvi	59°28"50""26°47"30""	51	ridge	C	Tammekann 1926	0.00
Kandle	59°30"23""26°16"40""	55-57	terrace	BIII	Ramsay 1929	-0.10
Kellisaare	58°41"30""25°14"45""	42-43	dunes	BIII	Pärna 1962	0.84
Kiviloo	59°16"45""25°14"50""	62.1	beach formation	BII/III	Pärna 1962	0.04
Kivisaare	58°33"30""25°20"43""	36.5	dune	BIII	Lõokene 1959	0.19
Kollanõmme	58°13"45""24°52"	32.7	beach ridge	BIII	Pärna 1962	-0.68
Kollanõmme	58°13"10""24°52"05""	33.5	beach ridge	BIII	Pärna 1962	0.29
Kolu	59°11"30""25°02"40""	61	scarp	BIII	Pärna 1962	-0.07
Konju	59°23"50""27°35"30""	37	terrace, ridge	C	Tammekann 1926	0.06
Koogu	59°26"35""26°48"50""	50	terrace	BIII	Ramsay 1929	0.76
Kunda Hiiem.	59°29"30""26°32"13""	54.5	beach deposit	BIII	Kessel 1972	0.78
Kurgja	58°39"25°16"30""	38	beach ridge	BII/III	Väärsi et al. 1968	-0.73
Kursi	59°25"40""25°30"25""	64	beach formation	BIII	Ramsay 1929	-0.35
Kuusiku	58°58"36""24°42"36""	58	scarp	BIII	Pärna 1962	0.39
Kuusiku	58°58"36""24°42"37""	57.4	scarp	BIII	Pärna 1962	-0.21
Kõrkküla	59°25"46""26°57"10""	46	terrace	C	Tammekann 1926	0.11
Laagna	59°23"30""27°57"45""	33.5	ridge	BIII	Kessel 1975	0.97
Laagna	59°23"30""27°57"40""	32	ridge, terrace	BIII	Ramsay 1929	-0.52
Labida N	58°32"45""25°20"46""	36	dune	BIII	Lõokene 1959	-0.02
Labida S	58°32"40""25°20"40""	36-38.5	dune	BII/III	Lõokene 1959	0.00
Laugaste	59°24"25°29"15""	65	ridge	BIII	Pärna 1962	0.87
Laulaste	57°58"24""24°33"45""	32.8	dune	BIII	Kessel 1980	-0.05
Lehma	58°15"24°56"30""	33	sands	BIII	Pärna 962	0.00
Liivaselja	58°14"20""24°55"53""	33	beach ridge	BIII	Pärna 1962	0.10
Lubjasaare	58°25"30""25°19"	33	dune	BII/III	Väärsi et al. 1968	-0.53
Lüganuse	59°23"04""27°03"31""	43	beach ridge	BIII	Kessel 1972	-0.01
Maasika	58°26"48""25°18"57""	35	dune	BII/III	Väärsi et al. 1968	0.82
Malla	59°30"01""26°33"50""	53	terrace	BIII	Ramsay 1929	-0.41
Maltsaare	58°35"38""25°20"10""	37-38	dune	BII/III	Väärsi et al. 1968	-0.15
Merinäki	58°02"10""24°35"58""	32.5	beach formation	BIII	Pärna 1962	-0.37
Miiliaugu	58°24"52""25°19"07""	32.5	dune	BIII/IV	Pärna 1962	-0.64
Miiliaugu	58°24"52""25°19"09""	33	dune	BII/III	Väärsi et al. 1968	-0.13
Muraka	58°33"45""25°20"30""	36.5	dune	BIII	Lõokene 1959	0.06
Mutioja	58°32"35""25°20"50""	36	dune	BII/III	Väärsi et al. 1968	0.06
Mädara	58°40"43""25°11"28""	41	dune	BIII	Pärna 1962	-0.16
Paelama	58°28"13""25°19"07""	35	dune	BIII	Pärna 1962	0.39
Palmse	59°30"12""25°56"40""	60	beach ridge	BIII	Kessel, 1972	-0.21
Pikva	59°16"10""25°23"20""	58	scarp	BIII/IV	Pärna 962	-0.32

Purtse Hiiem.	59°25“55““27°01“18““	44-45	terrace	C	Tammekann 1926	-0.44
Purtse-Liiva	59°24“33““27°02“02““	43-44	dunes	BIII	Kessel 1972	-0.30
Päevati	59°10“24°43“00““	64.5	scarp	BIII	Pärna 1962	0.16
Päiaru	58°07“40““24°44“00““	33.5	beach formation	BIII	Pärna 1962	0.08
Pärtle	58°18“34““25°06“39““	32.5	dune	BII/III	Väärsi et al. 1968	-0.09
Raikküla	58°56“37““24°45“07““	56.1	beach formation	BIII	Pärna 1962	0.21
Rannaküla	59°26“18““26°51“50““	47	terrace	C	Tammekann 1926	-0.64
Rassi	58°37“55““25°17“35““	38	dune	BII/III	Väärsi et al. 1968	-0.33
Ruunaraipe	58°24“16““25°18“53““	33-35	dune	BII/III	Väärsi et al. 1968	0.14
Rääka	58°33“43““25°21“06““	36	dune	BII/III	Väärsi et al. 1968	-0.34
Saeveski	58°37“50““25°17“29““	38	beach ridge	BII/III	Väärsi et al. 1968	0.00
Saeveski	58°38“12““25°19“07““	38	dune	BII/III	Väärsi et al. 1968	-0.18
Sagadi	59°32“04““26°02“33““	60	terrace	BIII	Ramsay 1929	-0.17
Sauga	58°23“50““25°20“	30-32	dune	BII/III	Väärsi et al. 1968	-0.27
Selja	59°30“30““26°25“	57	terrace, ridge	BIII	Ramsay 1929	0.23
Seljaste	59°17“25°18“40““	62	scarp	BIII	Pärna 1962	0.59
Sutlema	59°10“35““24°37“	68	beach formation	BIII	Pärna 1962	0.54
Sutlema	59°10“30““24°36“54““	67.8	scarp	BIII	Kessel 1975	0.38
Tammiku	59°12“19““24°56“07““	63.5	boulders	BIII	Pärna 1962	-0.29
Teaste	57°57“41““24°33“15““	34	scarp	BIII	Parts 1933	0.98
Toila-Oru	59°25“15““27°30“46““	39	terrace	C	Tammekann 1926	0.07
Türsamäe	59°24“25““27°43“30““	36	scarp	BIII	Tammekann 1926	0.05
Uia	58°20“20““25°12“05““	33	boulders	BII/III	Väärsi et al. 1968	0.22
Urisaare	58°01“40““24°35“10““	32	beach formation	BIII	Ramsay 1929	-0.87
Vahakõnnu	58°50“10““24°46“40““	51	scarp, ridge	BIII	Kessel 1972	-0.13
Vaivara	59°22“50““27°52“45““	33-34	terrace	C	Tammmekann 1926	0.04
Vanaõue	S58°35“19““25°21“07““	37.5	dune, scarp	BIII	Lõokene 1959	0.52
Varbola O	59°02“08““24°31“13““	62.5	beach formation	BIII	Pärna 1962	-0.18
Varbola SW	59°01“38““24°29“54““	62.8	beach formation	BIII	Pärna 1962	-0.07
Võhma	59°31“55““25°51“54““	64.5	beach ridge	BIII	Kessel 1980	0.54
Võlla	58°29“50““25°18“50““	35	beach ridge	BII/III	Väärsi et al. 1968	-0.18