Ancient buried valleys in the city of Tallinn and adjacent area

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Received 10 December 2008, accepted 10 August 2009

Abstract. The distribution, morphology, fillings, and origin of buried valleys are discussed. The direction of the valleys varies from NW to NE. Within the Viru-Harju Plateau the valleys have a more or less symmetric profile, but asymmetric profiles are dominating in the pre-klint area. They are mainly filled with glacial (till), glaciofluvial (sand, gravel, and pebbles), glaciolacustrine (varved clay), and marine (fine-grained sand) deposits. The Tallinn valley with its tributary valleys (Saku and Sausti) and fore-klint branches (Harku, Lilleküla, and Kadriorg) looks like a river system. The fore-klint branches extend over 20 km in the Gulf of Finland. They are probably tributaries of the ancient river Pra-Neva. Most likely, the formation of valleys was continuous, starting from pre-Quaternary river erosion, and was sculptured by variable processes during the ice ages and influenced by flowing water during the interglacial periods.

Key words: buried valleys, glacial erosion, fluvial erosion, glacial deposits, glaciofluvial deposits, glaciolacustrine deposits.

INTRODUCTION

Many deep valley-like incisions of different orientation and morphology exist on the territory of Estonia and neighbouring countries. Most of the valleys in the Baltic Sea area were probably formed in the Late Palaeogene and Neogene when the Earth's crust was much higher than at present due to the riftogenesis in the North Atlantic region (Puura 1980). According to Gibbard (1988), the foundation of the modern drainage system in NW Europe was laid in the vertical movements of the Miocene crust. The deeply incised valley system has largely developed during the past 2.4 million years.

The incisions in Tallinn are mainly filled with Upper Weichselian glacial, glaciofluvial, and glaciolacustrine deposits and Holocene marine deposits (Tavast & Raukas 1982). The genesis of incisions is explained in different ways: (1) as a result of glacial carving (e.g. Goretski 1972), (2) as a consequence of meltwater erosion (Rattas 2007), and (3) mainly as a result of erosion of preglacial rivers, which were later deepened and enlarged by glaciers and subglacial meltwaters. The role of glaciers is greater in meridionally orientated incisions (Raukas & Tavast 1984). In northern Estonia the contemporary river drainage is supposedly inherited from the ancient pre-Quaternary fluvial system and depends on the tectonic joints in the bedrock (Miidel 1966, 1971). The incisions are cut both in hard (carbonate) and soft (siliciclastic) bedrock, whereas their morphology differs depending on the rock type.

The incisions in Tallinn have great practical importance as they contain common building materials sand and gravel. They also contain high-quality water (Sepp 2002), which is used for water supply as well as in industry. An essential displacement of benchmarks takes place over buried valleys (Lutsar 1965). Land subsidence may reach several metres, impeding town construction and normal exploitation of water and sewage communications (Vallner 1965).

HISTORICAL BACKGROUND

The morphology and genesis of bedrock topography in Tallinn has been investigated for a long time (Tammekann 1934; Künnapuu & Raukas 1976; Künnapuu et al. 1981; Tavast & Raukas 1982; Tavast et al. 1983). Most of the initial data are concentrated in manuscripts, compiled by A. Verte, B. Belkin, H. Liivrand, V. Meriküll, L. Savitskaja, L. Savitski, K. Stumbur, A. Viigand, etc. and kept at the Depository of Manuscript Reports (DMR) of the Geological Survey of Estonia.

The collected data are contradictory and thus cause confusions about the age and genesis of the Quaternary fill. Based on the above reports, general conclusions can only be drawn: (1) bedrock topography has formed as a result of long-lasting pre-Quaternary continental denudation, (2) deep incisions result from the erosion of ancient rivers, and (3) small undulations in bedrock topography originate mainly from glacial erosion. The estimated amount (thickness) of the bedrock removed by Pleistocene glaciers is 50–60 m on the East European Plain (Isachenkov 1976), up to 100 m in the Riga–Jelgava depression and 20–40 m in the surrounding uplands (Makkaveyev 1976). According to Amantov (1995), 120–220 m of sediments were glacially removed in North Estonia.

However, glaciers are not responsible for all features in bedrock topography. Puura et al. (1999) demonstrated that in northern Estonia at least large bedrock uplands (e.g. Pandivere and Ahtme) have already formed in pre-Devonian time. Orviku (1929) believed that glaciers did not change the bedrock topography drastically because ancient (preglacial) crust of weathering still exists in several locations.

Different views have been expressed on the topography and number of incisions in the Tallinn area. The bedrock topography map of Tallinn by Künnapuu et al. (1981) includes nine valleys or valley-like depressions: Harku, Lilleküla, Kadriorg, Pirita, Saku-Nõmme, Saku-Vääna, Nabala-Saku, Sausti-Raudalu, and Rae. Tšeban (1978) and Sepp (2002) mentioned only four buried valleys: Lilleküla–Pelguranna, Kesklinna (Central Tallinn), Harku, and Mähe. Raukas & Rähni (1974) supposed that one valley could be followed up to Paunküla some 50 km southeast of Tallinn.

MATERIALS AND METHODS

Numerical data (location and altitude of the hole's mouth, depth of the bedrock, thickness of sediments and rocks) of 547 boreholes were obtained from unpublished reports deposited in the DMR, and from a few scientific publications (Künnapuu et al. 1981; Tavast et al. 1983). In the reports depth to the bedrock (thickness of Quaternary sediments, 7.5 m) is given with an accuracy of 0.1 m. Rounded off altitudes (i.e. 8 m) of the bedrock are shown on our maps. The data were interpreted manually by interpolating between higher and lower values, and contour maps were drawn. The interpreted contours were digitized and perspective views were drawn up using the software Surfer 8.

BEDROCK GEOLOGY

Palaeoproterozoic metavolcanic rocks (mostly gneisses) compose the ~1.88 Ga crystalline basement of the Tallinn region. The Mesoproterozoic (Koistinen 1996) or Palaeoproterozoic (Ogg 2008) rapakivi granite intrusion at Maardu (Maardu Pluton) is 1.62–1.65 Ga old. The southerly dipping (8′) top surface of the crystalline basement is located at a depth of 120–180 m below sea level (b.s.l.).

The basement is covered by an up to 210 m thick sequence of subhorizontally layered 450–600 Ma old Neoproterozoic and Palaeozoic sedimentary rocks. The Ediacaran, Cambrian, and Lower Ordovician sections are dominated by sandstone, siltstone, and claystone. The Middle and Upper Ordovician are represented by carbonate rocks (mostly limestone and marlstone). The regional low-angle (8′) southerly dipping homoclinal structure of the sedimentary bedrock is complicated by the asymmetric NE–SW-trending Maardu anticline. The distance from the crest of the anticline to the northwestern trough is 10–17 m.

MAIN OUTLINES OF BEDROCK TOPOGRAPHY

The Estonian bedrock topography is cuesta-like. The northern edge of the largest, gently sloping bedrock surface feature, the Viru-Harju Plateau, falls abruptly to the Gulf of Finland, forming the steep North Estonian Klint. In the area under consideration the klint is highest in its eastern part (46 m). Many small elongated or oval bedrock hills, some kilometres long and several hundred metres wide, are found in the fore-klint area. The largest one (4.0 km long, 1.2 km wide, and 10–12 m high) is located between the Lilleküla and Kadriorg incisions (Fig. 1a). It includes also Toompea Hill with a maximum altitude of 43 m (borehole (b.h.) No. 2 in profile B′–B″, Fig. 2). Southwest of the klint the hills are about 1 km long and several hundred metres wide (Künnapuu et al. 1981). Seven incisions exist on the territory of Tallinn (Figs 1a, 3): Tallinn (major), Harku, Lilleküla, Kadriorg (branches), Saku, Sausti (tributaries), and Mähe (separate). The Vääna incision and most part of the Tallinn and Sausti incisions are located beyond city limits.

DESCRIPTION OF INCISIONS

The **Tallinn incision** (major) is an elongated (over 30 km long), 0.5–1.5 km wide N–S-trending feature that extends to Kohila settlement (Fig. 1b), where its floor is 41 m above sea level (a.s.l.). The incision has a more or less symmetrical profile. It is slightly meandering and, at the northern edge west of Lake Ülemiste, diverges into three branches: Harku, Lilleküla, and Kadriorg (Fig. 1).

The floor of the incision is markedly deepened near the diverging centre (b.h. No. 315), lying 80 m b.s.l. Thus, the average longitudinal gradient of the incision's floor is 4 m/km. The Geological map of the Estonian shelf, composed on the basis of seismic investigations (Lutt & Raukas 1993), shows extension of the branches (Harku, Lilleküla, Mähe) of the Tallinn incision for over 20 km in the Gulf of Finland. Figure 4 shows perspective views of the valleys.

The **Lilleküla incision** (central branch) represents a N–S-trending continuation of the Tallinn incision. The floor of this branch deepens rapidly (average gradient is up to 14 m/km): in one of the northernmost boreholes (No. 14) it is as low as 128 m b.s.l. (Fig. 1a). The incision has a more or less symmetrical profile but widens northwards.

The **Harku incision** (western branch, continuation of the Tallinn incision) is a more than 10 km long feature that is widest (about 800 m) and deepest (143 m b.s.l., b.h. No. 1; Figs 1a, 2a) near the coastline (NW end of the incision). There the incision has rather steep V-like asymmetric shape, with a gentler western slope (Fig. 2a). In plan view it starts (is higher) at the northern mouth of the Tallinn incision, runs in the southwestern direction, and then turns gradually to the northwest (Fig. 1a).

The **Kadriorg incision** (eastern branch, continuation of the Tallinn incision) starts from the diverging centre at Lake Ülemiste, extends first for 4 km in the NW direction and then to the north up to the Old Port of Tallinn (Fig. 1a). The incision is about 600 m wide, asymmetric, with a gentler eastern slope. The floor is deepest in b.h. No. 694 (80 m b.s.l.; Fig. 2c).

The **Mähe** (or **Pirita** or **Merivälja**) **incision** is mostly located in the northeastern part of Tallinn. From Lake Maardu (Fig. 3), where its floor is 18 m a.s.l., the incision extends for 3 km in the NNW direction and then turns to the NWW. The incision is widest (10 km) and asymmetric (Fig. 3b) near the coast with a floor lying at a depth of 135 m b.s.l. (Fig. 3a), making the average gradient as high as 13 m/km.

The **Vääna** (or **Saku–Vääna**) **incision** is highest in Saku where its floor is 25 m a.s.l. and extends generally in the NW direction, following the Vääna River (Fig. 1a). Its average gradient within the first 10 km under the present study is very small (some 0.5 m/km). Altogether this incision is about 24 km long, over 140 m deep, and almost fully filled with till at its deepest end near the coast of the Gulf of Finland (outside the study area).

The **Saku** (or **Saku–Nõmme**) **incision** (tributary) begins several kilometres north of Saku, extends for about 4 km to the north, and then turns to the NNW. At the southern end the incision is about 10 m deep and its floor lies at 27 m a.s.l. (Fig. 1a). It crosses the klint and joins the Harku incision at the northern side of Lake Harku.

The **Sausti** (or **Sausti–Raudalu**) **incision** (tributary) is a 10 km long, partially SSW–NNE and partially S–N elongated feature, extending from Sausti Manor until joining the Tallinn incision in the vicinity of Lake Ülemiste (Fig. 1a). At its higher end the incision is several metres deep, with the floor lying at 29 m a.s.l. (Fig. 1a). The average longitudinal gradient of the floor is 1.5 m/km.

QUATERNARY INFILLING OF INCISIONS

The incisions in the fore-klint area are mainly filled with glacial, glaciofluvial, and glaciolacustrine deposits (Tavast et al. 1983). Gravelly sand often covers the bottom parts of the valleys (Figs 2, 3). Holocene, mainly marine deposits form the topmost layers. Among glacial deposits everywhere the tills of the last Järva (Weichselian) glaciation are prevailing (Table 1). Different Järva tills are probably oscillatory or stadial formations, with up to 7.5 m thick sand or gravel interlayers. The sediments of at least penultimate Late Ugandi (Saalian) glaciation are also present. Older till in the bottommost parts of the valleys is rare and thin (less than 8 m thick).

A continuous Middle and Upper Pleistocene sequence has been studied 18 km NNE of Tallinn on Prangli Island in the Gulf of Finland. The Prangli (Eemian) intermorainic deposits are underlain by two brown tills and covered by two grey tills undoubtedly in the initial position. The section on Prangli serves as an interglacial stratotype section (Raukas & Kajak 1995).

The Tallinn incision between Kohila and the city boundary is filled with 10–40 m thick till, covered mostly with an up to 20 m thick sand layer. Till occurs only at a few points. Within 1.5 km north of the city boundary, 2–3 m thick lenses of varved clay were found in the lower part of the sand layer. In the southern part of the fore-klint area (b.h. No. 315) the fill is composed of (from bottom to top) lower till (10 m) with a lens of gravel (2 m), gravelly sand (73 m), upper till (19 m) with a lens of gravelly sand (7.5 m), gravel (5.5 m), and fine-grained sand (2 m).

Figures 2 and 3b illustrate the composition of the Quaternary fill of the incisions in the northern part of the fore-klint area. The deepest, central section of the Lilleküla incision along the profile B–B′ (Fig. 2b), and in boreholes Nos 84 and 25, is filled with 40–70 m of gravelly sand. The superposed 8–20 m thick layer of till ranges all over the section (about 4 km). The till layer is covered by a thin (some 3 m) lens of varved clay (Fig. 2b)

(a)

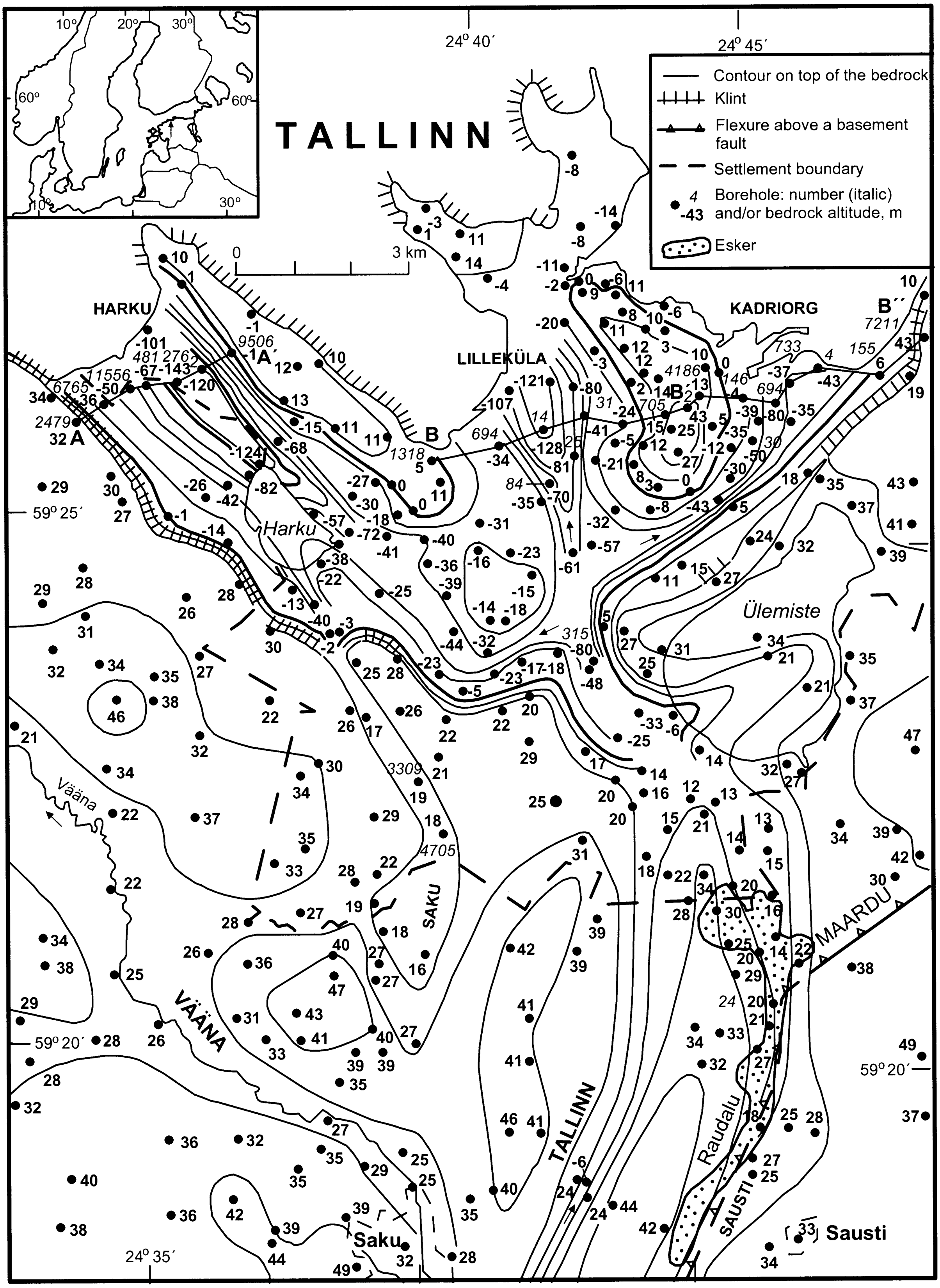

Fig. 1. For explanation see p. 41.

(b)

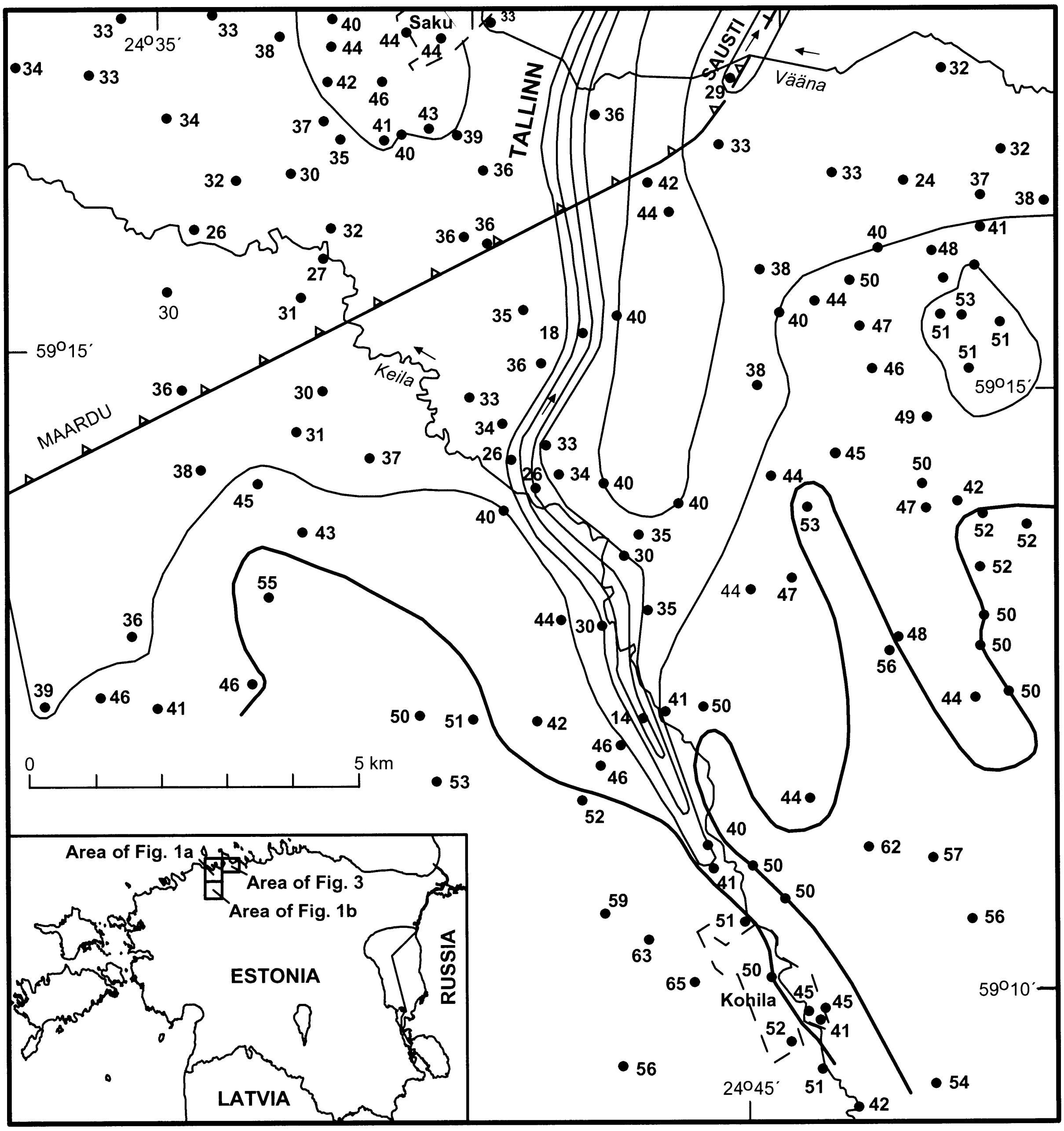

Fig. 1. Bedrock topography of the city of Tallinn and adjacent area: (a) northern part, (b) southern part. Contour interval 10 m (a.s.l.) or 20 m (b.s.l). Data from the Depository of Manuscript Reports (Geological Survey of Estonia) and Institute of Geology at Tallinn University of Technology.

and a 10–35 m thick sand layer including 4–11 m thick lenses of varved clay (Fig. 2b, b.h. Nos 25, 84).

The fill of the Harku incision along the profiles A–A′ (Fig. 2b) and at Lake Harku (fig. 2 in Tavast et al. 1983) is much the same as in Lilleküla: gravelly sand (10–40 m), till (50–100 m) including thin (2–6 m) lenses of (gravelly) sand, varved clay (10–25 m), and sand (10–20 m) on top. The fill of the Kadriorg incision (Fig. 2c; b.h. No. 30) is similar to those of the neighbouring incisions, including (from bottom to top) gravelly sand (10–60 m), till (10–25 m), and sand (up to 10 m). No varved clay and sandy lenses were found inside the till body. The

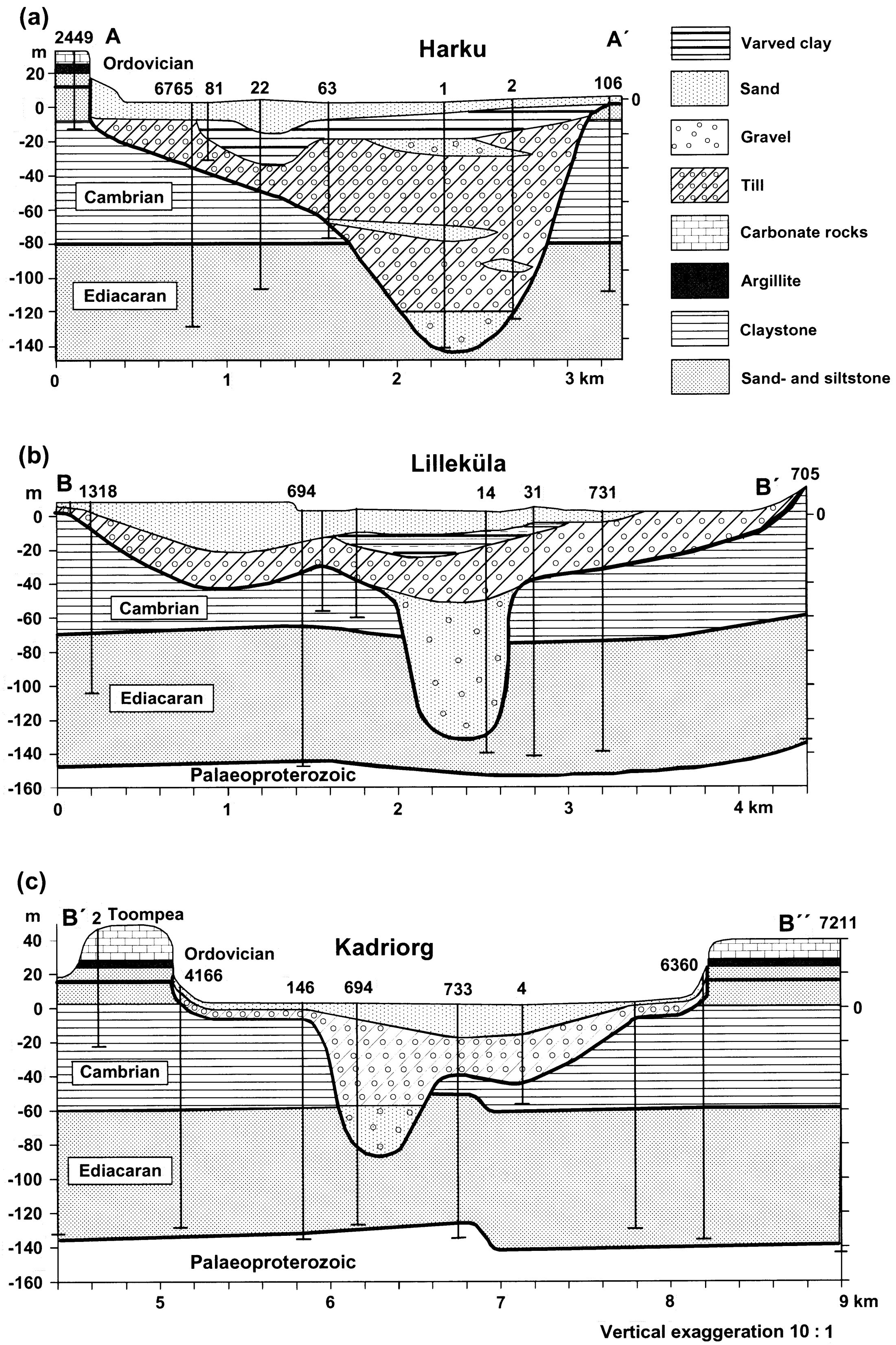

Fig. 2. Cross sections of the Harku (a), Lilleküla (b), and Kadriorg (c) branches of the Tallinn incision. Data from the Depository of Manuscript Reports, Geological Survey of Estonia.

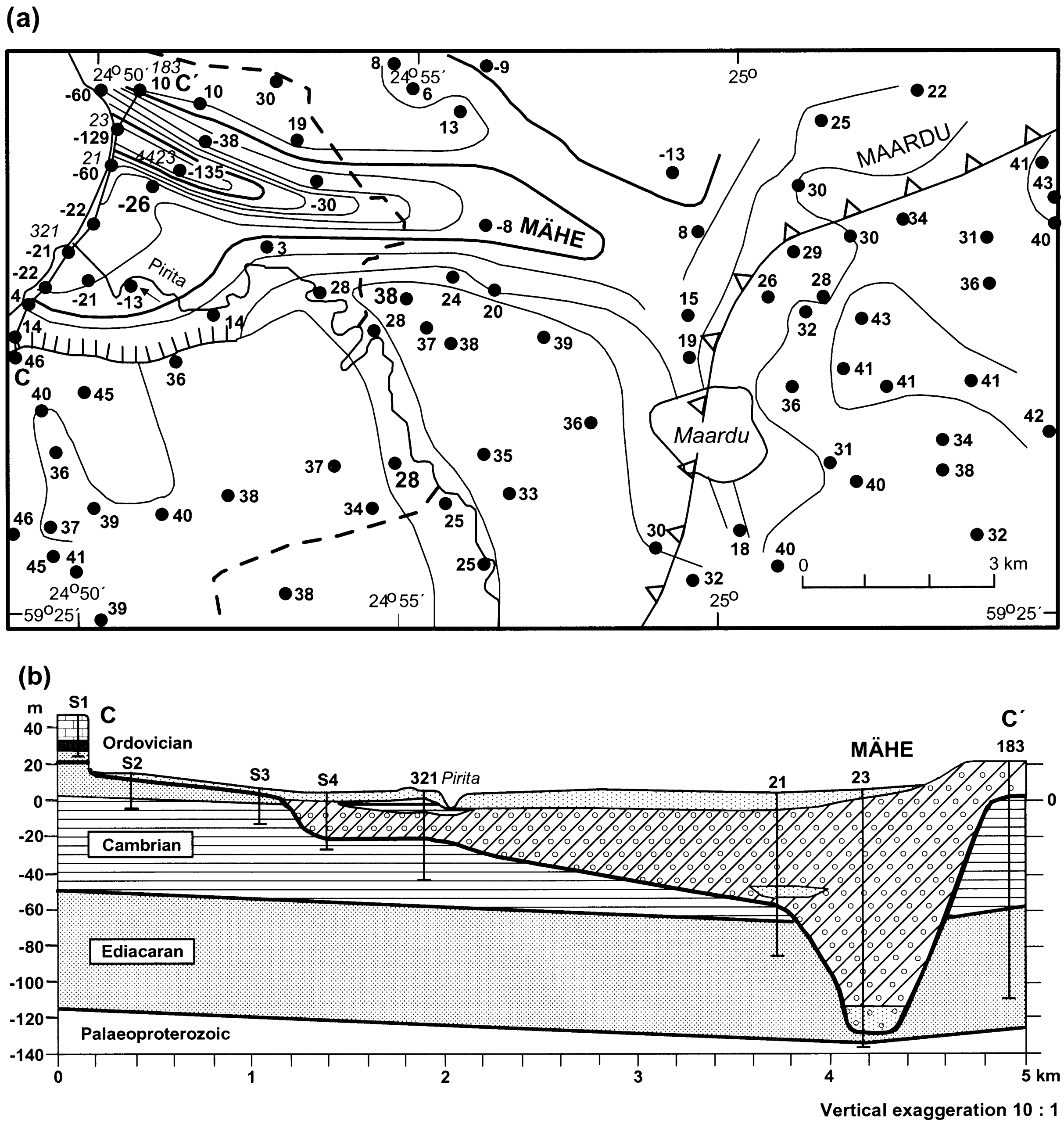

Fig. 3. Bedrock topography (a) and cross section (b) of the Mähe incision. Contour interval 10 m (a.s.l.) or 20 m (b.s.l). For legend see Figs 1 and 2. Data from the Depository of Manuscript Reports, Geological Survey of Estonia.

Mähe incision (Fig. 3b; b.h. No. 4423) is filled with (from bottom to top) gravelly sand (15–130 m), a layer of till (10–100 m) with lenses of sand (5–10 m), a lens of varved clay (15 m), and an up to 10 m thick sand layer.

The Sausti incision is mostly filled with gravelly (seldom fine to coarse) sand (23–33 m). In b.h. No. 24 the bottommost 2 m is till covered with gravelly (18 m) and fine (topmost 5 m) sand. The Saku incision, in b.h. No. 4705, is filled with gravelly sand (20 m). One kilometre to the NW (b.h. No. 3309), the lower 14 m is till covered with gravelly sand (16 m). The Vääna incision is mostly filled with till, which is often covered with sand.

DISCUSSION

Much controversy has arisen about the origin of deep incisions. Therefore they are often called linear incisions,

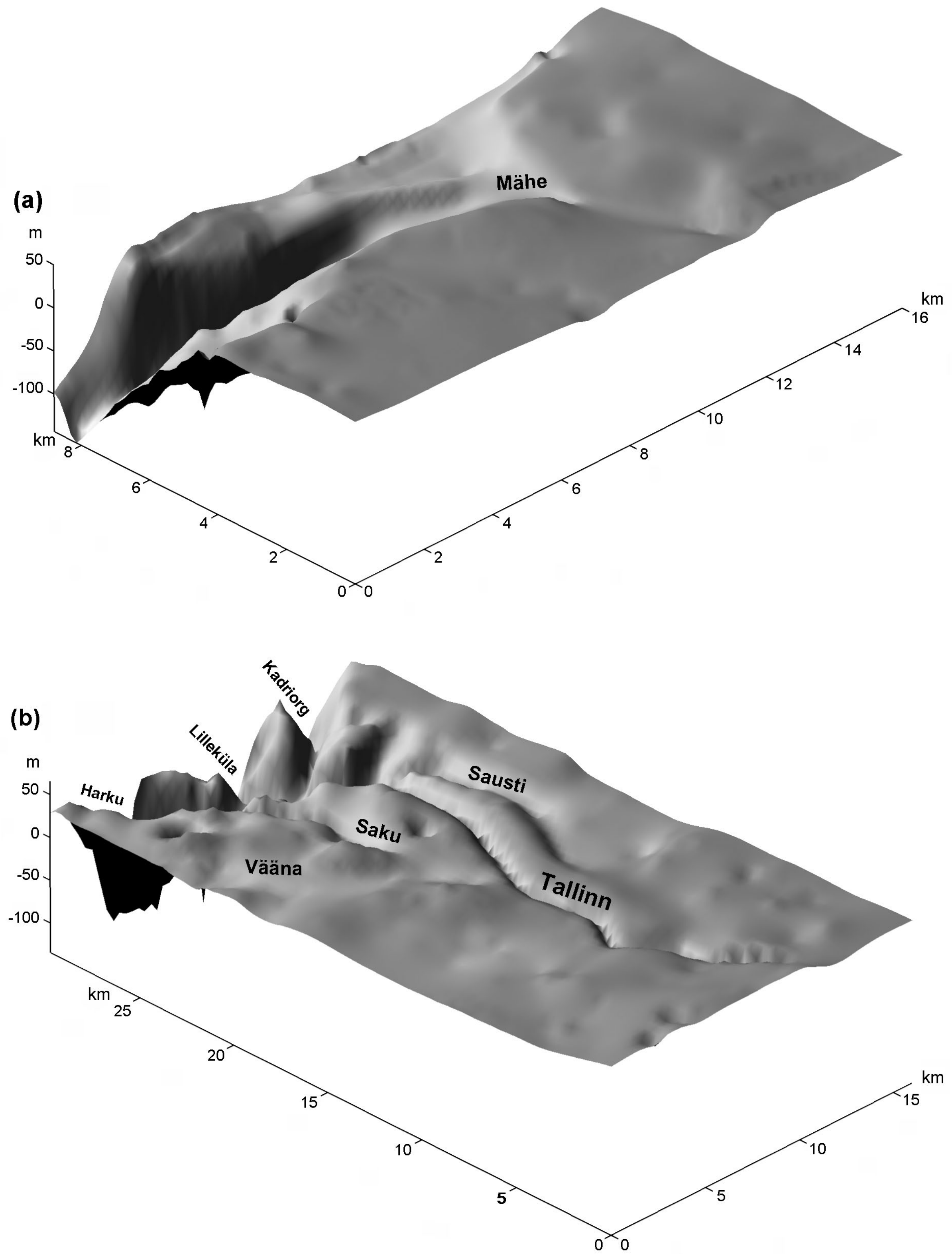

Fig. 4. Perspective views of the bedrock topography of areas of Fig. 3a (a) and Fig. 1 (b).

Table 1. Different genetical types of Quaternary deposits in ancient valleys of Tallinn, % (weighted mean value)

Valley	I	II	III	IV	V	VI	VII
Tallinn	?	2.0	38.9	36.9	18.8	2.0	1.6
Harku	0.5	22.4	42.3	13.8	6.6	14.3	0.1
Lilleküla	0.9	18.4	22.3	43.4	8.9	5.9	0.2
Kadriorg	8.3	24.2	16.4	3.2	5.6	42.3	?
Pirita	0.2	16.1	56.9	2.2	20.4	4.2	?
Sausti	?	?	4.4	91.2	?	4.4	?

I, technogenic; II, Holocene organic and marine; III, Upper Järva (Upper Weichselian) till; IV, glaciofluvial deposits above the Upper Järva (Upper Weichselian) till; V, glaciofluvial deposits below the Upper Järva (Upper Weichselian) till; VI, glaciolacustrine deposits above the Upper Järva (Upper Weichselian) till; VII, older till (Lower–Middle Järva/Lower–Middle Weichselian or Upper Ugandi/Saalian).

but this is a nongenetic term, good for the neutral description of such phenomena (Ehlers &Wingfield 1991). Frequently these are assumed to be earlier tectonic depressions carved by glaciers or subglacial meltwaters (e.g. Koch 1924; Goretski 1972). Gripp (1975) introduced the term *glazielle* for such incisions excavated by glacial ice. However, we suggest that incisions in the Tallinn area were also influenced by river flows during post-Devonian times and compare them with the large European rivers Elbe, Saale, Rhine, Seine, and Thames that existed already in the Miocene (Gibbard 1988). The deep incisions in North Germany are also long known to be a result of preglacial fluvial action (Wolff 1907).

In the area under discussion rivers probably activated already in the Palaeogene due to intensive asymmetric uplift of Fennoscandia and uplift of the East European Craton (Puura 1980). The great Eridanos River resulting from such an uplift (comparable with the contemporary Amazonas; Overeem et al. 2001), also named as the Baltic River (e.g. Bijlsma 1981), formed along the Baltic Sea basin in the Neogene. Sediments of the Baltic River system are present in the Early to Middle Miocene of Germany and Poland, and are associated with brown coal deposition (Gibbard 1988). One of the tributaries of this hypothetical river system could be the Pra-Neva (along the present Gulf of Finland) into which rivers of northern Estonia discharged. On the geological map of the Gulf of Finland (Amantov et al. 1988) twelve valleys with the direction between NW and NNW are shown. Lately, Rhebergen (2009) supported this idea. He studied Ordovician sponges and other silicifications in the Miocene to Early Pleistocene fluvial deposits, which were laid down in the delta of the Eridanos River System. He demonstrated that these erratics were transported from the draining area of the Pra-Neva. Rivers probably had a convex longitudinal profile with a low stream gradient on the upper end and knickpoints at the klint. It is even supposed that rivers, spilling over the edge of the klint, formed waterfalls (Kajak 1970). The Pra-Neva was their local base level of erosion but there are no reliable data about its depth in relation to the present sea level. The bedrock in the deepest part of the Gulf of Finland is about 150 m below the present sea level (Amantov et al. 1988). However, it should not be regarded as the local base level of erosion of the North Estonian ancient rivers, because glaciers unevenly deepened the Pra-Neva and its tributaries, but the extent of the deepening is not known.

To refute the glacial genesis of incisions, it is important to find out genetical connections with glaciotectonic disturbances, and glacial and aqueoglacial landforms (Ehlers & Linke 1989). Kozarski (1966) distinguished two types of subglacial channels. The subglacial channels that have formed by erosion of meltwaters usually have conical outwash plains at the outlets and end moraines, but glaciotectonic disturbances of the substratum are not observed at their edges. On the contrary, the subglacial channels formed by glacial erosion are accompanied by end moraines at the outlets and along the edges, and glaciotectonic disturbances in the neighbourhood. According to Ehlers & Linke (1989), the abrupt onset of the accumulation at the proximal ends of the channel indicates that the fill results from strong outbursts of meltwater. The glacial genesis must be reflected also in channel geometry. Compared to rivers, glaciers removed much greater rock mass in carving their valleys in the same geological setting. Greater removal of rock through glacial widening and deepening provides an estimate of erosion associated with conversion of a fluvial valley to glacial valley form.

The substantial widening and deepening of river valleys implies also the potential for isostatically and glacio-tectonically induced rock uplift (Montgomery 2002).

The connection of Tallinn incisions with glacio-tectonic disturbances and glacial landforms is rather weak. Seven step-like faults with vertical displacement of 15–60 cm, in all 2.2 m, occur between the Lilleküla and Kadriorg incisions on the slope of Toompea Hill (Heinsalu 1971). They are perpendicular to the ice movement and probably of glaciotectonic origin. The older Maardu zone of tectonic disturbances crosses the Mähe and Tallinn incisions, but does not influence their direction. It is possible that part of the tectonic zone is in agreement with the Sausti incision, as shown in Fig. 1b.

Different tadpole and whaleback forms, ranging from a few metres to 10 m in height, are sculptured in the more or less flat bedrock surface. Morphologically, such small bedrock protuberances can be rounded, oval, elongated, or irregular, sometimes even compound structures, where two or more smaller hillocks overlie a longer protuberance (Künnapuu et al. 1981).

The glacial and aqueoglacial landforms in Tallinn have been flattened by sea water and are in many places covered with deposits of the Baltic Sea (Künnapuu 1962). The about 12 km long and 200–300 m wide S-shaped flat Raudalu marginal esker is located on the western slope of the Sausti incision. This esker, together with two glaciofluvial deltas, belongs to the Palivere ice-marginal zone (Raukas 1992). The older delta is some 4 km wide, lies just adjacent to the NWW part of the esker, extends from Lake Ülemiste for 10 km to the SW, and is lowering to the NE. A 10 m high abrasional bluff is located on the NW border of the delta. The delta deposits are over 20 m thick and underlain by varved clays. Another delta north of the above delta is about 7 km long and 2–2.5 km wide. An up to 18 m high bluff occurs on the northern border of this delta (Raukas et al. 1971).

The above data support neither the glacial origin of incisions nor the formation of incisions by discharging excess meltwater in spontaneous events or catastrophic outbursts of subglacial meltwater from subglacial ponds or lakes, as was established in northern Germany (Piotrowski 1994, 1997). It is well known that meltwater reaching the bed of an ice sheet will tend to flow radially outwards towards the ice sheet margin, driven by the pressure gradient of the thinning ice sheet (Boulton et al. 1996). Eskers reflect the former locations of subglacial streams. Such connection is absent in Tallinn and the North Estonian Klint has blocked the meltwater flow on soft rocks in front of the klint. However, lately Rattas (2007) demonstrated that in northern Estonia some bedrock valleys, especially with eskers upon their slopes or floor, were formed by subglacial meltwater flow. Some buried valleys or their segments may result from tunnel valley formation.

The main difference of the present maps from earlier ones (Künnapuu et al. 1981; Tavast et al. 1983; Suuroja 2003) lies in the absence of the major (Tallinn) valley on older maps. The latter include only the area of our Figs 1a and 3a, excluding Tallinn valley between Kohila and Tallinn (Fig. 1b).

Unfortunately no river deposits were found in the valleys. They were probably carried away by glaciers, which moved from northwest to southeast in the Early and Middle Pleistocene and from north to south in the Upper Pleistocene (Tavast & Raukas 1982). However, it is possible that these deposits were just not drilled or not recognized. The fluvial genesis of the incisions is indicated by different orientation of valleys (from south to north, from southeast to northwest, and from south-west to northeast) and branching of the major valley in the fore-klint area. Tallinn valley with its tributary valleys (Saku and Sausti) and fore-klint branches (Harku, Lilleküla, and Kadriorg) reminds us of a river system. Such a pattern of the valleys supports the idea about primary fluvial genesis and pre-Quaternary age of buried valleys in Estonia, suggested already by Orviku (1946, 1960) and Kajak (1970).

Most likely, the formation of valleys has been continuous, starting from pre-Quaternary river erosion, sculptured by variable processes during ice ages, and influenced by flowing water during interglacial periods. If this is the case, the primary fluvial erosion took place in two stages, as seen in Figs 2b and 2c where an older wide terrace in Cambrian claystones is penetrated by a younger and deeper incision.

CONCLUSIONS

The following new conclusions could be made based on the results of the study:

1. Tallinn valley with its branches and tributaries looks like a river system;
2. such a pattern of the valleys supports the idea about primary fluvial origin and pre-Quaternary age of buried valleys in Estonia;
3. the primary fluvial formation of the valleys took place in two stages.

It is likely that the formation of the valleys started from pre-Quaternary river erosion, which was followed by glacial carving and subglacial meltwater erosion during all Pleistocene glaciations and influenced by flowing water during the interglacial periods. We doubt the leading role of high-pressure subglacial streams in the initial formation of incisions on hard carbonate rocks, but they definitely contributed to the reshaping of the incisions on soft siliciclastic rocks in the fore-klint area.

Acknowledgements. Financial support of the Estonian Ministry of Education and Research (project SF0320080s07) is acknowledged. The authors are grateful to Dr Albertas Bitinas from the Lithuanian Geological Survey and the anonymous referee for helpful advice.

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Mattunud orud Tallinnas

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Artikkel põhineb 547 puuraugu andmetel. Tallinnas ja selle lähiümbruses on hästi jälgitavad mitu mattunud orgu ja liustikukündelist orutaolist süvendit. Keskne Tallinna org jaotub klindiesisel alal kolmeks haruks (Lilleküla, Harku ja Kadriorg). Varem on neid harusid kirjeldatud iseseisvate orgudena, mis on erineva kuju, ehituse ja orientatsiooniga. Need on täitunud liustiku- ja liustiku sulamisveetekkeliste setetega, ülaosas ka Holotseeni, peamiselt meretekkeliste setetega. Orgude orientatsioon ja paigutusviis viitavad nende fluviaalsele tekkele. Orgudel on linna veevarustuses ja ehitusmaterjalide kaevandamisel tähtis osa. Nende kohal on jälgitav ebaühtlane maapinna vajumine, mis raskendab ehitustegevust ja geodeetilisi mõõdistamistöid.