Proc. Estonian Acad. Sci. Geol., 1994, 43, 3, 137—146

ZONATION OF THE BEDROCK TOPOGRAPHY OF ESTONIA AND NORTHERN LATVIA

Elvi TAVAST

Eesti Teaduste Akadeemia Geoloogia Instituut (Institute of Geology, Estonian Academy of Sciences), Estonia pst. 7, EE-0100 Tallinn, Eesti (Estonia)

Presented by A. Raukas

Received December 3, 1993; accepted March 25, 1994

Abstract. The history of the research into the bedrock topography in Estonia and northern Latvia goes back well over a century. In the well-investigated continental part of this area the basic data for studying the bedrock have been obtained from several thousand boreholes and by means of geophysical research techniques. A new map of the bedrock topography and a zonation scheme are presented.

Key words: bedrock topography, zonation, large and medium-sized relief forms, Estonia and northern Latvia.

INTRODUCTION

The bedrock topography has played an important role during the Quaternary period as one of the agents responsible for the formation of the Pleistocene and Holocene cover. It has controlled the dynamics of the ice movement and glacial erosion and has determined the thickness, structure, and distribution of the Quaternary deposits.

The formation of big, medium-sized, and even small and tiny forms of the bedrock topography is highly dependent on the lithology of the rocks involved, which have different resistance to erosional processes (Орвику, 1955). Tectonic movements responsible for the formation of the cuesta-like topography and the downcutting of ancient rivers are also of great importance. During the Ice Age most medium-sized and small forms were reshaped by glaciers. Such factors as the erosional processes of the Baltic Sea, rivers, and human activity proved less important in the formation of the main features of the bedrock topography. However, in the mining region of North-East Estonia human impact is rather impressive (Таваст & Раукас, 1982).

In differentiating big, medium-sized, and small relief forms the author used mainly absolute and relative heights of the bedrock topography. Big forms were separated from one another on the basis of isohyps 40 m above sea level; uplands and heights are bordered by 80 m isohyps. Small forms have a relative height of 2—15 m, tiny forms less than 2 m, often some centimetres or millimetres only (ice scratches, furrows).

HISTORY OF RESEARCH

Peculiarities of bedrock topography are easier to study in Estonia than in northern Latvia. This concerns first of all North Estonia, where the Quaternary cover is rather thin or in many places even lacking. Numerous boreholes, made in search of mineral resources or ground water, provide valuable information allowing to describe the bedrock topography in great detail.

The first data concerning the bedrock topography of Estonia were presented by Schmidt (1854, 1865). He described the cuesta-like topography of Estonia with abrupt northern and rather flat southern slopes. Schmidt connected this phenomenon with the different durability of the bedrock during long-term erosional processes. Later, Giere (1932) transformed the idea about the cuesta-like topography to all the Baltic countries.

Several escarpments have been distinguished and investigated in the 20th century: Vendian (Nilsson, 1913; Amantov et al., 1988), Cambrian (Martinsson, 1958; Amantov et al., 1988), Ordovician (Tammekann, 1940; Künnapuu, 1959; Miidel, 1992), Silurian (Jaanusson, 1947; Aaloe, 1958; Aaloe & Miidel, 1967), and Devonian (Мейронс et al., 1974; Страуме, 1979). The Sub-Cambrian peneplain was described by Giere (1938) and Fromm (1943).

The first schemes of the bedrock topography of Estonia were published by Tammekann (1928, 1949) and Orviku (Орвику, 1955). In mainland Estonia, Tammekann (1928) distinguished the North-Estonian denudation area, Middle- and Upper-Devonian uplands, and the depression at the foot of the Upper-Devonian Upland. Later, he added several other relief forms, such as the depressions of the Gulf of Finland and the Gulf of Riga, lakes Võrtsjärv and Peipsi, the North-Estonian Klint, and the Middle-Estonian Plain (Tammekann, 1949). Quite a similar but more precise scheme was compiled by Orviku (Орвику, 1955). In 1953 Rähni, under the guidance of Orviku, compiled a map of the bedrock topography of Estonia on a scale of 1 : 200 000 (see Орвику, 1953). This map was not published.

In 1957, geological surveys were established in all Baltic States, and foundation was laid to a medium-scale geological mapping. On the basis of the new information obtained Kajak (Каяк, 1966, 1970) published a map of the bedrock topography of Estonia with isolines after every 20 m. He distinguished big and several new medium-sized forms, such as the Ahtme Eminence, Luuga-Narva and Ojamaa lowlands. A more detailed map of North Estonia was compiled by Miidel in 1970 (Раукас et al., 1971); in this map the isolines were drawn after every 10 m. Kovalevski (Ковалевский, 1959, 1961) composed a map of the bedrock topography for Latvia and compared the bedrock and recent topographical features. Later Meirons (Мейронс et al., 1974) compiled a map of the bedrock topography with isolines after 20 m. In these maps several big relief forms, such as the Vidzeme and Aluksne heights and the East-Latvian Lowland were distinguished. On the basis of this map they composed also a morphological map where the ancient valleys, slopes, escarpments, and local elevations were shown.

In 1977, the author of this paper compiled a map of the bedrock topography of Estonia on a scale of 1 : 200 000 (isolines after 10 m; Таваст, 1978) based on data from nearly 2500 bore- and dugholes, geophysical evidence, and earlier maps. Many new negative and positive large and medium-sized forms were defined on the basis of this map. The impact of the bedrock topography on the formation and distribution of the Quaternary deposits and land forms was analysed (Tavast & Raukas, 1978). Together with Eberhards (Таваст & Эберхардс, 1989) a common bedrock topography map of northern Latvia and southern Estonia was compiled.

New investigations of the floor of the Baltic Sea (Свиридов et al., 1976; Amantov et al., 1988), the Gulf of Finland (Таваст & Амантов, 1992), and Lake Peipsi (Ряхни & Таваст, 1981) allowed the comparison of the peculiarities of the bedrock topography below and above sea level.

In this paper a new map (Fig. 1) and zonation of the bedrock topography (Fig. 2) are presented, and a brief characterization of large and medium-sized relief forms is given.

ZONATION OF THE BEDROCK TOPOGRAPHY

The zonation of the bedrock topography in the area under consideration was carried out on the basis of relative and absolute heights. Earlier subdivisions conducted in the Gulf of Finland (Martinsson, 1958; Flodén & Winterhalter, 1981; Таваст & Амантов, 1992), Estonia (Орвику, 1955; Каяк, 1970; Раукас et al., 1971; Tavast & Raukas, 1978; Таваст & Раукас, 1982), and Latvia (Ковалевский, 1959, 1961; Мейронс et al., 1974) were critically analysed and partly used.

The author proposes the following big forms of the bedrock topography (Fig. 2): I—the depression of the Gulf of Finland; II—Viru-Harju Plateau; III—Livonian Lowland; IV—Middle-Devonian Plateau; V—Central-Estonian Depression; VI—the depression of Lake Peipsi; VII—Valga and Southeast-Estonian Lowland; VIII—Upper-Devonian Plateau. Medium-sized forms are Sub-Vendian and Cambrian-Vendian plains; Vendian, Cambrian, Ordovician, Silurian, and Devonian escarpments; Pandivere, Sakala, and Karula uplands; Otepää, Haanja-Aluksne, and Vidzeme heights; Ahtme Eminence; West-Estonian, Narva-Luuga, North-Vidzeme, and East-Latvian lowlands; and the depression of the Gulf of Riga. Small (elongated eminences and hollows) and tiny forms are described within the boundaries of the large forms of the bedrock topography.

CHARACTERIZATION OF RELIEF FORMS

Depression of the Gulf of Finland

Two plains (Sub-Vendian and Cambrian-Vendian) with different geological structure and bedrock topography occur in the depression. They are separated from each other by the Vendian escarpment. The **Sub-Vendian plain** is composed of magmatic and metamorphic rocks. Its surface is rugged, especially in the northern and central parts of the Gulf. The absolute height of the bedrock surface ranges from 0 m in the northern part to —120 m in the southern part of the Sub-Vendian plain. Rocky islands serve as an exception, e.g. on Suursaari Island the surface of crystalline rocks rises up to 158 m above sea level.

Skerry topography is distributed in the northern part of the peneplain along the Finnish coast. It occupies a 10—15-km-wide zone. Elongated hillocks "*roches moutonnées*" (from several hundred metres up to 6 km long) are the most characteristic forms of this region. The northern slopes of hillocks are usually steeper than the southern ones. The area of the outcrops of crystalline rocks decreases to the south from the skerry area. Till, glaciofluvial and glaciolacustrine sediments cover the bedrock surface. At some places till has been washed away, and only pebbles and cobbles have remained on the top of hillocks. There is an abundance of ridges, hills, and depressions with relative heights of 30—60 m (Amantov et al., 1988). The features of the topography depend mainly on the physico-mechanical properties of the rocks involved.

The bedrock topography is smoother in the eastern part of the Gulf, where the bedrock surface lies at a depth of 35—60 m below sea level. The relative height is usually 25—30 m, only in ancient valleys and on the islands of Suursaari, Suur-Tütarsaari, Sommers, and Nerva it is more; e.g. on Sommers Island the surface of crystalline rocks rises from −100 up to +25 m. The islands are rising steeply from the surface of the crystalline basement.

The **Cambrian-Vendian plain** lies between the Vendian escarpment in the north and the Ordovician escarpment in the south. Its geological structure differs from the Sub-Vendian plain, where the Quaternary sediments immediately overlie the crystalline basement. On the Cambrian-Vendian plain the crystalline rocks are covered with a layer of Vendian and Cambrian sediments. The rather flat surface of the Cambrian-Vendian plain is actually made up of numerous old erosional plateau-like plains. The levelling of the relief is due to long-term denudation of sediments, low in mechanical resistance. As a result of differences in bedrock lithological composition, numerous isometric hills and ridges have developed. Relative elevations of these forms range from 5 to 15 m.

The underwater **Vendian escarpment** (20—60 m high; Amantov et al., 1988) has formed at the contact of the crystalline rocks and the Vendian sand- and siltstone. It begins near Hiiumaa Island (about 15 km to the north) and bends to the spit of Kuroniemi. The outcrop of Vendian rocks has a width of a few kilometres in the western part and 45 km in the eastern part of the Gulf.

The **Cambrian escarpment** has formed on the boundary of the Vendian readily erodible siltstone and the Cambrian clays, which are more resistant to erosion. The escarpment is hardly observable in the topography of the eastern part of the Gulf, but starting from Aseri, it runs uninterruptedly at least as far as Prangli Island.

Viru-Harju Plateau

The Viru-Harju Plateau is composed of carbonate rocks with a heterogeneous lithological composition. The 40 m isoline borders the plateau in the southwest and east (Tavast & Raukas, 1978), and the Ordovician escarpment separates it from the depression of the Gulf of Finland.

The **Ordovician escarpment** (the Baltic Klint) was formed due to different resistance of Cambrian and Ordovician terrigenous rocks and Ordovician limestones. This escarpment is well expressed in the topography running in the described area almost at its whole length on land, and it has been studied in great detail (Tammekann, 1940; Künnapuu, 1959; Miidel, 1992; a.o.). The escarpment begins near the western coast of Öland Island and runs almost continuously through the northern coast of Estonia as far as Lake Laadoga. The length of the escarpment in Estonia is about 250 km. The absolute height of the klint increases from west to east. In the western part, on Osmussaar Island, the absolute height of the klint is only 6 m, on Väike-Pakri Island 13 m, and near the Pakerort Lighthouse 24 m (Orviku & Orviku, 1969). In Tallinn, the absolute height of the klint is 47.6 m (Maarjamägi). The klint reaches its maximum height (67 m) near Vihula (north of the town of Rakvere). The maximum relative height is 56 m near Ontika.

The surface of the plateau is slightly undulating. There are many medium-sized relief forms, such as the Pandivere Upland, Ahtme Eminence, Ojamaa and Narva-Luuga lowlands, and several ancient buried valleys. The average height of the plateau is 40—60 m. The **Pandivere Upland** is the highest (up to 132 m) region of the plateau. The **Ahtme Eminence** in the eastern part of the plateau has an absolute height of up

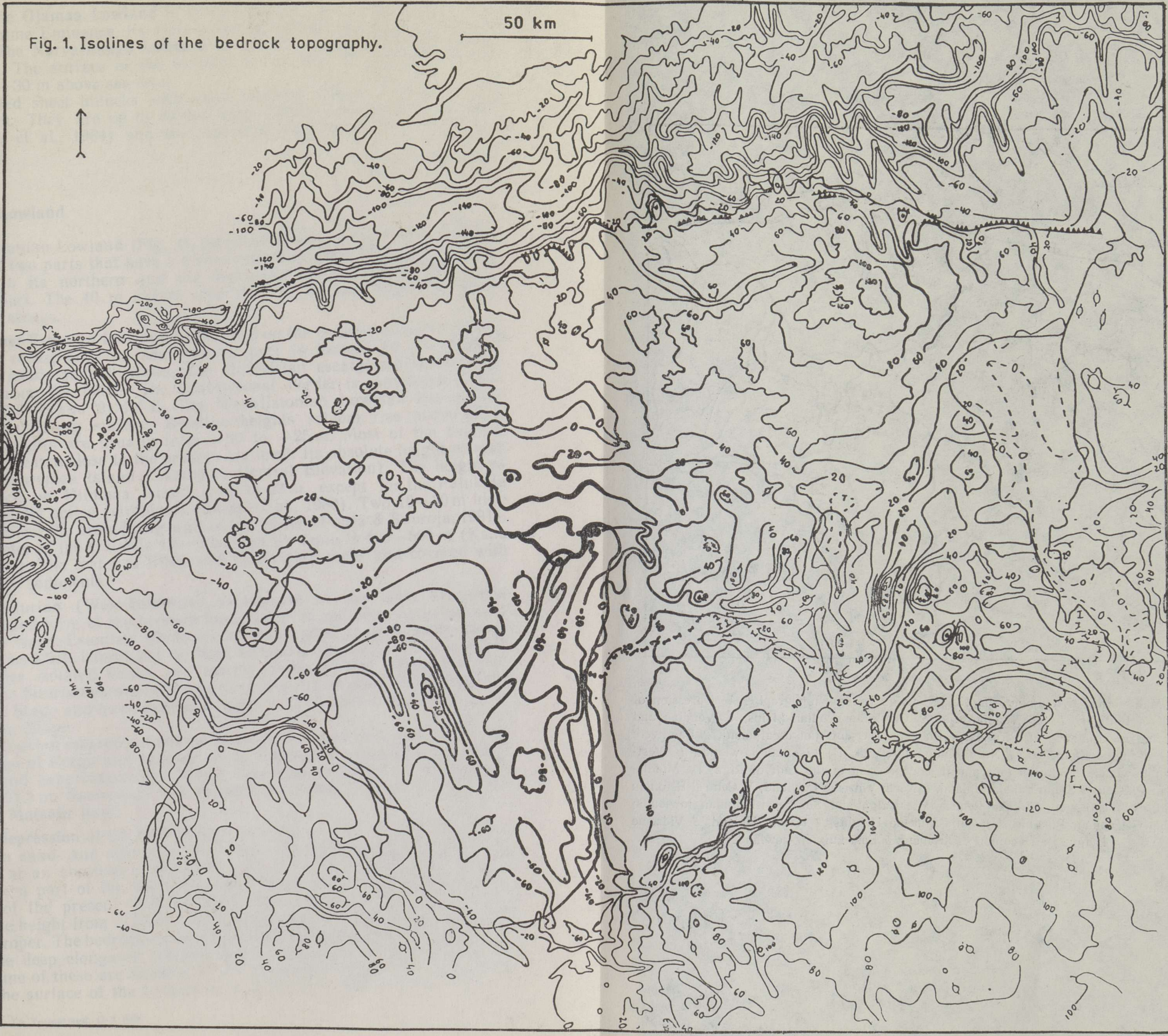

Fig. 1. Isolines of the bedrock topography.

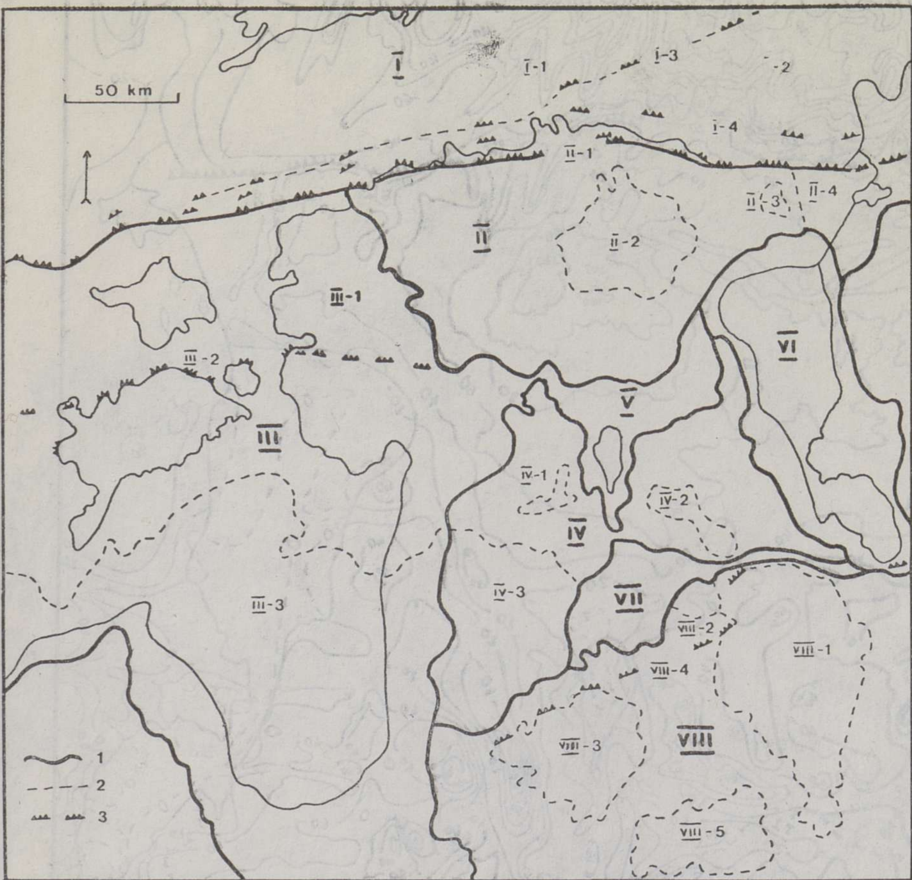

Fig. 2. Main forms of Estonian and North-Latvian bedrock topography. I depression of the Gulf of Finland: *1* Sub-Vendian and *2* Cambrian-Vendian plains, *3* Vendian and *4* Cambrian escarpments; II Viru-Harju Plateau: *1* Ordovician escarpment, *2* Pandivere Upland, *3* Ahtme Eminence, *4* Narva-Luuga Lowland; III Livonian Lowland: *1* West-Estonian Lowland, *2* Silurian escarpment, *3* depression of the Gulf of Riga; IV Middle-Devonian Plateau: *1* South-Sakala Upland, *2* North-Vidzeme Lowland; V Central-Estonian Lowland; VI depression of Lake Peipsi; VII Valga and Southeast-Estonian lowlands; VIII Upper-Devonian Plateau: *1* Haanja-Aluksne Heights, *2* Karula Upland, *3* Vidzeme Heights, *4* Devonian escarpment, *5* East-Latvian Lowland.

to 75 m. The **Ojamaa Lowland** is located between the Pandivere Upland and the Ahtme Eminence, its surface lies at a height of 40—50 m above sea level. The **Narva-Luuga Lowland** is situated in the northeastern part of Estonia. The surface of the lowland is flat and the absolute height usually 25—30 m above sea level.

Elongated sheet hillocks with steep northern slopes are common in the plateau. They are up to 2600 m long, 1200 m wide, and 18 m high (Künnapuu et al., 1984) and are separated from one another by small depressions.

Livonian Lowland

The Livonian Lowland (Fig. 2), proposed by the author (Tavast, 1992), consists of two parts that have a transitional boundary: the West-Estonian Lowland in its northern and the depression of the Gulf of Riga in its southern part. The 40 m isoline separates the lowland from the neighbouring plateaus.

The **West-Estonian Lowland** has formed on the Ordovician and Silurian carbonate rocks, only its southeastern part is located on the Middle-Devonian sand- and siltstones. The Ordovician escarpment borders the lowland from the north. The conventional border is considered to run along 57°30′ N and 21°40′ E. The West-Estonian Lowland has a flat, slightly undulating surface. Relative heights seldom rise above 20 m, absolute heights are usually from −20 to +25 m. Most of the bedrock surface is located close to the present sea level. Its absolute height attains 25 m on Saaremaa Island (Saaremaa Central Elevation). The height of the bedrock on Hiiumaa Island is up to 23 m, except for the Paluküla neotectonically active astrobleme (Baxep et al., 1980). Two 10—30 m high hillocks reflect the buried ring wall of the crater (Puura & Suuroja, 1991). The diameter of the crater is 4.5—5 km and its depth is 400—500 m (Кала et al., 1984). The crater is filled with Ordovician rocks and covered with Quaternary sediments.

The **Silurian (West-Estonian) escarpment** is the most expressive medium-sized form of the bedrock topography on the West-Estonian Lowland. The North-Estonian (Ordovician) escarpment spreads continuously almost at its whole length, but the West-Estonian escarpment is represented with rather isolated banks and scarps, forming a line (Aaloe & Miidel, 1967). The Silurian escarpment was formed at the contact of soft marls of the Jaani Stage and more resistant flaggy and biohermal dolomites of the Jaagarahu Stage.

The Silurian escarpment begins in the continental part of Estonia near the village of Kergu and runs as far as the northwestern coast of Saaremaa Island (approximately 170 km). The highest banks in Estonia are Panga (21.3 m; Saaremaa) and Mõisaküla-Salumägi (15 m; the southern coast of Matsalu Bay).

The **depression of the Gulf of Riga** is formed on the Middle and Upper Devonian sand- and siltstones and clays. The bedrock surface is usually situated at an absolute height from −60 to +20 m. It is higher only in the eastern part of the depression and lower in the central part of the bottom of the present Gulf of Riga. The saddle in the Irben Straits (absolute height from −30 to −40 m) separates the Gulf of Riga from the Baltic Proper. The bedrock surface rises on Ruhnu and Kihnu islands. There are some deep elongated submeridional depressions in the bedrock surface. Some of these are situated at the northeastern foot of Ruhnu Island, where the surface of the bedrock is at a depth of 100—110 m below sea level (Свиридов et al., 1976). Meridionally oriented elongated depressions (−80 m) occur near the mouth of the Koiva River and the city of Riga (Мейронс et al., 1974).

Middle-Devonian Plateau

The Middle-Devonian Plateau consists of easily erodible sand- and siltstones and clays and therefore its surface is strongly dissected. Its absolute heights range from 40 to 130 m. The depression of Lake Võrtsjärv divides the plateau into two parts, the Sakala and Ugandi plateaus (Орвику, 1955).

The Sakala Plateau is triangular in plane, its acute angle oriented to the north. The eastern slope of the plateau is deeper than the western one. The **South-Sakala Upland** (Tavast & Raukas, 1978) is the highest point (95 m) of the plateau. The asymmetrical Ugandi Plateau with the **Otepää Heights** (up to 130 m) is situated east of the Võrtsjärv depression. The wide and deep ancient valleys divide the elevation into three parts.

The **North-Vidzeme Lowland** is located in the southern part of the Middle-Devonian Plateau on the Middle Devonian silt- and sandstones and clays. The northern border with the West-Estonian Lowland is transitional. In the south and southeast the lowland borders on the steep northwestern slope of the Vidzeme Heights. The surface of the lowland is dissected by a complicated system of ancient valleys, Vaida (−141 m) and Salatskrīva (−86 m) being the deepest (Эберхардс, 1975).

Central-Estonian Lowland

The Central-Estonian Lowland, elongated from east to west, is situated between the Viru-Harju and Middle Devonian plateaus. Its southern part forms the depression of Lake Võrtsjärv. The surface of the Central-Estonian Lowland is approximately 20—30 m above sea level. The surface of the bedrock is rather flat, only in the Kolga-Jaani drumlin field elongated depressions and hillocks with a relative height of 3—4 m occur (Орвику, 1961). Several sandstone banks, 3—4 m high, are situated on the eastern coast of Lake Võrtsjärv. The lowest part of the bedrock depression is occupied by Lake Võrtsjärv.

Depression of Lake Peipsi

The meridionally elongated lake depression is cut into Ordovician and Silurian carbonate rocks in its northern part, and into Middle-Devonian terrigenous sediments in its middle and southern parts. Small eminences and hollows with a relative height of 5—10 m dissect the bedrock surface. The absolute height of the depression is 20 m in its northern part, in the southern part it reaches 30 m (Саммет et al., 1967; Исаченков, 1969). The bedrock surface under the waters of the present-day Lake Peipsi is situated close to zero level.

Valga and Southeast-Estonian Lowland

The western part of the lowland is situated between the Sakala and Ugandi plateaus and the Karula Upland. Its narrow eastern part is between the Haanja and Otepää heights. This lowland has developed on Middle Devonian sand- and siltstones. The level surface of the western part of the lowland is usually located 40 m above sea level.

Upper-Devonian Plateau

The Upper-Devonian Plateau has formed on rather hard and resistant dolomites, dolomitic limestones, and marls; therefore its surface is much less dissected than that of the Middle-Devonian Plateau, and it stands hypsometrically higher. The biggest relief forms here are the Haanja-Aluksne and the Vidzeme heights, the Devonian escarpment, and the East-Latvian Lowland.

The egg-shaped **Haanja-Aluksne Heights** forms the highest part of the Upper-Devonian Plateau. Its absolute height reaches 169 m in Latvia (Мейронс et al., 1974) and 166 m in Estonia. In general the height is 100—120 m. The steep northern slope falls abruptly (80 m per km) to the bottom of the Petseri-Võru Valley. The smooth southern slope lowers towards the East-Latvian Lowland (inclination only 3 m per km). The relative height of the elevation is about 90 m, but if the altitude of the bottom of the Petseri-Võru Valley is taken into consideration it will be up to 135 m. The northern part of the elevation is more rugged than the southern one.

The **Karula Upland** is separated from the Haanja Heights by an ancient valley. The altitude of the bedrock surface within the boundaries of the upland is usually 40—70 m, maximally 80 m. The surface of the upland is quite flat.

The slopes of the isometric **Vidzeme Heights** are rather smooth, only a 30—70 m high escarpment occurs at its northwestern slope (Аболтыньш et al., 1975; Аболтиньш, 1989). The relative elevation of the heights does not exceed 30—40 m. The absolute height reaches 144 m in the northern and 110—120 m in the southern part of the heights.

The **Devonian escarpment** begins in the area under observation near the southern coast of Lake Pihkva and continues at the northern and northwestern slopes of the Haanja-Aluksne Heights. In the territory of Latvia the escarpment runs at a length of 150 km from Sigulda to Aluksne at the slopes of heights and along the saddle that connects the Haanja-Aluksne and Vidzeme heights. The escarpment is mostly buried under Quaternary sediments. The Devonian escarpment has been formed at the contact of the Upper Devonian terrigenous and carbonaceous rocks with different resistance. The highest part of the escarpment is on the northwestern slope of the Vidzeme Heights, where the relative elevations are 30—40 m (Аболтыньш et al., 1975). The absolute height reaches 100 m. The northeastern part of the escarpment is lower: near Lake Pihkva its relative height is only 15 m and absolute height 51 m.

The surface of the **East-Latvian Lowland** is usually 70—75 m above sea level. The lowland lies between the Vidzeme, Aluksne, and Latgale heights, and its surface is rather flat (Мейронс et al., 1974). Only some small eminences occur in the western part of the lowland.

CONCLUSION

The data on bedrock topography and its zonation are important both for scientific and practical purposes. Information on bedrock topography is needed for solving many practical problems related with prospecting for water and building materials, engineering geology, land and forest improvement, oil-shale and phosphorite mining. The author hopes that the proposed new zonation of the bedrock relief and recent factual data will help solve both practical and theoretical questions.

ACKNOWLEDGEMENTS

This study was supported by the Institute of Geology, Estonian Academy of Sciences. My special thanks are due to Anto Raukas, Avo Miidel, and Guntis Eberhards for their kind cooperation during my long years of research into bedrock topography. I am grateful to Avo Miidel and Anto Raukas for critical reading of the manuscript and to Helle Kukk for helping me with the English text.

REFERENCES

Aaloe, A. 1958. Jaagarahu lademe pangad. — Eesti Loodus, 1, 14—18.

Aaloe, A., Miidel, A. 1967. Eesti pangad ja joad. Eesti Raamat, Tallinn.

Amantov, A. V., Spiridonov, M. A., Moskalenko, P. E. 1988. Geology of pre-Quaternary formations along the margin of the Baltic shield as an indicator of the evolution of the Gulf of Finland up to the most recent stage. — Geol. Surv. Finland. Spec. paper No. 6, 87—93.

Flodén, T., Winterhalter, B. 1981. Pre-Quaternary geology of the Baltic Sea. — In: Voipio, A. (ed.). The Baltic Sea. Elsevier Oceanography Series 30, Amsterdam, 1—121.

Fromm, E. 1943. Havsbottnens morfologi utanför Stockholms södra skärkärd. — Geogr. Ann., Stockholm, 3/4, 137—169.

Giere, W. 1932. Morphologie der estländischen Nordküste. — Veröff. Geogr. Inst. Albertus Univ. Königsberg N. F., Reihe Geographie, 6.

Giere, W. 1938. Die Entstehung der Ostsee. — Schriften der Albertus Univ. Naturwissenschaftliche Reihe, Königsberg: Berlin (gedr. Tilsit), 1.

Jaanusson, V. 1947. Über die glaziale Erosion in Nord-Estland. — Bull. Geol. Inst. Univ. Uppsala, 32, 21—28.

Künnapuu, S. 1959. Põhja-Eesti glindi kujunemisest. — In: Eesti Geograafia Seltsi aastaraamat 1958. Eesti NSV TA, Tallinn, 41—47.

Künnapuu, S., Raukas, A., Tavast, E. 1984. Aluspõhja reljeefi kesk- ja väikevormide morfoloogiast ja kujunemisest. — In: Eesti Geograafia Seltsi aastaraamat 1980. Eesti pinnavormide genees. Valgus, Tallinn, 38—48.

Martinsson, A. 1958. The submarine topography of the Baltic Cambro-Silurian area. — Bull. Geol. Inst. Uppsala, 38, 1, 11—35.

Miidel, A. 1992. Balti klindi päritolu. — Eesti Loodus, 2, 76—82.

Nilsson, B. 1913. Gotland. Chart accompanying De Geer: Översiktskarta över södra Sveriges Landformer. Ser. Ba, 9.

Orviku, K., Orviku, K. jun. 1969. Über die Beständigkeit der Entwicklung der Küstengebiet in der Gegenwart. — ENSV TA Toim. Keem. Geol., 28, 2, 128—139.

Puura, V., Suuroja, K. 1991. Ordovician impact crater at Kärdla, Hiiumaa Island, Estonia. — Tectonophysics, 216, 143—156.

Schmidt, F. 1854. Flora der Insel Moon, nebst orographisch-geognostischer Darstellung ihres Bodens. — Arch. Naturk. Liv-, Ehst- und Kurl., Ser. 2, 1, 1—62.

Schmidt, F. 1865. Untersuchungen über die Erscheinungen der Glacialformation in Estland und auf Oesel. — Bull. Acad. Sci. St.-Petersb., 6, 207—248.

Tammekann, A. 1928. Das Relief und die Abflussverhältnisse in Estland. 2. Baltische hydrologische und hydrometrische Konferenz, Tallinn, Juni 1928.

Tammekann, A. 1940. The Baltic Glint. Morphology of the Glint. A Geomorphological Study. — Eesti Loodusteaduse Arhiiv, Seeria 1, 11, 3/4, 1—103.

Tammekann, A. 1949. Die präglazialen Züge in der Oberflächengestaltung Estlands. — Apoph. Tartu. Soc. Litt. Est. in Sveccia. Stockholm, 440—452.

Tavast, E. 1992. The Bedrock Topography on the Southern Slope of the Fennoscandian Schield and in the Transitional Zone to the Platform. Abstract of the Doctoral dissertation, University of Tartu.

Tavast, E., Raukas, A. 1978. Eesti aluspõhja reljeefist ja selle mõjust liustikutekkeliste pinnavormide kujunemisele. — In: Eesti Geograafia Seltsi aastaraamat 1976. Valgus, Tallinn, 5—26.

Аболтиньш О. П. 1989. Гляциоструктура и ледниковый морфогенез. Зинатне, Рига.

Аболтыньш О., Страуме Я., Юшкевичс В. 1975. Особенности рельефа и основные этапы морфогенеза Центрально-Видземской возвышенности. — In: Вопросы четвертичной геологии, 8. Зинатне, Рига, 31—47.

Вахер Р., Раукас А., Таваст Е. 1980. О роли тектонических движений и подстилающей поверхности в формировании островных возвышенностей Эстонии. — Геоморфология, 3, 55—65.

Исаченков В. А. 1969. Материалы по геоморфологии долины реки Великой. — Уч. зап. Псковского пед. ин-та. География и биология, **22**, 21—31.

Кала Э., Пуура В., Сууроя К. 1984. Главные черты строения Кярдлаского погребенного кратера. — Изв. АН ЭССР. Геол., **33**, 1, 1—7.

Каяк К. Ф. 1966. Геоморфология. — In: Гидрогеология СССР, **30**. Эстонская ССР. Недра, Москва, 51—58.

Каяк К. 1970. Древний рельеф Эстонии. — In: Тезисы докладов VII научной конференции геологов Прибалтики и Белоруссии. АН ЭССР, Таллинн, 158—161.

Ковалевский М. И. 1959. О рельефе поверхности коренных пород Латвийской ССР. — Изв. АН ЛатвССР. Сер. геол., **11** (148), 123—127.

Ковалевский М. И. 1961. Соотношение рельефа и тектонической структуры территории Латвийской ССР. — In: Неотектоника СССР. АН ЛатвССР, Рига, 101—110.

Мейронс З. В., Страуме Я. А., Юшкевичс В. В. 1974. Характеристика дочетвертичной поверхности Латвии и некоторые вопросы формирования погребенных «долин». — In: Вопросы четвертичной геологии, **7**. Зинатне, Рига, 9—21.

Орвику К. 1953. Объяснительная записка к «Геологической карте четвертичных отложений Эстонской ССР» в масштабе 1 : 200 000. I. II. Manuscript at the Estonian Academy of Sciences.

Орвику К. К. 1955. Основные черты геологического развития территории Эстонской ССР в антропогеновом периоде. — Изв. АН ЭССР, **IV**, 2, 233—243.

Орвику К. К. 1961. Геологическое строение друмлинов Эстонии. — In: Материалы совещания по изучению четвертичного периода, **II**. Изд-во АН СССР, Москва, 64—72.

Раукас А. В., Ряхни Э. Э., Мийдел А. М. 1971. Краевые ледниковые образования Северной Эстонии. Валгус, Таллинн.

Ряхни Э., Таваст Э. 1981. Рельеф коренных пород в Псковско-Чудской впадине и его роль в распределении донных отложений. — In: Донные отложения Псковско-Чудского озера. АН ЭССР, Таллинн, 127—133.

Саммет Э. Ю., Сущенко Н. А., Экман И. М. 1967. Влияние литологии, структуры и рельефа дочетвертичных пород на формирование четвертичных отложений. — In: Геология четвертичных отложений северо-запада Европейской части СССР. Недра, Ленинград, 29—32.

Свиридов Н. И., Литвин В. М., Гайгалас А. И., Репечка М. А. 1976. Рельеф дочетвертичной поверхности Балтийского региона. — Советская геология, 5, 60—69.

Страуме Я. 1979. Геоморфология. — In: Геологическое строение и полезные ископаемые Латвии. Зинатне, Рига, 297—439.

Таваст Э. 1978. Рельеф коренных пород Эстонии и его влияние на формирование четвертичных отложений и форм рельефа. Автореф. канд. дис. Вильнюс.

Таваст Э., Амантов А. 1992. Рельеф коренных пород. — In: Геология Финского залива. АН Эстонии, Таллинн, 53—71.

Таваст Э., Раукас А. 1982. Рельеф коренных пород Эстонии. Валгус, Таллинн.

Таваст Э., Эберхардс Г. 1989. Древние врезы северной Латвии и южной Эстонии. — In: Палеогеография озерных и морских бассейнов Северо-Запада СССР в плейстоцене. Географическое об-во СССР, Ленинград, 5—13.

Эберхардс Г. Я. 1975. О некоторых особенностях древних врезов на территории Латвии и их формирование. — In: Вопросы четвертичной геологии, 8. Зинатне, Рига, 24—30.

EESTI JA PÕHJA-LÄTI ALUSPÕHJA RELJEEFI RAJOONIMINE

Elvi TAVAST

Artiklis on antud Eesti ja Põhja-Läti aluspõhja reljeefi kaart ja sellel põhinev rajoonimisskeem. Nimetatud kaart ühendab varem koostatud Eesti mandriala, Soome lahe, Põhja-Läti ja Lõuna-Eesti ning Peipsi nõo aluspõhja reljeefi kaarte. Lühidalt on iseloomustatud kõiki piiritletud rajoone ja neis paiknevaid pinnavorme. Suur-, kesk- ja väikevormid on eristatud vastavalt reljeefi kõrgussuhetele ja geoloogilisele ehitusele. Arvestatud on ka varasemaid aluspõhja reljeefi rajoonimise kogemusi.

ЗОНИРОВАНИЕ РЕЛЬЕФА КОРЕННЫХ ПОРОД ЭСТОНИИ И СЕВЕРНОЙ ЛАТВИИ

Эльви ТАВАСТ

В рельефе поверхности коренных пород вырисовывается ряд крупных положительных и отрицательных форм, в частности Виру-Харьюское, Средне-Девонское и Верхне-Девонское плато и низины Финского залива, Лифляндская, Средне-Эстонская, Валга-Юго-Восточно-Эстонская и Пейпсиская, в пределах которых выделяются более мелкие формы. В статье охарактеризованы крупные и средние формы рельефа, выделенные в основном по абсолютным высотам эрозионных поверхностей.