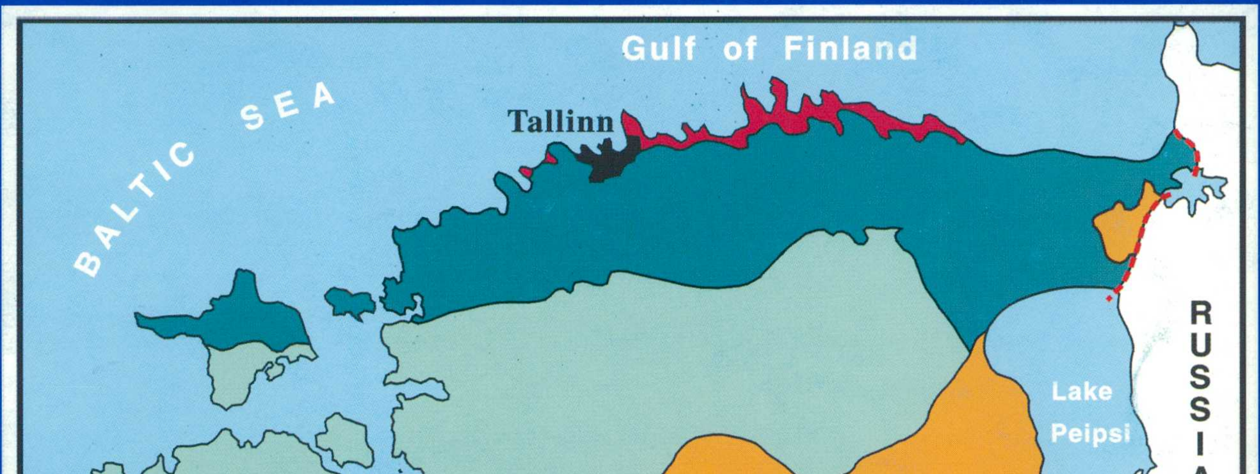
EESTI GEOLOOGIAKESKUS
GEOLOGICAL SURVEY OF ESTONIA

ESTONIAN GEOLOGICAL SECTIONS

BULLETIN 3

VALGA (10) DRILL CORE



TALLINN 2001

EESTI GEOLOOGIAKESKUS
GEOLOGICAL SURVEY OF ESTONIA

ESTONIAN GEOLOGICAL SECTIONS

BULLETIN 3

VALGA (10) DRILL CORE

TALLINN 2001

Estonian Geological Sections
Ilmub 1998. aastast

Eesti Geoloogiakeskuse geoloogiline ajakiri.
Ilmub ebaregulaarselt.

Toimetus: Kadaka tee 82, 12618 Tallinn
Tel. (0) 672 0094
Faks (0) 672 0091
E-post egk@egk.ee

Koostaja: Anne Põldvere
Keeleline toimetaja: Anne Noor
Küljendaja: Mare Kukk
Kaanekujundus: Heikki Bauert

Estonian Geological Sections
Published since 1998

Geological journal of the Geological Survey of Estonia, published irregularly.

Editorial office: Kadaka tee 82, 12618 Tallinn
Tel. (372) 672 0094
Fax (372) 672 0091
E-mail egk@egk.ee

Editor: Anne Põldvere
English text revision: Anne Noor
Layout: Mare Kukk
Cover design: Heikki Bauert

ISSN 1406-3476

CONTENTS

*foldout

PREFACE

Detailed restudy of high-quality drill cores has been carried out at the Geological Survey of Estonia since 1995. The cores are relabelled, photographed and thoroughly described. For the problematic parts of the sections, additional micropalaeontological analyses are performed, and clastic sediments and carbonate rocks are examined using different methods. The lithological descriptions of the cores are supplemented by photo-logs and generally accepted legends, providing information on the mineral composition and other characteristics of the rock.

In 1998 the journal *Estonian Geological Sections* was started in order to disseminate the findings. The first two issues give an overview of the lithology and stratigraphy of the Tartu (453) (southern Estonia; Põldvere, 1998) and Taga-Roostoja (25A) (NE Estonia; Põldvere *et al.*, 1999b) drill cores. The present issue deals with the Valga (10) drill core in southern Estonia. The source material for this study is available in an unpublished report (Põldvere *et al.*, 1999a), held in the Depository of Manuscript Reports, Kadaka tee 82, Tallinn.

INTRODUCTION

The Valga (10) drill hole (latitude 57° 48.24' N and longitude 26° 4.65' E) is located in southern Estonia, on the NE outskirts of the town of Valga (Fig. 1). It is 424.4 m deep and penetrates the Ordovician (111.8 m), Silurian (7.6 m) and Devonian (251.0 m) sedimentary rocks (Fig. 2), which are covered by 54.0 m thick Quaternary deposits. The hole was drilled in 1986 to check the groundwater supplies of the town (Liibert *et al.*, 1986). The core extracted is a property of the Geological Survey of Estonia; it is housed at the Särghaua field station of the Institute of Geology at Tallinn Technical University.

Many specialists assisted in preparation of this report. Anne Põldvere (Geological Survey of Estonia) compiled the macrolithological characterization of the Ordovician and Silurian parts of the section using the results of the groundwater study in the town of Valga (Liibert *et al.*, 1986) as supplementary material. Anne Kleesment (Institute of Geology at Tallinn Technical University) provided the lithology of the Devonian strata (description, mineralogical and grain-size analyses). Juozas Valiukevičius (Institute of Geology of Lithuania) identified Devonian acanthodians in collaboration with Anne Kleesment.

The Ordovician and Silurian parts of the Valga (10) core were sampled additionally for microfossils with the aim of improving the stratigraphic subdivision. Chitinozoans were identified by Jaak Nõlvak, data on conodonts were improved by Peep Männik and on scolecodonts by Olle Hints (all from the Institute of Geology at Tallinn Technical University). Ostracodes were identified by Tõnu Meidla (Institute of Geology, University of Tartu).

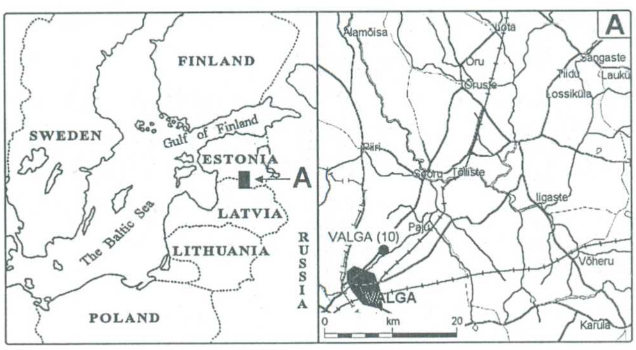


Fig. 1. Location of the Valga (10) drill hole.

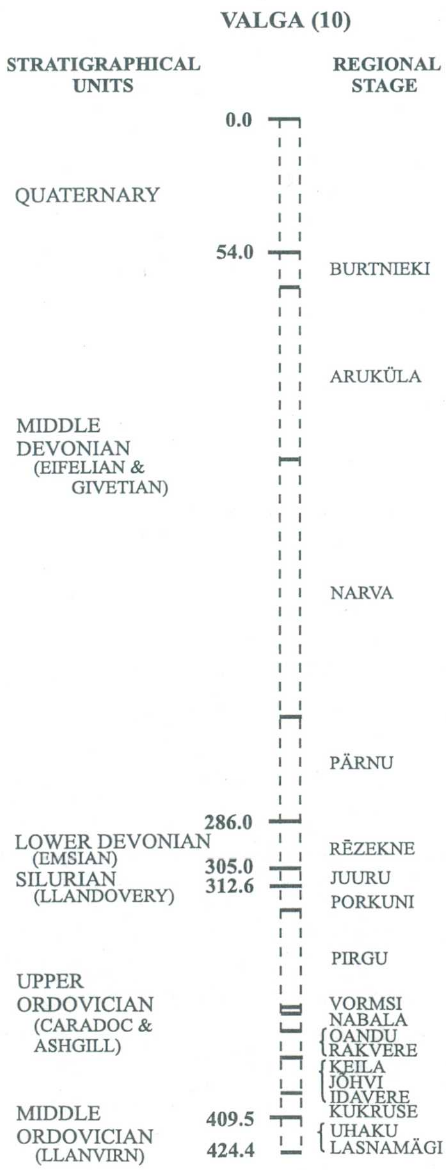


Fig. 2. Generalized stratigraphy of the Valga (10) core section.

X-ray diffractometry of Ordovician rocks was provided by Jaan Aruväli, Kalle Kirsimäe (both from the Institute of Geology, University of Tartu) and Toivo Kallaste (Institute of Geology at Tallinn Technical University).

Photos of the core were taken by Anne Põldvere. Ene Pärn (Geological Survey of Estonia) provided various technical assistance. Olle Hints, Anne Põldvere and Elar Põldvere prepared the manuscript in the computer.

Useful comments by Tõnu Meidla (Institute of Geology, University of Tartu), Asta Oraspõld and Jaak Nõlvak (both from the Institute of Geology at Tallinn Technical University) were of great help in finalizing the report. Thanks are addressed to all colleagues for assistance at several stages of the work.

CORE DESCRIPTION AND TERMINOLOGY

The description of the Valga (10) core is presented in the form of a table containing the main lithological features of the rock (Appendix 1). From the Devonian part 40 samples were studied for grain-size composition and 40 for mineral composition of the very fine sand fraction (0.1–0.05 mm). From the Ordovician strata 30 samples (1 from the Kinnekulle bed, 25 from the Keila to Rakvere stages, 4 from the Pirgu to Porkuni stages) were analysed using X-ray diffractometry, and 11 thin sections were described. For age specification different groups of fauna were used. The acanthodian scales and other fossils were recovered from 18 samples of Devonian rocks as a by-product of mineralogical analyses. Ostracodes from the Ordovician part of the section were investigated in 104 samples. A total of 156 samples from the Ordovician and Silurian strata were studied for conodonts, chitinozoans and scolecodonts. The field-testing of the degree of dolomitization of the carbonate rocks was performed by means of 3% hydrochloric acid. The content of clay was estimated visually and the rocks were referred to as slightly argillaceous (insoluble residue 10–15%), medium argillaceous (15–20%) and highly argillaceous (20–25%) (Oraspõld, 1975).

The descriptions of the textures of carbonate rocks are based on the traditional Estonian classification (Vingisaar *et al.*, 1965; Loog & Oraspõld, 1982), which is based on the relative amounts of clastic and micritic components. The comparison of this classification with Dunham's classification (Dunham, 1962; Põldvere & Kleesment, 1998) is given as much as possible in Appendix 1. In most cases the content of carbonaceous clasts (including bioclasts) is given in per cent.

The particles with the diameter above 0.05 mm are described as grains. For most of the core, the content of grains was determined with the magnifying glass on the slabbed surfaces. Skeletal remnants of organisms or their fragments (bioclasts) were systematically recorded. The size of chemogenic or biochemogenic ooliths is usually less than 1 mm, while the size of carbonate intraclasts exceeds 1 mm. The micritic component of chemogenic, biochemogenic or polygenic origin consists of particles less than 0.05 mm in diameter. The terms cryptocrystalline (crystal sizes < 0.005 mm), microcrystalline (0.005–0.01 mm) and very finely crystalline (0.01–0.05 mm) are used to describe the primary texture of the micritic component in the carbonate rocks. Very finely crystalline (0.01–0.05 mm), finely (0.05–0.1 mm) and medium crystalline (0.1–1.0 mm) textures are of secondary origin; these appeared due to recrystallization of the sediment during diagenesis. Depending upon the degree of recrystallization, in addition to the above-mentioned textures, several transitional ones can be observed (secondary textures occur as patches or spots). In case of mixed texture, the word marking the dominant component is given last, while those marking less important components are placed before the basic word as appositions. The same principle is followed in all terms describing the rock properties.

The variation in discontinuity surfaces, ripple marks and layered or nodular structures is illustrated in Plates 1–4. Discontinuity surfaces are marked in the core description (Appendix 1).

The terms thick- (thickness of the bed 10–50 cm), medium- (2–10 cm), thin- (0.2–2 cm) and microbedded (< 2 mm) are used for the description of the bedding features. Intervals without visually observable bedding are referred to as massive. The bedding is described as horizontal or wavy. Carbonate rocks (especially the clay containing varieties) are often characterized by nodular or seminodular structure. Seminodular structure is often described as irregularly nodular: carbonate rock contains numerous irregularly diverging laminae or patches of argillaceous material, but only a few distinct nodules. In case of a nodular structure, the limestone/marl ratio is roughly 1:1 or marl is dominating. Considering the size of nodules, thick-nodular (vertical diameter of nodules > 5 cm), medium-nodular (2–5 cm) or thin-nodular (< 2 cm) structures are distinguished. Irrespective of the bedding features, the contacts between different types of rock are either distinct or indistinct.

Classification of the Devonian sandstones is based on the 5-fractional classification (Švanov, 1969; Pettijohn *et al.*, 1987), where the diameter of the finest sand particles is 0.05 mm instead of 0.0625 mm recommended by Pettijohn (1949). In the present paper the following fractions and terms are used for the Devonian rocks: the size of grains < 0.005 mm – clay, 0.005–0.01 mm – fine silt, 0.01–0.05 mm – coarse silt, 0.05–0.1 mm – very fine sand, 0.1–0.25 mm – fine sand, 0.25–0.5 mm – medium sand, 0.5–1 mm – coarse sand and > 1 mm – very coarse sand.

A peculiar feature of sandstones of the Aruküla and Narva stages is the occurrence of strongly dolomite cemented sandstone globules (diameter 2–3 cm) in up to 20 cm thick irregularly cemented interbeds. In some intervals of the core dolomitic marl and claystone break after drilling and look rubbly (Pl. 2, fig. 11).

GENERAL GEOLOGICAL SETTING AND STRATIGRAPHY

The bedrock succession in the Valga (10) section can be generally divided into two parts: the Ordovician–Silurian carbonate strata and the Devonian, predominantly terrigenous rocks. The Devonian is overlain by the Quaternary cover (Fig. 2; Appendix 1).

During the **Ordovician**, the present Baltoscandian area constituted the northern part of an epicontinental marine basin (Fig. 3), surrounded from the north, east and south by the Fennosarmatian land (Männil, 1966; Põlma, 1982; Jaanusson, 1995; Nestor & Einasto, 1997). The shallow water sediments occur in the present-day outcrop area in the North Estonian Confacies Belt, while those formed in deeper water environments are found in western Latvia and Sweden (Central Baltoscandian Confacies Belt). The Valga (10) core log represents the transition between these two belts (Fig. 3).

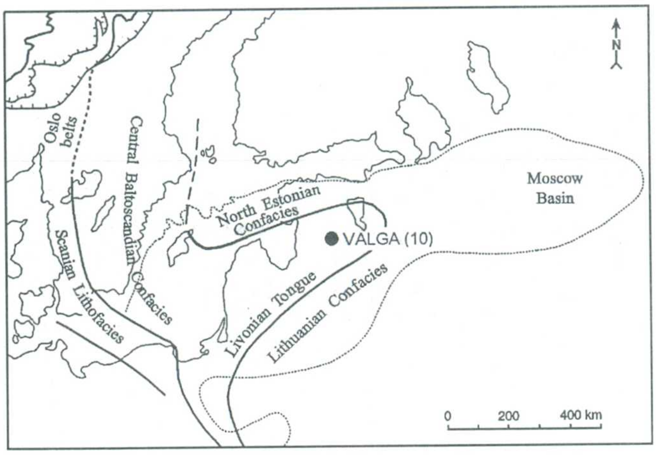


Fig. 3. Baltic Ordovician confacies belts (after Jaanusson, 1995, modified from Nõlvak, 1997).

The present paper is based on the most recent correlation charts for the Ordovician of the East European Platform (Nõlvak, 1997, p. 54; Table 7; Männil & Meidla, 1994). The lower part of the Mossen Formation of Keila–Oandu (?) age, represented by brownish to blackish grey, splitting shale-like marl and claystone, is referred to as the Plunge Member known from Lithuanian sections (Paškevičius, 1994; Ainsaar & Meidla, 2001).

In the Valga (10) core the measured thickness of Ordovician sediments (Llanvirn, Caradoc and Ashgill) is 111.8 m (Appendix 1, sheets 12–16). An analogy with the core sections of the North Estonian Confacies Belt is noted, which can be explained by main trends in the evolution of the basin. The distribution of formations is analysed using the well studied core material from northern Latvia (Ulst *et al.*, 1982) and southern Estonia. Like in Latvian sections (Ulst *et al.*, 1982), the boundaries of relatively monotonous formations (Pl. 4, figs 37–39) below the metabentonite layer (395.4–424.4 m) were justified using also gamma-logging data (Liibert *et al.*, 1986). The changes in the structure of the rock at the boundary of the Stirnas and Taurupe formations (Pl. 4, fig. 39) are comparable with the changes in the Mehikoorma (421) core section (Kajak *et al.*, 1974; Põldvere et al., 1999a).

The presumable level of the Dreimani Formation was determined by gamma-logging data, but there was also observed an abundance of pyritized bioclasts.

By the comparison of different facies belts remarkably distinct aphanitic limestones were recorded on the level of the Rägavere (or Dzērbene; see Ulst *et al.*, 1982, p. 36) Formation of the Rakvere (or Nabala) Stage (Pl. 4, fig. 32) and on the level of the Saunja Formation of the Nabala Stage (Pl. 4, fig. 30).

One of the more reliable marker levels in Estonian sections is the metabentonite at the lower boundary of the Keila Stage. In the Valga (10) section it lies in the interval of 395.2–395.4 m (observed thickness 2 cm). X-ray diffractometry (see Kiipli & Kallaste in this volume) has revealed the identity of this metabentonite bed with the widely distributed Kinnekulle bed, which is confirmed also by biostratigraphical data (see Meidla, Nõlvak and Männik in this volume).

Biostratigraphical subdivision of the Valga (10) section is based on the distribution of chitinozoans, conodonts, scolecodonts and ostracodes, but in detail it does not always conform to the picture recorded in other core sections (Appendix 1, sheets 14, 15; see Meidla and Nõlvak in this volume). For several reasons (bad preservation of species, shortage of the comparative material from this particular area, etc.) the interpretation of the Keila–Nabala interval is complicated.

Early **Silurian** sedimentation began with a glacio-eustatic rise of the sea level and deposition of pure lime muds on wide areas of central and eastern East Baltic. Only in the deeper water environments lime muds were replaced by calcareous-argillaceous muds (Õhne Formation). In the Valga (10) section the Ordovician–Silurian boundary is lithologically well defined. Presumably the early Silurian sedimentation was influenced by some barrier in the sedimentary basin. The Silurian (Llandovery) is represented by 7.6 m thick (interval 305.0–312.6 m) indistinctly bedded dolostones and dolomitic marls of the Õhne Formation (Juuru Stage; Appendix 1, sheet 12; Pl. 2, fig. 19; Pl. 3, fig. 20). Compared to the Tartu (453) core (Põldvere *et al.*, 1996), the Õhne Formation in the Valga (10) section is more dolomitized (dolomites and dolomitic marls). The thickness of the Puikule Member is only 0.9 m in the Valga (10) section, reaching 3.4 m in the Tartu (453) section.

In the **Devonian**, the Estonian territory was covered by an epicontinental shallow sea, characterized by extensive sedimentation of terrigenous material transported from the area of northward mainland. The small sedimentary basin, which formed in the central Baltic area at the end of the early Devonian, expanded gradually during the middle–late Devonian. In the Valga (10) section the Devonian sediment complex (Emsian, Eifelian, Givetian; Appendix 1, sheets 2–11) is 251.0 m thick (interval of 54.0–305.0 m) and lies unconformably on the Silurian (Pl. 2, fig. 18). The Valga (10) drill hole is located on the Valmiera–Lokno Uplift, which developed in the Late Silurian–Middle Devonian (Puura & Vaher, 1997). However, the character of the Devonian sediments in the Valga (10) core is seemingly not influenced by this uplift. The Devonian part of the section is described in a special chapter (see Kleesment in this volume).

The **Quaternary** cover is 54.0 m thick but only 3.9 m of core is available (Appendix 1, sheets 1, 2). The fragmentary core and gamma-logging data show that the Devonian rocks are covered by a 19 m thick layer of loamy sand till, predominantly overlain by clay.

DEVONIAN

The Devonian sequence of Estonia (Kleesment & Mark-Kurik, 1997, p. 108; Table 10) begins with an incomplete succession of Lower Devonian rocks which are represented by three units of different age, separated from each other by big gaps. The Tilže Regional Stage (Lochkovian) occurs in southeastern Estonia as a narrow tongue and has been determined only in some drill cores of this region (Kleesment & Mark-Kurik, 1997, p. 107, fig. 74). The northernmost part of the presumable distribution area of the Ķemeri Regional Stage (Pragian) takes up a limited territory in southwestern Estonia (Kleesment & Mark-Kurik, 1997, p. 111, fig. 79). Only the Rēzekne Regional Stage (Emsian) is relatively widespread in Estonia (Kleesment & Mark-Kurik, 1997, p. 111, fig. 80).

The Middle Devonian is the most complete part of the Devonian sequence in Estonia. Both the Eifelian (Pärnu, Narva and Aruküla regional stages: Kleesment & Mark-Kurik, 1997, pp. 113–117, figs 81, 82, 84) and lower Givetian (Burtnieki Regional Stage: Kleesment & Mark-Kurik, 1997, p. 119, fig. 86) are widely distributed. The Middle Devonian is exposed in numerous outcrops, which are included into the list of geosites. The Gauja and Amata regional stages (upper Givetian) have a more restricted distribution (Kleesment & Mark-Kurik, 1997, pp. 120–121, figs 87, 88). The Pļaviņas Regional Stage (Upper Devonian, Frasnian) is known from a limited area in southeasternmost Estonia (Kajak, 1997).

The Devonian part of the Valga (10) section includes the entire succession of the Rēzekne, Pärnu, Narva and Aruküla stages, and also the lower part of the Burtnieki Stage (Appendix 1, sheets 2–11). The successions of the Narva and Aruküla stages are well represented.

The **Rēzekne Stage** lies unconformably on the dolostones of the Lower Silurian Õhne Member (Juuru Stage). It is represented by the Mehikoorma Formation (286.0–305.0 m; Appendix 1, sheet 11), which grades into the Lemsi Formation occurring in western Estonia (Ljarskaja & Kleesment, 1981). It consists of grey, in places greenish, pinkish or yellowish grey loose sandstone containing thin dolomite-cemented interlayers of grey silty sandstone and siltstone (Pl. 2, figs 17, 18), and a 10 cm dolostone layer at the top.

The **Pärnu Stage** (Formation; 244.0–286.0 m; Appendix 1, sheets 9–11) is represented by its typical rocks: pinkish and yellowish grey sandstone including thin interlayers of grey claystone (Pl. 2, figs 15, 16). The sandstone is mainly weakly cemented, but with strongly dolomite-cemented interbeds in the upper part (Tamme Member). Thin inclined lamination is common in the sandstone; large mica flakes concentrate on bedding surfaces.

The **Rēzekne** and **Pärnu stages** correspond to the *Laliacanthus singularis* acanthodian Zone embracing the boundary interval between the Lower and Middle Devonian, with the type section at 199.0–246.2 m in the Mehikoorma (421) drill core (Valiukevičius, 1994, 1998). The scales of the zonal species have not been found in the Valga (10) core (Appendix 2).

The **Narva Stage** is represented by all three successive formations.

The lower, Vadja Formation (216.0–244.0 m; Appendix 1, sheets 8, 9) is characterized by alternating light grey and yellowish grey dolostone containing interlayers of dark grey claystone and grey dolomitic marl (Pl. 2, figs 12–14). The sequence is thin-bedded, in places horizontal-, often wavy-bedded. The dolostone is often cracked; in dolomitic marl slickensides occur. The surfaces on crack planes and slickenside planes are covered by films of dark grey or brownish grey claystone, in some cases by coatings of scattered pyrite or dolomite crystals, or by galena films. The widespread layer of sedimentary breccia in the basal part of the Vadja Formation (Kleesment & Valiukevičius, 1998) is missing in the Valga (10) section.

The Leivu Formation (157.0–216.0 m; Appendix 1, sheets 6–8) is highly variable laterally. In the Valga (10) section it is relatively thick (59 m) and lithologically similar to the facies distributed in the South East Baltic region: in the sequence dominates dolomitic marl with a varying clay content, including thin interbeds of dolostone and claystone, and few siltstone interlayers (Pl. 1, figs 8, 9; Pl. 2, figs 10, 11). Dolomitic marl is mainly grey in the lower part of the section and mottled in the upper part. The core yield is very high, up to 95%.

The Gorodenka Formation (139.6–157.0 m; Appendix 1, sheets 5, 6) has its typical appearance. It is represented by a horizontal thin-bedded complex where brownish red and grey, loose and dolomite-cemented very fine-grained sandstones alternate with siltstone, claystone and dolomitic marl (Pl. 1, fig. 6). Sandy rocks with globular structure occur in the basal part of the section.

The section of the **Narva Stage** is faunally well studied in the Valga (10) core (Appendix 1, sheets 5–9). There have been distinguished the *Cheiracanthoides estonicus*, *Ptychodictyon rimosum* and *Nostolepis kernavensis* acanthodian zones corresponding to the Vadja, Leivu and Gorodenka formations, respectively (Valiukevičius, 1994, 1998). These zones can be traced also in the South East Baltic and western Belarus (Valiukevičius *et al*., 1986).

The succession of the **Aruküla Stage** (Formation) is complete in the Valga (10) core – all three members are present.

The lower, Viljandi Member (112.2–139.6 m; Appendix 1, sheets 4, 5) is typically characterized by reddish brown, fine-grained sandstone containing thin interlayers of varicoloured clay- and dolostone, and brown and grey siltstone (Pl. 1, fig. 5). Sandstone is horizontally thin-bedded, inclined bedding occurs in some levels. Bedding surfaces are often wavy, covered by concentrations of mica flakes or claystone films.

The middle, Kureküla Member (90.0–112.2 m; Appendix 1, sheets 3, 4) is represented by a horizontal thin-bedded complex of intercalating purplish red and reddish brown sandstone and reddish brown claystone, containing rare siltstone interbeds (Pl. 1, figs 3, 4). The claystone content is comparatively high.

The upper, Tarvastu Member (68.0–90.0 m; Appendix 1, sheet 3) consists of alternating reddish brown and purplish brown sandstone, greyish brown siltstone and reddish brown siltstone (Pl. 1, fig. 2). Sandstone, in some cases also siltstone, contains conglomeratic interbeds with strongly dolomite-cemented sandstone globules.

The *Diplacanthus gravis* acanthodian Zone, distinguished by Valiukevičius (1998) and corresponding to both the Aruküla and Burtnieki stages, is well represented in the Valga (10) section.

The **Burtnieki Stage** is represented in the section only by its lower unit, the Härma Member (54.0–68.0 m; Appendix 1, sheet 2). In its lower part mainly brown and reddish brown sandstones predominate, grading upwards to interbedding varicoloured claystone and greenish grey siltstone (Pl. 1, fig. 1).

The Devonian sediments in the Valga (10) section are mineralogically well studied (Appendices 3–6). The deposits of the Rēzekne and Pärnu stages are typical examples of rocks of these units (Kleesment & Mark-Kurik, 1997). Only the glauconite content is somewhat higher, especially in the Pärnu Stage. In the Narva Stage some deviations from the average contents are noticed. The Vadja Member is extremely poor in transparent allothigenic minerals but comparatively rich in zircon (Appendix 5). In the uppermost part of the Leivu Member a baryte-rich level occurs in the interval of 163.0–164.0 m (Appendix 4), which may indicate a break in sedimentation. The mineralogical composition of the rocks of the Aruküla Stage is almost typical of this level (Appendices 3–6; Kleesment, 1994). Exceptional is only a somewhat higher leucoxene content in the Viljandi Member, exceeding the average, and mica-enrichment of the rocks of the Kureküla Member (dominated by green biotite). In the Tarvastu Member anatase, in its upper part also leucoxene show a bit elevated concentrations. We cannot exclude the possibility that anatase and leucoxene in these rocks formed due to alteration processes during diagenesis (Kleesment, 1998). The mineralogical composition of the rocks of the Härma Member of the Burtnieki Formation was studied only in two samples. The results obtained concord with the earlier data (Kleesment, 1995).

DISTRIBUTION OF CHITINOZOANS

A total of 153 samples from the middle–upper Ordovician and lower Silurian part of the Valga (10) core were studied for chitinozoans (Appendix 7). Of these, 53 samples, mainly from the Pirgu and Porkuni stages were processed at the Geological Survey of Estonia. The others were prepared at the Institute of Geology at Tallinn Technical University, where the collection is stored.

The sample size varied from 0.3 to 1.0 kg, being commonly over 0.5 kg. Thirty-seven samples were barren, or only some indeterminable fragments of chitinozoans were found. Barrenness of samples was caused mainly by the occurrence of marine redbeds and secondary dolomitization, which destroyed or influenced strongly the preservation of organic-walled microfossils in the uppermost Ordovician and Silurian of the Valga (10) section.

The Ordovician chitinozoan zonation of Baltoscandia is introduced in Nõlvak & Grahn (1993) and revised in Nõlvak (1999a). In the Valga (10) section 16 zones and subzones were established. Altogether, 77 chitinozoan taxa were distinguished, the distribution of which is presented in Appendix 8. The number of specimens in samples was highly variable. The richest samples came from the lower half of the section (Lasnamägi–Nabala stages), where chitinozoans are particularly well preserved and species diversity is relatively high. The core was missing from the interval of 363.4–365.7 m. Most probably this interval is represented by the argillaceous limestones of the Vormsi Stage, containing in the other investigated sections (Nõlvak, 1980, fig. 2) a rich, diverse and specific chitinozoan assemblage.

The four lowermost samples, from the interval of 420.8–424.3 m, represent the *Conochitina clavaherculi* Subzone of the *Laufeldochitina striata* Zone, which corresponds to most of Lasnamägi time and early Uhaku time (Nõlvak & Grahn, 1993). Despite the absence of some clear change level among chitinozoans marking the lower boundary of the Uhaku Stage, the chitinozoan assemblages in the two lowermost samples are similar to those from the uppermost portion of the Lasnamägi Stage. This is supported by finds of the graptoloid *Gymnograptus* cf. *linnarssoni* at 420.8–421.8 m, indicating early Uhaku time (see Männil, 1976, 1986a). The base of the Uhaku Stage can be drawn below that interval.

The boundary of the *Laufeldochitina striata* and *L. stentor* zones lies within the uppermost part of the Uhaku Stage as, for example, in the Taga-Roostoja (25A) section (Nõlvak, 1999b). However, the middle portion of the Uhaku beds, represented by the *Conochitina tuberculata* Subzone needs more detailed sampling to clarify why this species is so rare in the Valga (10) section. The next, *Eisenackitina rhenana* Subzone can be followed clearly. Its range coincides roughly with the *Laufeldochitina stentor* Zone. In general, these both species occur throughout the Kukruse beds in the whole of Baltoscandia. The appearance of *Conochitina* sp. 2 in the lower part of the Kukruse Stage is most noteworthy (= *C. viruana* nom. nud. in Männil, 1986a, fig. 2.1.1; Bauert & Bauert, 1998; Nõlvak, 1999b) as in the sections of the North Estonian Confacies Belt this species occurs in the middle part of the *stage*. Because of the absence of *Conochitina* sp. 1 (= *C. savalaensis* nom. nud. in Männil, 1986a, fig. 2.1.1; Bauert & Bauert, 1998; Nõlvak, 1999b) we can conclude that the lower third of the Kukruse Stage, which in northern Estonia is characterized by oil shale-bearing beds, is absent in the Valga (10) section. At the same time, the considerable break occurring in the northern Estonian sections in the upper part of that stage is filled up in the Valga (10) section by the beds containing among others *Conochitina tigrina*, *Lagenochitina* sp. A aff. *capax* and *Cyathochitina* sp. 2. In general, this is in accordance with the earlier correlations (see also Männil, 1986a).

The lower boundary of the Haljala Stage (Idavere Substage) can be followed very clearly at the level of the lower boundary of the *Angochitina curvata* Zone, which is supported by the disappearance of the index species *Laufeldochitina stentor* and by an abrupt increase in the number of *Leiosphaeridia baltica* at about 400.3 m (in the sample taken at 400.2 m). Such a mass occurrence of acritarchs is observed at the same level in northern Estonian and Swedish sections (Nõlvak *et al.*, 1999). This level coincides broadly also with the boundary between the Dreimani and Adze formations in Latvian sections. *Armoricochitina granulifera* was not encountered in the samples studied and thus this small zone is probably missing in the Valga (10) section.

The next stratigraphically important zone is the *Lagenochitina dalbyensis* Zone in the interval of 398.4–400.2 m corresponding to the lowermost Idavere Substage of the Haljala Stage. This zone enables the correlation of the sections over the whole of the Baltica palaeocontinent and with North Gondwana (Nõlvak, 1999a; Paris *et al.*, 1999). It is noteworthy that in the Valga (10) section the portion of beds belonging to the Haljala Stage has a very restricted thickness not exceeding 4.9 m, of which the *A. dalbyensis* Zone occupies almost half, and the beds of the Jõhvi Substage (above the *Belonechitina hirsuta* Zone) about 1 m. The latter substage can be identified between the phosphatic discontinuity surface at 396.3 m and the Kinnekulle K-bentonite bed at 395.4 m.

In general, the distribution and diversity of chitinozoans in the Uhaku, Kukruse and Haljala stages, to some extent also in the Keila Stage, in the Valga (10) section is in good accordance with earlier data (e.g. Taga-Roostoja, see Nõlvak, 1999b), despite smaller thicknesses of those beds compared with the sections of the North Estonian Confacies Belt in central Estonia.

The lower boundary of the Keila Stage coincides with the base of the Kinnekulle K-bentonite bed (Hints & Nõlvak, 1999) at 395.4 m in the Valga (10) section. However, the stratigraphically valuable *Angochitina multiplex* Subzone that usually lies just above the Kinnekulle bed (see Hints & Nõlvak, 1999, fig. 4) has not been found here. Possibly some break occurs in the oldest part of the Keila beds, which is proved by a very low disappearance level of *Cyathochitina calix* and by a very low appearance level of a specific population – curved specimens of *Euconochitina primitiva*, referred here as cf. (see Appendix 8). The latter form is widely distributed only in the uppermost beds of the Keila Stage, in the interval where mass extinction of chitinozoans takes place, e.g. in the Rapla section about 63% of the species disappear (see Kaljo *et al.*, 1996). A similar disappearance rate of about 45% can be followed also in the Valga (10) section. However, the late Keila extinction, diversity minimum in Oandu time and considerable lithological change, which are very obvious in the sections of the North Estonian Confacies Belt (Hints *et al.*, 1989), are not so clearly connected with some level in the Valga (10) section. Chitinozoans disappear here more gradually. Transition is observable also in lithology. The possible level of the boundary between the Keila and Oandu stages can be defined by the disappearance of *Leiosphaeridia baltica* and *Euconochitina primitiva* at 389.2 m. The only species appearing in the Keila Stage is *Ancyrochitina* sp. n. 1, which comes in at a depth of 389.9 m. The same rate of changes is observed in the Rapla section (Kaljo *et al.*, 1996). The lower boundary of the Rakvere Stage is also difficult to recognize and even more problematic according to the data available. The problem is that up to now there are no clear biostratigraphical criteria or definitions for the lower boundaries of the Oandu and Rakvere stages in the North Estonian and Central Baltoscandian confacies belts, and also in the transitional area between them, from where the sediments in the Valga (10) core originate. There are gaps on those levels in the stratotype area making boundaries easy to define. In the Valga (10) section, the beds containing the species like *Desmochitina juglandiformis* and *Ancyrochitina* sp. n. 1, not overlapping in the northern sections, fill up this break.

The boundary between the *Spinachitina cervicornis* and *Fungochitina fungiformis* zones is somewhat uncertain because originally these zones were defined (Nõlvak & Grahn, 1993) based on the total ranges of the corresponding species. This has to be revised in future. In the Valga (10) section, the lower boundary of the *Cyathochitina angusta* Subzone in the interval of 383.6–385.2 m can be suggested as a provisional level for the lower boundary of the Rakvere Stage (see Appendix 8). In addition, the appearance of *Conochitina* sp. 4 and *Lagenochitina baltica*, the latter species coming in on a stratigraphically unusually low level, supports that conclusion. Thus, with regard to chitinozoans, these data show that in the Valga (10) section all beds in the interval of 380.4–389.2 m are most probably not represented in the northern sections.

A relatively clear change in the succession of chitinozoans occurs on the level of the lower boundary of the *Armoricochitina reticulifera* Subzone at a depth of 373.5 m, which coincides with the beginning of the Nabala Stage. It shows that lithologically the upper boundary of the Rägavere Formation can be traced below the first argillaceous intercalation (373.9–374.0 m) in the Valga (10) section; the alternative position of this boundary is on an upper level – above the younger aphanitic limestone bed (372. 2–372.9 m) of the Nabala Stage. In other words, it shows that often a lithological subdivision has transitional boundaries.

Above the barren redbed portion of the lower Pirgu Stage and below the lower boundary of the *Conochitina rugata* Zone (at 341.0–351.3 m) there are found chitinozoans most of which range up to the end of the Pirgu Stage. However, the presence of a new form *Conochitina* sp. 3 unknown in the northern sections indicates that these beds may be missing in northern Estonia. Such a possibility is supported by the absence of the species (e.g. *Belonechitina wesenbergensis* s.l., *Lagenochitina balti*ca) disappearing at the top of the *Tanuchitina bergstroemi* Zone (see Nõlvak & Grahn, 1993). Most probably they disappear earlier, in the redbed part. This proves the metachronous character of the boundaries of the redbed portions in different sections, which is true of the boundaries of the Kuili Formation in the Valga (10) section.

Most likely the *Belonechitina gamachiana* chitinozoan Zone is not fixed in the Valga (10) section for the same reason – the distribution of redbeds in the topmost part of the traditional Pirgu Stage. It makes uncertain the beginning of continual distribution of *Spinachitina taugourdeaui*, which is suggested as a relatively good criterion for the lower boundary of the Porkuni Stage (Nõlvak, 1999a).

In the Valga (10) section, the upper boundary of the *S. taugourdeaui* Zone coincides with the disappearance level of three other taxa (see Appendix 8), as in other sections of that facies belt, e.g. Ruhnu, Ikla and Taagepera. In the interval between 324.2 and 324.5 m, within the Bernati Member of the Kuldiga Formation, there is a radical change level: mass extinction among chitinozoans, associated with a glaciation and mass extinctions of biota in the latest Ordovician (see Kaljo *et al.*, 1998). Just above that change at 322.6–323.7 m occurs the highest Ordovician chitinozoan zone, the *Conochitina scabra* Zone. This interval is represented by massive argillaceous limestone, characterized specifically by an abundance of burrows (up to 321.0 m). Interestingly, these beds are lithologically very similar to those occurring in the Puikule Member (lowermost Silurian by Nestor, 1994) in some sections from the transitional zone (defined by Põlma, 1982, fig. 2), e.g. Ohesaare, Seliste, Häädemeeste, Laeva and Tartu. However, our data are insufficient to state that these parts are different in age; their precise age should be determined by further investigations.

Higher in the Valga (10) section, above some barren samples (interval of 321.1–322.6 m), the classification of beds by chitinozoans is complicated for several reasons: (1) *C. scabra*, rare *Rhabdochitina gracilis* (disappears in the middle part of the Porkuni Stage in the Ruhnu section), also *Ancyrochitina ancyrea* s.l. and *Cyathochitina campanulaeformis* are characteristic of the beds of the Kuldiga Formation, extending to the lower portion of the Silurian. Except for the last one, these species are absent in the beds under discussion (above 322.6 m). Stratigraphically important *C. scabra* disappears abruptly at a very low level. In other studied sections *C. scabra* ranges throughout the beds interpreted as belonging to the Kuldiga Formation. (2) In general lithology of these beds a trend towards shallower, active water environments, compared with e.g. Ruhnu and Taagepera sections, is noted. There can be observed rhythmical income of sand and silt, micro- to cross-bedding, etc. (see Appendices 1 and 9). Such beds are traditionally defined as the Saldus Formation, and samples from there have always been barren. (3) Six different forms of chitinozoans are not identified on the species level due to extremely poor preservation, but these have never been met in the Porkuni beds. These specimens could be interpreted as reworked material from earlier beds. On the other hand, it is not excluded that there are some similarities with the association distributed in the Silurian, in the boundary beds of the Juuru and Raikküla stages (see Nestor, 1994, figs. 5, 9, 13/1, 21/1). (4) Samples just below the Devonian redbeds, from the interval of 305.0–312.1 m, were barren or yielded only some unidentifiable fragments. Therefore the Ordovician–Silurian boundary remains open in terms of chitinozoans, but most probably can be drawn at a depth of 312.6 m based on lithological criteria (see Appendix 1). (5) Also, extensive secondary dolomitization in the beds under discussion has great influence on the preservation of the organic-walled microfossils, as in the Taga-Roostoja (25A) section (Nõlvak, 1999b).

In general, the changes in chitinozoan succession conform well to the boundaries of most Ordovician stratigraphical units, above all the bases of stages. The general pattern of diversity in the Valga (10) section is similar to that established in the sections of the North Estonian Confacies Belt, e.g. in the Rapla core (Kaljo *et al.*, 1996), except in the late Caradoc (Oandu time). In northern Estonia the so-called Oandu crisis is characterized by a marked diversity low, distinct changes in the composition of the chitinozoan assemblages on their boundaries, and is preceded by a conspicuous extinction event at the end of Keila time. In the Valga (10) section all these features are not so clearly developed on some definite levels.

DISTRIBUTION OF CONODONTS

So far only 114 out of the 140 samples from the Valga (10) core, collected by P. Männik (in 1996) and O. Hints (in 1998) to study microfossils (conodonts, scolecodonts and chitinozoans), have been processed and picked for conodonts (Appendix 7). All 114 samples (except two from the Porkuni Stage at 313.45–313.60 m and 316.40–316.55 m) yielded conodonts. Conodonts are amber in colour (CAI=1 *sensu* Epstein *et al.*, 1977). The majority of specimens (particularly ramiform and platform elements) are broken.

The collection is stored at the Institute of Geology at Tallinn Technical University.

The lowermost sample studied (from 424.13–424.31 m) contained, among others, *Pygodus serra*, *Baltoniodus prevariabilis* and *Baltoplacognathus reclinatus* (Appendix 10). The occurrence of *B. reclinatus* indicates the presence of the *reclinatus* Subzone of the *serra* Zone and correlates these strata with the upper Lasnamägi Stage (Bergström, 1971; Dzik, 1978; Männil, 1986b). The occurrence of *Baltoplacognathus robustus* in the sample from 420.80–420.96 m shows that the boundary between the *reclinatus* and *robustus* zones, but also between the Lasnamägi and Uhaku stages, lies below this level, probably below the interval of 421.60–421.80 m where *B.* cf. *robustus* was identified.

The upper boundary of the *serra* Zone cannot be identified precisely, but the occurrence of *Eoplacognathus lindstroemi* in the sample from 415.88–416.06 m evidently marks the upper part of the zone (the *lindstroemi* Subzone). At the same level appears *Sagittodontina kielcensis*, so far found in Estonia only in the Taga-Roostoja (25A) section (Viira & Männik, 1999). In the Mojcza section, Poland, *S. kielcensis* appears already in the lower part of the Kunda Stage and reaches the *tvaerensis* Zone. This taxon is most abundant in the upper *serra* and lower *anserinus* zones (Dzik, 1994). The occurrence of *S. kielcensis* in samples from 415.88–416.06 m, 413.70–413.90 m, 412.90–413.05 m and, probably, also from 410.80–410.86 m in the Valga (10) section evidently indicates that the boundary between the *serra* and *anserinus* zones lies in this interval. It should be noted here that the elements identified as *Complexodus pugionifer* (Drygant) in Viira & Männik (1999, appendix 4) in reality belong to *S. kielcensis*, and the range of this taxon in the Valga (10) section coincides with the upper part of its range in the Taga-Roostoja (25A) section.

The appearance of *Amorphognathus tvaerensis* at 403.32–403.42 m (probably at 403.90–404.07 m) indicates that this level is already well in the Kukruse Stage. *A. tvaerensis* is continuously present up to the depths of 396.75–397.00 m (incl.). Three subzones, *variabilis*, *gerdae* and *alobatus*, were recognized in the *tvaerensis* Zone based on the evolutionary changes in the *Baltoniodus* lineage (Bergström, 1971). The upper boundary of the zone was defined by the disappearance of *A. tvaerensis* and appearance of *A. superbus*. In the Valga (10) section, the boundary between the *variabilis* and *gerdae* subzones lies between the intervals of 401.15–401.21 m and 400.05–400.23 m, and the boundary between the *gerdae* and *alobatus* subzones between the intervals of 400.05–400.23 m and 397.70–397.90 m (the sample from 399.00–399.10 m was not processed). As in the Taga-Roostoja (25A) section (Viira & Männik, 1999), also in the Valga (10) section *B. alobatus* reaches higher than *A. tvaerensis*. The disappearance of both taxa just below the "Big Bentonite" in the Valga (10) section evidently indicates that the upper part of the Haljala Stage is highly condensed or missing in this section. The sample just above the "Big Bentonite" (from 394.97–395.15 m) yielded already a low diversity fauna, represented mainly by long-ranging taxa. In the Taga-Roostoja (25A) section, a similar change in the conodont sequence occurs about 6 m below the "Big Bentonite" (Viira & Männik, 1999, appendix 4).

Samples from an about 14 m thick interval (corresponds to the upper part of the Adze, the entire Blidene, and the main part of the Mossen formations) above this level have not yet been processed.

The only identifiable M element of *A. superbus* comes from the upper part of the Rägavere Formation (from 374.85–374.95 m). The strata between this level and the level of the disappearance of *B. alobatus* below are here also assigned to the *superbus* Zone. However, in reality, due to the very rare occurrences and poor preservation of *Amorphognathus* in the strata between the Haljala and Rakvere stages, the real appearance level of *A. superbus* in Estonia is not known (Männik, 1992).

Based on the appearance of *A. ordovicicus* at 368.25–368.35 m (probably already at 368.70–368.80 m), the boundary between the *superbus* and *ordovicicus* zones can be defined below this level. As the interval between the level of 374.85–374.95 m and that with the lowermost *A. ordovicicus* did not yield any identifiable specimens of *Amorphognathus*, it is possible that the zonal boundary lies even further downwards. It is noteworthy that in the Valga (10) section *A. ordovicicus* appears already in the uppermost part of the Mõntu Formation and occurs also in the overlying cryptocrystalline limestones assigned to the Saunja Formation. Based on previous data, but also on the distribution of chitinozoans and ostracodes in the Valga (10) section (Nõlvak in this volume; Meidla in this volume), both formations are considered to be of Nabala age. So far, *A. ordovicicus* has been known to appear in the lowermost Vormsi Stage (in the Kõrgessaare or Tudulinna formations – Männik, 1992). The first occurrence of *A. ordovicicus* in the strata of Nabala age in the Valga (10) section evidently indicates that the real appearance level of *A. ordovicicus* in Estonia has not been fixed yet. Identifiable specimens of *A. superbus* are extremely rare in collections available so far, all of them coming from the Rakvere Stage. From the Nabala Stage only unidentifiable fragments of *Amorphognathus* have been found up to now (Männik, 1992).

Also *Hamarodus europaeus* appears unusually early in the Valga (10) section. Previous studies have shown that in Estonia the distribution of this taxon is limited to the Nabala Stage only, particularly common it is in the Mõntu Formation (Männik, 1992). However, in the Valga (10) section *H. europaeus* appears, most probably, already in the uppermost Mossen Formation and ranges throughout the Rägavere and Mõntu formations. In the uppermost part of the Mõntu Formation the morphology of *Hamarodus* changes and *H. europaeus* is probably replaced by an undescribed species of *Hamarodus*. The *Hamarodus* lineage in the Valga (10) section can be followed up into the lowermost Kuldiga Formation, where it becomes extinct together with other *ordovicicus* Zone taxa. However, one probable specimen of *Hamarodus* has been found also above this level (Appendix 10).

No major changes occurred and no stratigraphically diagnostic taxa of conodonts were found between the levels of the appearance of *A. ordovicicus* and disappearance of the *ordovicicus* Zone faunas in the lowermost Kuldiga Formation. The only interesting taxon is *Icriodella* sp. n., identified in the samples from 340.40–340.50 m and 339.00–339.10 m, i.e. from the upper part of the Jelgava Formation. The same taxon has been found from the Halliku Formation in the Seliste (Viira, 1974, identified as *Icriodina* sp.) and Laeva (18) core sections (Männik, 1992). In the lower part of the Kuldiga Formation the fauna characteristic of the *ordovicicus* Zone disappears. It is replaced by a single taxon, *Noixodontus girardeauensis*, which appears at 323.80–323.95 m (just below the boundary between the Bernati and Ēdole members of the Kuldiga Formation) and is, as a rule, the only taxon occurring in the main part of the Kuldiga Formation. The uppermost specimens of *N. girardeauensis* came from 318.75–318.85 m. The samples above this level up to the Ordovician–Silurian boundary were barren or yielded few fragments of *Dapsilodus* sp.

The strata with *N. girardeauensis* are evidently younger than the youngest Ordovician strata known from the outcrop area. Considering the co-occurrences of *N. girardeauensis* and the Hirnantian shelly faunas in the central United States, and the position of *N. girardeauensis* in the Yukon graptolite sequence, Barrick (1986) concluded that most probably *N. girardeauensis* is restricted to the Hirnantian interval. Accordingly, the main part of the Kuldiga Formation (excluding the Bernati Member) and the Saldus Formation in the Valga (10) section correspond to the Hirnantian, which agrees with previous datings (Hints *et al*., 2000). Also, the conodont data fit well with chitinozoan-based correlations (Nõlvak & Grahn, 1993), according to which the Ärina Formation in the stratotype area of the Porkuni Stage corresponds to the Bernati Member in southern Estonia and Latvia.

The Silurian fauna, including *Distomodus* sp., *Ozarkodina* ex gr. *oldhamensis* and *Walliserodus curvatus*, appears in the lowermost part of the Rūja Formation and indicates probably the *kentuckyensis* Zone.

DISTRIBUTION OF SCOLECODONTS

Scolecodonts are minute jaws of fossil polychaete worms. Composed of very resistant organic substance, they constitute a common element of microfossil assemblages of Ordovician age. In recent years the taxonomy of scolecodonts has been greatly improved and they can be classified under natural system instead of the form classification (Kielan-Jaworowska, 1966; Szaniawski, 1996).

In the Valga (10) core, scolecodonts have been recovered from a number of samples together with conodonts and chitinozoans (Appendix 7). Some results of the investigation of this material have already been published (Hints, 1999, 2001). The Valga (10) section is the type locality for one species and may become such for several other species since the taxonomic study is still in progress. However, in general, more information on scolecodont distribution is available for the shallower water facies spread in northern Estonia (Hints, 1998) and the data from the Valga (10) section can be compared against that material. At present, several species recovered can be classified only under the open nomenclature.

The samples examined for scolecodonts were collected by P. Männik, J. Nõlvak and O. Hints. Specimens were extracted in the Institute of Geology at Tallinn Technical University (where also the collection is housed) mostly using acetic acid and the technique described in detail in Hints (1998).

Altogether, nearly 70 taxa (species or groups of tentative generic or family assignment) of jawed polychaetes were recorded in 64 out of the nearly 80 samples studied. The preservation of scolecodonts is commonly somewhat influenced by compaction and dolomitization. No scolecodonts or other organic-walled microfossils have preserved in the red-coloured (and green-coloured) rocks of the Jonstorp and Kuili formations. Some other intervals were devoid of scolecodonts. However, this can be due to insufficient sample size rather than poor preservation.

The relative abundance of scolecodonts (calculated as the sum of the most numerous jaw elements of a species per 1 kg rock, illustrated in Appendix 11) remains well below 100 in most samples, being thus generally much lower than the average for the contemporaneous strata in the northern Estonian sections (see also Hints, 2001). Only in two intervals in the Dreimani and Ēdole formations a much higher abundance of up to about 500 specimens per 1 kg has been recorded. Like the abundance, the diversity index illustrated in Appendix 11 reflects decreased diversity as compared to northern Estonia. The number of species in a sample, which roughly corresponds to the diversity index, is 5 on average, reaching 14 in one sample in the Valga (10) section. In shallower water facies frequently more than 20 species occur in the samples of similar size.

The Ordovician jawed polychaete fauna recovered from the Valga (10) section may be tentatively divided into five more or less clearly defined associations, each featured by certain assemblage composition and characteristic forms. The samples taken from the Silurian were barren of scolecodonts (except the lowermost one, which contained an indistinct and poorly preserved assemblage).

The **first** (the oldest) **association** occurs in the Lasnamägi, Uhaku and Kukruse stages. It is characterized by a high percentage of polychaetaspids, particularly the genus *Oenonites* (=*Polychaetaspis*), mochtyellids and ramphoprionids. Typical of this interval is the occurrence of *Ramphoprion* sp. n. A. The disappearance level of this species, or possibly a group of closely related species, seems to coincide with the boundary between the Kukruse and Haljala stages. Also, notable changes in the frequency of "*Mochtyella*" *fragilis* and *Oenonites varsoviensis* more or less clearly mark the upper limit of this interval. Two other species, *Euryprion rarus* and *Atraktoprion* sp. n. A, regarded as of some stratigraphical value (Hints, 2001), also occur in the Uhaku–Kukruse interval of the Valga (10) section. Some species typical of this interval in northern Estonia, like *Pistoprion* sp. A, are not recorded in the Valga (10) core most likely due to their stenotopic character.

In the Dreimani Formation, relative frequency of scolecodonts is approximately two times higher than in directly under- and overlying strata. This, together with certain changes in the assemblage (the decrease in *Rakvereprion balticus* and increase in *Protarabellites* cf. *staufferi*) may indicate some biofacies shift, possibly resulting from the sea level change.

The **second association**, corresponding to the interval from the Haljala to Oandu stages, has few distinctive features. The species characteristic of these stages in northern Estonia, such as *Pistoprion transitans*, *Pteropelta kielanae*, *Ramphoprion bialatus*, *Oenonites gadomskae*, *Oenonites latus*, *Oenonites tuberculatus* and *Mochtyella cristata*, have not been found in the Valga (10) section.

The dynamics of *Protarabellites* cf. *staufferi*, which is a predominant species in the lower part of this interval in the Valga (10) section, does not coincide with the distribution pattern revealed in northern Estonia (see Hints, 1998), where a conspicuous decrease in the abundance of this species can be observed approximately at the Idavere–Jõhvi boundary.

Other common forms in the second association are *Oenonites* ssp., *Atraktoprion* ssp. (most probably represented by *Atraktoprion cornutus*), Tetraprionidae gen. et sp. n. and *Lunoprionella symmetrica*. Occasionally the last three taxa make up a considerable part of the assemblage.

The **third association**, occurring in the Rakvere and Nabala stages, has a number of specific features. First of all, several species not confined to, but characteristic of this interval in the northern Estonian sections (e.g. *Ramphoprion elongatus*, *Xanioprion* sp. *A*, *Atraktoprion major*, *Mochtyella polonica*, *Ramphoprion* sp. C, "*Mochtyella*" *fragilis* and *Oenonites varsoviensis*) have been recovered from the Valga (10) section. Other forms commonly found in the Rakvere and Nabala stages include *Oenonites* ssp., *Rakvereprion balticus*, *Kalloprion* sp., *Leptoprion* sp. and *Atraktoprion* sp.

The core of the Vormsi Stage is missing, and the red-coloured sediments of the Jonstorp Formation are barren of organic-walled fossils.

The **fourth association** is represented by the low-diversity polychaete fauna recovered from the Jelgava Formation and part of the overlying strata. A particular feature of this association is strong predominance of *Rakvereprion balticus*. Other taxa include *Oenonites* ssp., *Leptoprion* sp., Tetraprionidae gen. et sp. n. and *Ramphoprion* cf. *deflexus*. Noteworthy is the exceptional preservation of the last species – one jaw apparatus per about four single elements of *R.* cf. *deflexus* was found in two samples. Usually one intact polychaete jaw apparatus per several hundreds of detached jaws can be found in the Ordovician rocks extracted by the same technique. The reason for this remarkable preservation seems to lie in the specific lithology. The clayey rocks were not completely dissolved and the jaws in the apparatuses were "clued" together by insoluble sediment particles. This case implies that the polychaete jaw apparatuses, which rather frequently may have preserved in the rock in clusters, have mostly no chances to stay fused even if the samples and residues are treated with extra care.

The **fifth association** occurs in the beds that correspond to the main part of the Kuldiga Formation (Ēdole Member) and are the most interesting with respect to the jaw-bearing polychaetes. This interval is characterized by the bloom of benthos, represented mainly by melanoskleritoids and scolecodonts, and almost an absence of planktic organisms, such as chitinozoans and graptolites. A very distinct assemblage of conodonts has also been recovered from the same level (see Männik in the present volume).

The most striking feature is the disappearance of *Rakvereprion balticus* and the appearance of *Pistoprion transitans*, *Conjungaspis minutes* and *Mochtyella cristata* at the base of this interval. The abundance of scolecodonts increases very rapidly to nearly 500 per 1 kg in the lower part, and decreases after a short peak continuously to about 30 per 1 kg. The abundance peak corresponds to the thriving of *Pistoprion transitans*, which may constitute about 60% of all specimens. The *Pistoprion*-ruled assemblage is succeeded by the one predominated by *Oenonites* sp. n. B (up to 45%), *Mochtyella cristata* (up to 30%) and Tetraprionidae gen. et sp. n. (up to 35%). In addition, several other species (e.g. *Kettnerites* sp. and Atraktoprionidae gen. et sp. n.) have been recorded from this interval.

The above succession is, in several respects, very similar to the one observed in the Puikule Formation (traditionally assigned to the lowermost Silurian) of some other sections, including Laeva (18) and Võhma in central Estonia. It remains yet to be cleared out whether this correspondence is just due to the exceptionally similar facies, or misinterpretation of the age of some rock unit.

The fauna recovered in the Saldus Formation is distinct from that of the fifth association. However, as that assemblage (containing, e.g., *Mochtyella* ex gr. *trapezoidea*, *Symmetroprion* sp. n., *Kettnerites* sp. and *Pteropelta gladiata*) is present in one sample only, a separate association cannot be established for it.

To sum up, the distribution pattern of scolecodonts revealed in the Valga (10) section confirms a relatively low rate of evolution of the majority of Ordovician jaw-bearing polychaetes. It can be seen from Appendix 11 that a number of species range through almost the entire interval studied (e.g. *Rakvereprion balticus*, Tetraprionidae gen. et sp. n. and *Xanioprion* sp.). The illusively short ranges of some taxa (e.g. *Pistoprion transitans*, *Mochtyella polonica*, *Mochtyella cristata*, *Rhytiprion magnus* and *Pteropelta gladiata*) reflect the presence/absence of suitable facies rather than the actual range of the species. Few species are less facies dependent and are confined to a relatively short interval but the material from other localities is yet insufficient for establishing a scolecodont zonation. It is apparent that wider knowledge on scolecodonts can make them more valuable in stratigraphy, particularly in palaeoenvironment analysis, where the relatively slow evolution may turn an advantage.

DISTRIBUTION OF OSTRACODES

The ostracode samples were taken from the Ordovician and Silurian (Llandovery) parts of the Valga (10) core section. The sampling density varied considerably (Appendix 12). For the study two laboratory methods were used. The material from 395.5–424.4 m was picked from insoluble residue and only a few specimens could be identified on the species level with confidence. The material from above 395.5 m was prepared by the disintegration method (see Meidla, 1996), which provided mostly a reasonable amount of well-preserved specimens. The exception is here the upper part of the studied interval where samples were often unfossiliferous. The collection is stored at the Institute of Geology, University of Tartu.

Owing to the specific geographic position of the drill hole (near the southern border of Estonia), the correlation of some levels with other Estonian sections is complicated and the comparison with the data from Latvia is important. Most of the Latvian data are available only in the form of a "summary table" compiled by L. Gailite (see Ulst *et al.*, 1982). Largely due to this fact, a number of taxonomic problems remained unresolved. Both the variability and stratigraphic ranges of some taxa (*Uhakiella curta*, *Pseudoancora parovina*, the species of the genus *Orechina*) appeared to be unexpectedly wide and require special study. The faunal log (Appendix 13) summarizes the distribution of stratigraphically valuable material which is commented on below.

The material from the interval of 395.5–424.4 m comprises mainly internal moulds and was mostly identified on the generic level only. More remarkable faunal changes recorded in this interval are probably due to different conditions of preservation. There are no clues to the lower boundary of the Lasnamägi, Uhaku and Kukruse stages in the faunal log. The boundary of the Haljala Stage could be defined at a depth of 400.2 m by the disappearance of *Tetrada perplana*, a palaeocope species related to the Uhaku and Kukruse stages in Estonia (Sarv, 1959) and in western Latvia (Ulst *et al.*, 1982). However, in southeastern Latvia and in Lithuania the range of this species is reported to be remarkably wider and may reach the Oandu Stage (Ulst *et al.*, 1982; Sidaravičiene, 1992).

The first richly fossiliferous sample from 394.45–394.52 m (corrected depth based on differently interpreted depths in the intervals with a small core yield is 394.5 m; see also Appendices 12, 13) contains exclusively the ostracode species characteristic of the Haljala and Keila stages in Estonia. Both the typical North Estonian material (*Pedom-*

phalella egregia, Sigmoopsis rostrata) and taxa characteristic of the Central Baltoscandian Confacies Belt (*Steusloffia costata*) occurred in this sample.

The interval of 391.13–392.7 m (corrected depth 391.9–393.7 m) is palaeontologically fairly uniform but specific. *Vogdesella subovata* occurring in association with *Pedomphalella egregia* has so far been documented only from the Plunge Member in Estonia (the lower member of the Mossen Formation in Meidla, 1996), although its range may be wider in Latvia (Ulst *et al.*, 1982). In Sweden, *V. subovata* is recorded from the Sularp Shale (Schallreuter, 1980), which is roughly equivalent to the Haljala and Keila stages in the East Baltic. The occurrence of poorly preserved specimens provisionally attributed to *Pelecybolbina graesgardensis* suggests that this particular interval is correlative of the uppermost Keila Stage in the Laeva (18) section (see Meidla, 1996, fig. 13). The rest of the material is mainly of open nomenclature and can be considered as of low stratigraphical value. This argumentation supports the Keila age for the interval of 391.13–392.7 m (corrected level 391.9–393.7 m) in the Valga (10) section (see also Ainsaar & Meidla, 2001).

The Blidene Formation in the interval of 387.0–390.8 m (corrected level 387.0–391.3 m) contains *Pedomphalella egregia*, *Klimphores bimembris*, *Klimphores minimus* and *Priminsolenia minima*. *P. egregia* is specific to the Haljala and Keila stages elsewhere in the East Baltic and was recorded in the lower part of the interval only. The occurrence of *K. bimembris* in Estonia and Lithuania is restricted to the Keila Stage (Sidaravičiene, 1992; Meidla, 1996), but generalized data from Latvia (Ulst *et al.*, 1982) show a considerably wider stratigraphical range for this species. Both *Klimphores minimus* and *Priminsolenia minima* range from the uppermost Keila Stage up into the Nabala Stage in Estonia (Meidla, 1996). The occurrence of *Klimphores minimus* in the Keila Stage is reported also from Latvia (generalized data set by L. Gailīte in Ulst *et al.*, 1982) and Lithuania (Sidaravičiene (1992) refers to occasional specimens; in Sidaravičiene (1996) the species is recorded from the Leliai-284 core, from the middle part of the Keila Stage). To sum up, although the ostracode composition in this interval is of a "mixed" character, there are no arguments for questioning the Keila age of the corresponding strata.

The Plunge Member of the Mossen Formation (385.9–387.0 m) is characterized by a flood of *Vogdesella subovata*, which matches the palaeontological characteristics of the same member in the Taagepera core (Meidla, 1996, fig. 17). In the Abja (92) section (*Ibid.*, fig. 18) the occurrence of Tetrada sp. (=*T. pseudoiewica*? in *Ainsaar et al.,* 1996) and *Consonopsis consona* in association with *V. subovata* suggests a pre-Oandu age for the base of the Variku Formation (Ainsaar & Meidla, 2001). This correlation is also supported by the stable isotopic data (*Ibid.*).

The diverse ostracode assemblage above the Plunge Member contains *Klimphores minimus*, *Easchmidtella fragosa* and *Pseudoancora parovina*. This assemblage is similar to those of the lower, Oandu part of the Priekule Member in the Taagepera section and of the middle part of the Variku Formation in the Abja (92) section.

In Meidla (1996) the Rakvere Stage is considered to equal the range zone of *Pelecybolbina pelecyoides*, which appears at 382.92 m in the Valga (10) section. This species is characteristic of the cryptocrystalline limestones of the Rakvere Stage and its basal transition in the Laeva (18) and Pärnu sections (Meidla, 1996, figs 13 and 14). The tripartite subdivision in ostracode logs has been described in several sections (Meidla, 1996) and it is present in its typical form also in the Valga (10) section. The appearance of a common metacope species *Pullvillites laevis*, appearing at 381.25 m, has usually been recorded from the upper part of the Rakvere Stage all over Estonia (Vinni (T-112), Moe (H-50), Kaugatuma (509), Pärnu, Viljandi (91), Laeva (18), Abja (92) and Taagepera core sections; see Meidla, 1996). The disappearance of *P. pelecyoides* at 377.85 m may refer to the lower boundary of the Nabala Stage at this particular level or higher. However, the overlap of the ranges of *P. pelecyoides* and *Gotlandina caudica*, so far documented only from the Nabala Stage in Estonia, suggests that the Rakvere–Nabala boundary interval in the Valga (10) section is more complete than in most Estonian sections. Another boundary marker, the *Daleiella admiranda* range zone, cannot be identified in the Valga (10) section, due to expected lack of the zonal species in this particular facies zone.

The record of *Pelecybolbina*? sp. in the interval of 376.9–377.0 m may adjust the position of the boundary of the Nabala Stage. Higher up in the section, the samples from the cryptocrystalline limestone contain an impoverished ostracode assemblage, which is usually characteristic of the Nabala Stage and might suggest that the lower stage boundary should be positioned at about 376.0 m. However, no key taxa have been recorded in the proposed Nabala interval.

The lower boundary of the Vormsi Stage represents a sharp facies boundary all over Estonia but is usually poorly distinguishable in the ostracode record. In the Valga (10) section, most of the core corresponding to the Vormsi interval is missing.

The basal part of the Pirgu Stage is poorly fossiliferous. The taxa characteristic of the Pirgu Stage appear usually above the lower part of the red-coloured Jonstorp Formation (Meidla, 1996). In the Valga (10) section, this level occurs at 358.63 m (appearance of *Daleiella rotundata*). The ostracode assemblage of the Jonstorp Formation (*Daleiella rotundata, Rectella explanata* and *Gryphiswaldensia plaviensis*) is similar to those of other South Estonian sections. The fossil content is very low in the upper part of the Pirgu Stage. Judging from the rock properties, the low fossil content could be rather due to a very high sedimentation rate ("dilution" effect) than secondary alteration of the rock (see also Appendix 14).

Most of the samples from the Porkuni Stage were unfossiliferous. The occurence of *Rectella composita, Pseudoancora confragosa, Drepanella*? *pauxilla* and others in the interval of 318.5–322.4 m refers to the Hirnantian. The basal beds of the Silurian were unfossiliferous.

The most problematic stratigraphical interval in the Valga (10) section is the depth range of 373.5–390.8 m (corrected level 373.5–391.3 m), where the correlation remains somewhat tentative. Data from the Ristiküla (174) core section suggest the possible shallow water origin of the basal part of the Variku Formation, based on the increase in the number of the taxa otherwise recorded mainly in North Estonian sections (Ainsaar *et al.*, 1999; Meidla *et al.*, 1999). This could be an additional clue to further interpretation of the critical depth interval in the Valga (10) section, once again confirming the uniqueness of this particular section and hinting at partial absence of the equivalent beds elsewhere in Estonia.

VOLCANOGENIC INTERBED

In the interval of 395.2–395.4 m, below the marl (4 cm) there occurs a claystone bed with an observed thickness of 2 cm. The high content of biotite of the claystone suggests its volcanic origin (Appendix 1, sheet 15). The lower boundary of the bed is marked by a clear contact with limestone. The upper surface of the limestone contains more than 50% pyritized

Table 1. Comparison of the volcanogenic bed of the Valga (10) section (interval 395.2–395.4 m) with the Kinnekulle bed

	Valga (10)	Kinnekulle bed Estonia–Norway
Main components (%)		
	1 sample	11 samples
LOI 920°	8.76	1.5–7.0
SiO_2	51.5	49.5–63.0
Al_2O_3	29.7	18.0–21.9
MgO	2.18	0.8–5.5
CaO	0.72	0.52–4.64
K_2O	4.1	6.8–14.9
Fe_2O_3 t	2.74	0.9–4.0
TiO_2	0.471	0.19–0.34
Trace elements (ppm)		
	1 sample	7 samples
Nb	19	8–18
Zr	285	109–322
Y	33	18–63
Sr	66	7–302
Ga	22	13–30
Rb	83	65–288
Pb	<10	<10–25
Zn	24	14–53
Ni	109	<10–47

	Valga (10)	Kinnekulle bed Estonia–Norway
Ratios of elements (m/m*100)		
	1 sample	5–11 samples
Ti/Al	1.8	1.1–2.2
Nb/Zr	6.7	5.6–10.1
Nb/Y	58	19–63
Nb/Ga	86	37–85
Nb/Al	0.012	0.008–0.016
Nb/Ti	0.67	0.68–1.0
Zr/Al	0.18	0.11–0.28
Zr/Ti	10	9.0–19.0
Y/Zr	12	14–42
Ga/Zr	7.7	9.3–20.0
Y/Al	0.021	0.017–0.049
Y/Ti	1.2	1.5–1.8
Y/Ga	150	80–190
Ga/Al	0.014	0.014–0.027
Ga/Ti	0.78	1.1–2.2
Magmatic minerals		
	1 sample	10 samples
$NaAlSi_3O_8$ mol% in sanidine	25.3	24.2–25.5
Sanidine/quartz XRD intensity ratio	0.2	0.22–0.56

Notes: LOI 920° – loss on ignition at 920° C; Fe_2O_3 t – total iron as Fe_2O_3 (Fe_2O_3 t=Fe_2O_3+1.111FeO).

organic detritus whose content decreases rapidly downwards below 10%. According to X-ray diffractometry, the claystone bed consists predominantly of kaolinite with small amounts of illite-smectite. Such association of main authigenic minerals is characteristic of the volcanogenic interbeds in deep palaeoshelf sediments in Estonia (Kiipli *et al.*, 1997). The occurrence of kaolinite in this claystone bed differentiates it notably from the volcanogenic beds of central and northern Estonia, which consist of the association of illite-smectite and potassium feldspar. X-ray fluorescence analysis has revealed considerable differences in the chemical composition between the volcanogenic bed of the Valga (10) section and the Kinnekulle bed in other localities of northern and central Estonia (10 samples analysed) and Norway (3 samples analysed from Vollen) (Table 1; see also Vingisaar & Murnikova, 1973).

The volcanogenic bed in the Valga (10) section is considerably richer in Al_2O_3 and poorer in K_2O than other beds in Estonia and Norway. The higher Al content gives evidence about greater loss of other chemical elements in diagenesis, leading to the residual enrichment with low-mobility elements. By the bulk composition the Valga (10) bed is closer to the volcanogenic interbeds in Latvia and Lithuania (Kepezhinskas *et al.*, 1994) than to Estonian ones. The marked difference in diagenetic changes compared to central and northern Estonia complicates seriously the correlation on the basis of chemical characteristics. The use of element contents is not valid; the comparison of ratios of immobile elements is more reliable (Table 1). Nine of the investigated ratios in the Valga (10) section fall within the ranges determined in the Kinnekulle bed in other regions. The remaining five ratios are close to these ranges. Thus, there are no data contradicting the correlation of the volcanogenic bed of the Valga (10) core with the Kinnekulle bed occurring at the lower boundary of the Keila Stage.

The correlation of volcanogenic interbeds can be best performed through the study of the composition of magmatic minerals not altered diagenetically. In the present work the composition of magmatic sanidine ($NaAlSi_3O_8$–$KAlSi_3O_8$ solid solution) was measured in coarse fractions with a high content of magmatic minerals. The clay component was removed by washing, chemical treatment and ultrasonic dispersion. The X-ray diffractometry was conducted according to the method of Orville (1967), improved using a contemporary computer. The accuracy estimated from repetitive analyses was 1 mol%. The results obtained are presented in Table 1.

The composition of magmatic sanidine in the claystone bed of the Valga (10) section (25.3 mol% $NaAlSi_3O_8$) concords well with the compositions determined in other core sections of Estonia and also with the sanidine composition at Kinnekulle, where Byström (1956) separated sanidine crystals and analysed these chemically. For comparison, in the Silurian volcanogenic beds of Estonia the composition of magmatic sanidine varies largely, containing 19–49 mol% $NaAlSi_3O_8$. The presence of magmatic sanidine serves as additional proof for the volcanic origin of the claystone bed under discussion. The X-ray reflection intensity ratio of sanidine/quartz is also similar in the Valga (10) and other cores. For comparison, the Silurian volcanogenic beds exhibit an almost 100-fold variation in this ratio. To sum up, we can say that the volcanogenic interbed occurring in the interval of 395.2–395.4 m in the Valga (10) section correlates with the Kinnekulle bed at the lower boundary of the Keila Stage.

LITHOSTRATIGRAPHY AND LITHOLOGY OF THE CARADOC

The Valga (10) drill hole is situated in the area of the Livonian Tongue, a gulf-like extension of the Central Baltoscandian Confacies Belt (Fig. 3). Therefore, here the traditional lithostratigraphical nomenclature of that region (Männil & Meidla, 1994) is used for Caradoc (Haljala to Nabala stages) rock units.

The Adze, Blidene, Mossen and Fjäcka formations are distributed over the whole of the Livonian Tongue and can be easily distinguished in the Valga (10) section (Appendix 1). The facially most variable interval is a complex of limestones lying between the claystones, marls and argillites of the Mossen and Fjäcka formations. The Rägavere and Mõntu (or Paekna, or Skrunda, or Dzērbene) formations can be distinguished in the lower portion of this complex in different parts of the Livonian Tongue; the Saunja Formation is more widely distributed in its upper portion (Ulst *et al.*, 1982). In the Valga (10) section, the limestone complex is divided between the Rägavere, Mõntu and Saunja formations (see also Pl. 4, figs 30–32). The lithostratigraphic separation of aphanitic limestone of the Rägavere Formation, occurring north of the Valmiera–Lokno uplift, and similar rock of the Dzērbene Formation south of the uplift, is based only on different biostratigraphic positions of these beds. Whether these sediments of Rakvere (Rägavere Formation in the Valga (10) section) and Nabala age (Dzērbene Formation in Latvia; Ulst *et al.*, 1982; Männil & Meidla, 1994) are parts of the same limestone unit remains still unknown.

Another problem is subdivision of the Mossen

Formation. The Mossen Formation was first established by Skoglund (1963) in Västergötland, Sweden, where it consists of dark graptolitiferous shales in the lower part, and grey calcareous mudstone in the upper part (Skoglund, 1963, p. 25). The upper, marl (mudstone) part with argillaceous limestone interbeds is referred to as the Priekule Member (Ulst, 1972), but the lower, "black argillite member" (claystones and argillaceous marls) remained unnamed in Latvia and southern Estonia (Ulst *et al.*, 1982; Männil & Meidla, 1994). For the Mossen Formation in the western Lithuanian region of the Livonian Tongue, Paškevičius (1994) introduced the subdivision into the Plunge (lower, argillite unit) and Zarenai members (upper, claystone unit), and used later (Paškevičius, 1997) the same subdivision also in the Latvian part of the Jelgava Depression. However, considering the identity of the subdivision of the Mossen Formation in Lithuania and Latvia, the name of the Priekule Member should have priority over Zarenai. Accordingly, Ainsaar & Meidla (2001) proposed a subdivision of the Mossen Formation into the lower, Plunge Member, and the upper, Priekule Member (see also Pl. 4, figs 33, 34) in the area of the Livonian Tongue, which is followed in the present volume.

The gamma-ray logs generally support the biostratigraphic correlation of the Caradoc interval of the Valga (10), Tartu (453) and Latvian sections (Fig. 4). The wireline logs have been used in geological mapping to confirm the lithostratigraphic boundaries in correlation of core sections. In carbonate sections the gamma-ray log is mainly sensitive to the clay content of the rock. Limestones have very low concentrations of U, Th and K, and give very low gamma-ray responses. Clay-rich rocks normally contain much more of these radioactive elements. Black shales in particular, with their substantial organic content, produce marked reactions on the gamma log because of their elevated uranium content (e.g. Bjørlykke, 1989).

The Central Baltoscandian Confacies Belt, an offshore area of the basin, was characterized by a stable sedimentation regime during the Middle and Upper Ordovician. Changes in carbonate productivity, input of fine siliciclastic material or burial of organic material are well reflected over a wide area. That makes gamma-ray logs, which usually are sensitive to facies changes of sediment composition, useful in chronostratigraphical correlation of core sections in the offshore area of the Baltoscandian palaeobasin (see Modlinski, 1982; Ulst *et al.*, 1982).

The gamma-ray logs of the Caradoc interval have two characteristic elevations in Latvian and southern Estonian sections (Fig. 4; Ulst *et al.*, 1982). The upper, very sharp, intensive and often double-peak excursion in the curve corresponds to the argillaceous marls, claystones and black shale of the Fjäcka Formation. The lower, usually wider and complex excursion of the curve corresponds to the Blidene and Mossen formations (Fig. 4).

Comparison of the gamma-ray logs of the Valga (10) section and Skrunda-33 section in western Latvia (Ulst *et al.*, 1982) shows that the lithostratigraphical correlation agrees well with geophysical data; main differences are in thicknesses of the beds (Fig. 4). The logs of the Valga (10) and Tartu (453) sections are also quite similar, although the lithostratigraphic nomenclature used in the Tartu (453) section (and lithology in some intervals) differs from that in the Valga (10) section.

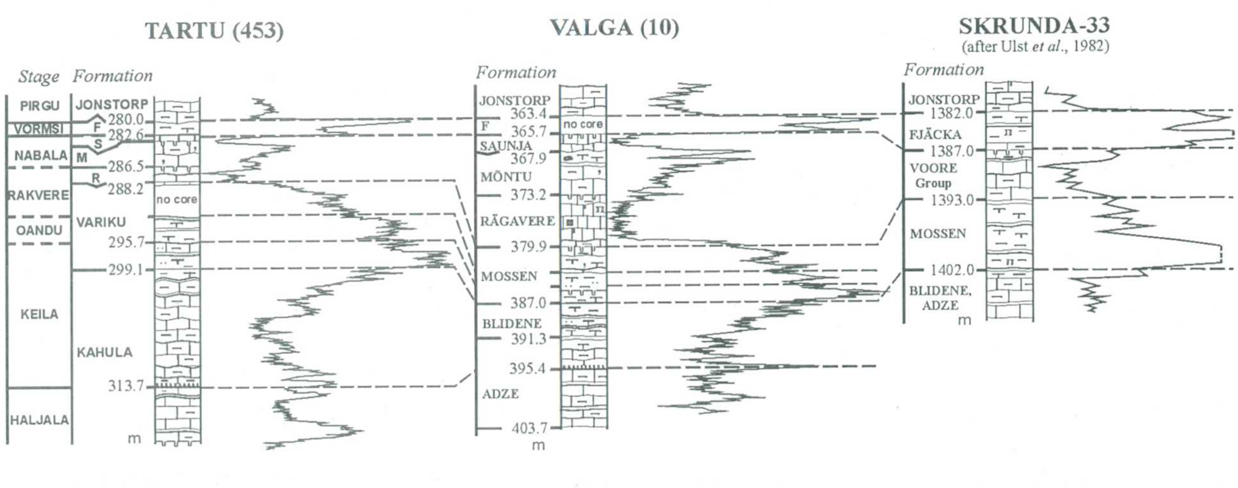


Fig. 4. Gamma-ray logs and correlation of the Tartu (453), Valga (10) and Skrunda-33 sections. F, Fjäcka Formtion; S, Saunja Formation; M, Mõntu Formation; R, Rägavere Formation. Refer to Appendix 1 for lithology. In the description of the Tartu (453) core (Põldvere, 1998) the lower boundary of the Oandu Stage is defined at 296.6 m and of the Rägavere Formation at 288.4 m.

Based on the distribution of ostracodes (see Meidla in this volume), the argillite and argillaceous marls of the Plunge Member are correlated with the uppermost part of the Keila Stage, the carbonaceous claystone and argillaceous marls of the Priekule Member with the Oandu and Rakvere stages (Meidla, 1996; Ainsaar *et al.*,1999; Ainsaar & Meidla, 2001). Comparison of the gamma-ray logs supports this correlation and shows the penecontemporaneity of the lower boundary of the Variku Formation (defined by Ainsaar & Meidla, 2001) and *Tetrada* Beds (named after the ostracode *Tetrada* (*Tetrada*) *pseudoiewica*; Ainsaar *et al.*, 1999) in the Tartu (453) section with the lower boundary of the Mossen Formation in the Valga (10) section (Fig. 4).

The geophysical data support the biostratigraphical correlation of the limestones of the Rägavere, Mõntu and Saunja formations between the Tartu (453) and Valga (10) sections. That limestone complex is much thicker in the Valga (10) section due to increased thickness of all three formations (Fig. 4).

Twenty-five samples from the Valga (10) core were subjected to sedimentological analysis (Fig. 5; Appendix 15). The composition of mixed siliciclastic-carbonate rocks of the Adze, Blidene and Mossen formations was determined by different methods. The carbonate component of the samples with an initial weight of 20–50 g was dissolved in dilute (3.5%) hydrochloric acid. Insoluble residue was fractionated by gravity sedimentation and sieving into the fractions of <2, 2–8, 8–16, 16–63 and >63 μm.

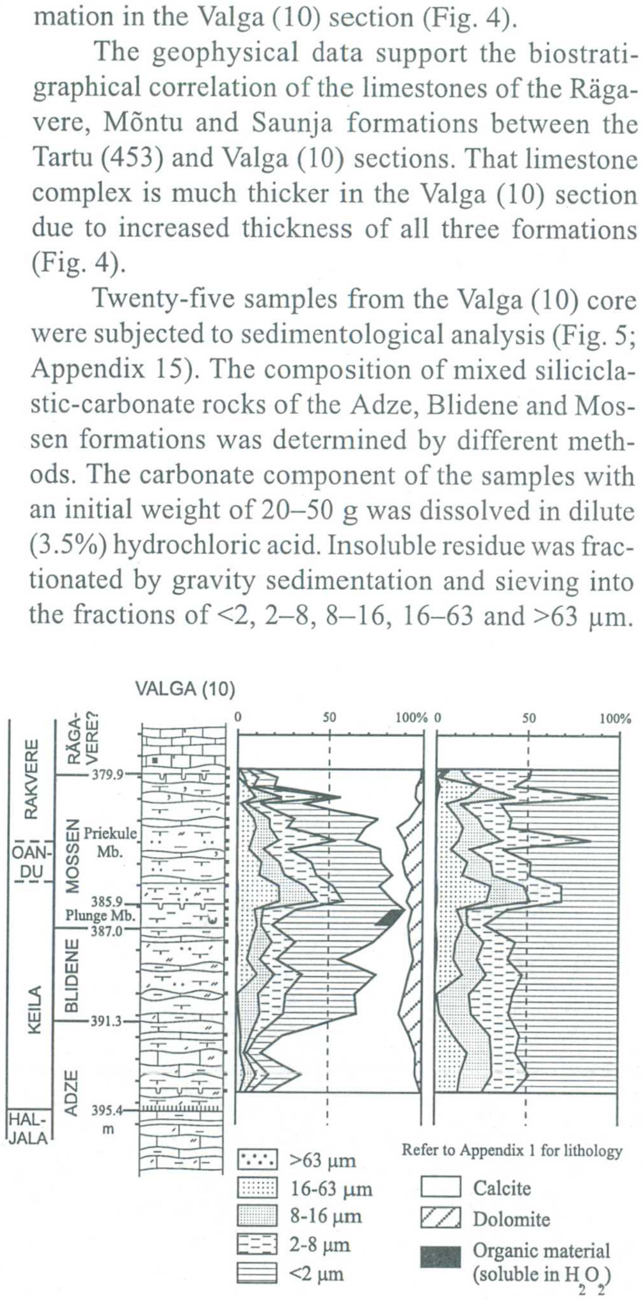


Fig. 5. Grain-size composition of noncarbonate material and carbonate mineralogy of rock (left side of the graph) and insoluble residue (right side of the graph) in the Valga (10) section.

Insoluble residues of two argillite samples of the Plunge Member were treated with H_2O_2 to remove organic material prior to granulometric analysis. Semiquantitative data on the mineralogical composition of the carbonate component in the whole-rock samples were obtained by X-ray diffraction (XRD) using the DRON-3M diffraction system (Mn-filtered Fe-Ka radiation). Calcite 3.04 Å and dolomite 2.89 Å XRD peak intensities were corrected with the proportional factors 0.7 and 0.6, respectively, for calculating the calcite/dolomite ratio. The same data were used by Ainsaar & Meidla (2001) as comparative material in characterizing the sediments of the lithofacially transitional zone in southern and central Estonia.

The Caradoc rocks of the Valga (10) section are rich in siliciclastic material, mainly mud (clay and silt). Some types of rock are predominantly siliciclastic, with minor carbonate content (<30%; Blidene, Mossen and Fjäcka formations). The content of dolomite in the rocks of mixed composition is in positive correlation with the content of noncarbonate material; in some samples of the Mossen Formation dolomite is prevailing over calcite (Fig. 5). The insoluble residue of wackestones of the Adze Formation contains about 50% clay fraction (<2 μm; mainly illite), 30–40% fine silt (2–16 μm), and 10–20% medium and coarse silt (16–63 μm; quartz and K-feldspar). The Blidene Formation in the Valga (10) section is composed mainly of clay and fine silt with a low content of medium and coarse silt (16–63 μm; 0–20%; Fig. 5).

The loss on ignition of organic-rich argillite of the Plunge Member was 4.3–7.5% at a temperature of 450°C and 5.3–8.8% at 550°C (data from three samples). The content of the material soluble in H_2O_2 was 5–9% in the same samples (Klaos, unpublished term paper 1999). The values 4–9% reflect the upward increasing content of organic material in that argillite in the Valga (10) section. The mineral insoluble residue fraction of the organic-rich argillite and carbonaceous clay of the Mossen Formation contains generally less than 20% medium and coarse silt and less than 1% sand. Only in the lowermost bed of the Priekule Member the content of the medium and coarse silt fraction reaches 25–30% of the total insoluble residue (Fig. 5). The content and composition of noncarbonate material in the rocks of the Rägavere Formation are typical of pure micritic limestones.

In the facies profile the marl, claystone and siltstone beds of the Variku Formation (e.g. in the Tartu (453) section) grade in the southern (offshore) direction into organic-rich claystones (Plunge Member) or pure claystones (Priekule Member). The higher content of medium and coarse silt in the lower part of the Priekule Member in the Valga (10) section may reflect the offshore extension of increased silt input in late Keila time. The sedimentation of organic-rich mud (Plunge Member) within the Livonian Tongue in Keila time can be explained as an episode of flooding after the regression. In the case of a transgression, it could be taken as an evidence of stratification of the sea. The lower boundary of the Mossen Formation and approximately the correlative lower boundary of the Variku Formation can be regarded as a transgressive surface which grades into an unconformity in northern Estonia and serves as a sequence boundary in this area (Ainsaar & Meidla, 2001).

REFERENCES

Ainsaar, L. & Meidla, T. 2001. Facies and stratigraphy of the middle Caradoc mixed siliciclastic-carbonate sediments in eastern Baltoscandia. *Proc. Estonian Acad. Sci. Geol.*, **50**, 1, 5–23.

Ainsaar, L., Kirsimäe, K. & Meidla, T. 1996. Regression in Caradoc: evidences from southwestern Estonia (Ristiküla core). *Geol. Surv. Denm. Greenl. Rep.*, 98, 5–12.

Ainsaar, L., Meidla, T. & Martma, T. 1999. Evidence for a widespread carbon isotopic event associated with late Middle Ordovician sedimentological and faunal changes in Estonia. *Geol. Mag.*, **136**, 1, 49–62.

Barrick, J. E. 1986. Conodont faunas of the Keel and Cason formations. In: Amsden, T. W. & Barrick, J. E. (eds). Late Ordovician–Early Silurian strata in the Central United States and the Hirnantian Stage. *Oklahoma Geol. Surv. Bull.*, **139**, 57–89.

Bauert, G. & Bauert, H. 1998. Distribution of chitinozoans in the Tartu (453) core. Appendix 14. In: Männik, P. (ed.). *Tartu (453) drillcore. Estonian Geol. Sections*, **1**.

Bergström, S. M. 1971. Conodont biostratigraphy of the Middle and Upper Ordovician in Europe and eastern North America. *Geol. Soc. Am. Mem.*, **127**, 83–157.

Bjørlykke, K. 1989. *Sedimentology and petroleum geology*. Springer-Verlag, Berlin, 363 pp.

Byström, A. M. 1956. Mineralogy of the Ordovician bentonite beds at Kinnekulle, Sweden. *Sver. Geol. Undersökn. Ser. C*, **540**, 1–62.

Dunham, R. J. 1962. Classification of carbonate rocks according to depositional texture. In: Ham, W. E. (ed.). *Classification of carbonate rocks. AAPG Mem.*, **1**, 108–121.

Dzik, J. 1978. Conodont biostratigraphy and paleogeographical relations of the Ordovician Mojcza limestone (Holy Cross Mts., Poland). *Acta Palaeont. Polonica*, **23**, 51–72.

Dzik, J. 1994. Conodonts of the Mojcza Limestone. In: Dzik, J., Olempska, E. & Pisera, A. (eds). Ordovician carbonate platform ecosystems of the Holy Cross Mountains. *Palaeont. Polonica*, **53**, 43–128.

Epstein, A. G., Epstein, J. B. & Harris, L. D. 1977. Conodont color alteration – an index to organic metamorfism. *U.S. Geol. Surv. Prof. Pap.*, **995**, 1–27.

Hints, L., Meidla, T., Nõlvak, J. & Sarv, L. 1989. Some specific features of the Late Ordovician evolution in the Baltic Basin. *Proc. Estonian Acad. Sci. Geol.*, **38**, 83–87.

Hints, L., Oraspõld, A. & Kaljo, D. 2000. Stratotype of the Porkuni Stage with comments on the Röa Member (uppermost Ordovician, Estonia). *Proc. Estonian Acad. Sci. Geol.*, **49**, 3, 177–199.

Hints, O. 1998. Late Viruan (Ordovician) polychaete jaws from North Estonia and the St. Petersburg region. *Acta Palaeont. Polonica*, **43**, 471–516.

Hints, O. 1999. Two new polychaete families from the Upper Ordovician of Estonia. *Palaeontology*, **42**, 897–906.

Hints, O. 2001. Ordovician eunicid polychaetes of Estonia and surrounding areas: a review of their distribution and diversification. *Rev. Palaeobot. Palynol.*, **113**, 41–55.

Hints, O. & Nõlvak, J. 1999. Proposal for the lower boundary-stratotype of the Keila Regional Stage (Upper Ordovician). *Proc. Estonian Acad. Sci. Geol.*, **48**, 3, 158–165.

Jaanusson, V. 1995. Confacies differentiation and upper Middle Ordovician correlation in Baltoscandian basin. *Proc. Estonian Acad. Sci. Geol.*, **44**, 2, 73–86.

Kajak, K. 1997. Upper Devonian. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 121–123.

Kajak, K., Kajak, H., Kivisilla, J., Pastuhova, A., Petersell, V., Puura, V., Saadre, T. & Remmel, P. 1974. Otčet južno-estonskogo otrjada o kompleksnoj geologo-gidrogeologičeskoj s"emke masštaba 1:200 000 jugo-vostočnoj časti Éstonii i zapadnoj okrainy Pskovskoj oblasti (list O-35-XVI) za 1970–1973 gg. Unpublished report of the Geological Survey of Estonia, Keila, 472 pp. [In Russian].

Kaljo, D., Nõlvak, J. & Uutela, A. 1996. More about Ordovician microfossil diversity patterns in the Rapla section, Northern Estonia. *Proc. Estonian Acad. Sci. Geol.*, **45**, 3, 131–148.

Kaljo, D., Hints, L., Martma, T. & Nõlvak, J. 1998. Refinements of carbon isotope stratigraphy in the latest Ordovician of Estonia. *Mineral. Mag.*, 62 A, 740–741.

Kepezhinskas, K., Laškovas, J. & Šimkevičius, P. 1994. The Ordovician metabentonites of the Baltic region as a reflection of volcanic activity in the Iapetus palaeoocean and Tornquist Sea. *Geologija, Vilnius*, **16**, 34–42.

Kielan-Jaworowska, Z. 1966. Polychaete jaw apparatuses from the Ordovician and Silurian of Poland and comparison with modern forms. *Palaeont. Polonica*, **16**, 1–152.

Kiipli, T., Kiipli, E. & Kallaste T. 1997. Metabentonite composition related to sedimentary facies in the Lower Silurian of Estonia. *Proc. Estonian Acad. Sci. Geol.*, **46**, 93–104.

Kleesment, A. 1994. Subdivision of the Aruküla Stage on the basis of the lithological and mineralogical criteria. *Proc. Estonian Acad. Sci. Geol.*, **43**, 2, 57–68.

Kleesment, A. 1995. Lithological characteristics of the uppermost terrigenous Devonian complex in Estonia. *Proc. Estonian Acad. Sci. Geol.*, **44**, 4, 221–233.

Kleesment, A. 1998. Authigenic overgrowths of detrital feldspar grains in the Devonian sequence of the East Baltic. *Proc. Estonian Acad. Sci. Geol.*, **47**, 4, 229–241.

Kleesment, A. & Mark-Kurik, E. 1997. Devonian. Lower Devonian. Middle Devonian. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 107–121.

Kleesment, A. & Valiukevičius, J. 1998. Devonian. In: Männik, P. (ed.). *Tartu (453) Drillcore. Estonian Geol. Sections*, 1, 17–18.

Liibert, S. A., Gromov, O. B., Välkman, S. A., Kupcov, L. N., Perens, H. E. & Širokov, V. E. 1986. Otčet o poiskah i predvaritel'noj razvedke podzemnyh vod dlja vodosnabženija g. Valga (s podsčetom ékspluatacionnyh zapasov podzemnyh vod po sostojaniju 01. 01.1987 g.) Unpublished report of the Geological Survey of Estonia, Keila, 440 pp. [In Russian].

Ljarskaja, L. & Kleesment, A. 1981. Rēzekne svita. In: Sorokin, V. S. (ed.) *Devon i karbon Pribaltiki*. Zinatne, Riga, 66–79. [In Russian].

Loog, A. & Oraspõld, A. 1982. *Settekivimite ja setete (setendite) uurimismeetodid*. TRÜ geoloogia kateeder, Tartu, 83 pp. [In Estonian].

Männik, P. 1992. *Upper Ordovician and Lower Silurian conodonts in Estonia. Doctoral thesis at the University of Tartu. Abstracts*. Tartu, 50 pp.

Männil, R. 1966. *Evolution of the Baltic basin during the Ordovician*. Valgus, Tallinn, 200 pp. [In Russian with English summary].

Männil, R. 1976. Distribution of graptoloids in the Ordovician carbonate rocks of the East Baltic area. In: Kaljo, D. & Koren, T. (eds). *Graptolites and stratigraphy*. Tallinn, 105–118. [In Russian with English summary].

Männil, R. 1986a. Stratigraphy of kukersite-bearing deposits C_Ib-C_{III}. In: Puura, V. (ed.). *Geology of the kukersite-bearing beds of the Baltic oil shale basin*. Tallinn, Valgus, 12–24. [In Russian with English summary].

Männil, R. M. 1986b. Ordovik. In: Kaljo, D. L. & Viiding, H. A. (eds). *Istorija geologičeskih nauk*. Valgus, Tallinn, 49–64. [In Russian].

Männil, R. & Meidla, T. 1994. The Ordovician System of the East European Platform (Estonia, Latvia, Lithuania, Byelorussia, parts of Russia, the Ukraine and Moldova). In: Webby, B. D., Ross, R. J. & Zhen, Y. Y. (eds). *The Ordovician System of the East European Platform and Tuva (Southeastern Russia). Correlation charts and explanatory notes. IUGS Publ.*, **28**, 52 pp.

Meidla, T. 1996. Late Ordovician ostracodes of Estonia. *Fossilia Baltica*, **2**, Tallinn, 222 pp.

Meidla, T., Ainsaar, L., Hints, L., Hints, O., Martma, T. & Nõlvak, J. 1999. The mid-Caradocian biotic and isotopic event in the Ordovician of the East Baltic. *Acta Univ. Carolinae Geol.*, **43**, 1/2, 503–506.

Modlinski, Z. 1982. Rozwoj litofacjalny i paleotektoniczny ordowiku na obszarze platformy prekambryjskiej w Polsce. *Prace Inst. Geol*, **52**, 66 pp. [In Polish].

Nestor, V. 1994. Early Silurian chitinozoans of Estonia and North Latvia. *Academia*, **4**,. Estonian Academy Publishers, Tallinn, 163 pp.

Nestor, H. & Einasto, R. 1997. Ordovician and Silurian carbonate sedimentation basin. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 192–204.

Nõlvak, J. 1980. Chitinozoans in biostratigraphy of the northern East Baltic Ashgillian. A preliminary report. *Acta Palaeont. Polonica*, **25**, 2, 253–260.

Nõlvak, J. 1997. Ordovician. Introduction. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 52–55.

Nõlvak, J. 1999a. Ordovician chitinozoan biozonation of Baltoscandia. *Acta Univ. Carolinae. Geol.*, **43**, 287–290.

Nõlvak, J. 1999b. Distribution of chitinozoans. In: Põldvere, A. (ed.). *Taga-Roostoja (25A) drill core. Estonian Geol. Sections*, **2**, 10–12.

Nõlvak, J. & Grahn, Y. 1993. Ordovician chitinozoan zones from Baltoscandia. *Rev. Palaeobiol. Palynol.*, **79**, 245–269.

Nõlvak, J., Grahn, Y. & Sturkell, E. E. F. 1999. Chitinozoan biostratigraphy of the Middle Ordovician Dalby Limestone in the Fjäcka section, Siljan District, Sweden. *Proc. Estonian Acad. Sci. Geol.*, **48**, 2, 75–85.

Oraspõld, A. 1975. Lithology of the Pirgu Stage in South Estonia. *Acta Comment. Univ. Tartuensis*, 359, 14–32. [In Russian with English summary].

Orville, P. M. 1967. Unit cell parameters of the microcline – low-albite and the sanidine high albite solid solution series. *Amer. Mineralogist*, **52**, 55–86.

Paris, F., Verniers, J., Achab, A., Albani, R., Ancilleta, A., Asselin, E., Brocke, R., Chen, X., Fatka, O., Grahn, Y., Molyneux, S., Nõlvak, J., Samuelsson, J., Sennikov, N. V., Soufiane, A., Wang, X. & Wincester-Seeto, T. 1999. Correlation of Ordovician regional chitinozoan biozonations. *Acta Univ. Carolinae. Geol.*, **43**, 291–294.

Paškevičius, J. 1994. Ordovikas. In: Grigelis, A. & Kadunas, V. (eds). *Lietuvos Geologija*. Mokslo ir Enciklopediju Leidykla, Vilnius, 46–67. [In Lithuanian].

Paškevičius, J. 1997. *The geology of the Baltic Republics*. Lietuvos geologijos tarnyba, Vilnius, 387 pp. [In Lithuanian].

Pettijohn, F. J. 1949. *Sedimentary rocks*. New York, 526 pp.

Pettijohn, F. J., Potter, P. E. & Siever, R. 1987. *Sand and sandstone*. New York, 553 pp.

Puura, V. & Vaher, R. 1997. Cover structure. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 167–177.

Põldvere, A., Saadre, T. & Kleesment, A. 1996. Tugiläbilõigete täienduurimine. Unpublished report of the Geological Survey of Estonia, Tartu, 232 pp. [In Estonian].

Põldvere, A. 1998. General geological setting. In: Männik, P. (ed.). *Tartu (453) drillcore. Estonian Geol. Sections*, **1**, 6–7.

Põldvere, A. & Kleesment, A. 1998. Basic concepts and methodology. Description and terminology. In: Männik, P. (ed.). *Tartu (453) drillcore. Estonian Geol. Sections,* **1**, 7–10.

Põldvere, A., Kleesment, A., Mens, K., Meidla, T., Kiipli, T. & Männik, P. 1999a. Tugiläbilõigete täienduurimine. III etapp. Unpublished report of the Geological Survey of Estonia, Tartu, 202 pp. [In Estonian].

Põldvere, A., Mens, K. & Koppelmaa, H. 1999b. General geological setting. In: Põldvere, A. (ed.). *Taga-Roostoja (25A) drill core. Estonian Geol. Sections*, **2**, 5–8.

Põlma, L. 1982. *Comparative lithology of the Ordovician carbonate rocks in the Northern and Middle East Baltic*. Valgus, Tallinn, 164 pp. [In Russian with English summary].

Sarv, L. 1959. Ordovician ostracodes in the Estonian S.S.R. *ENSV TA Geol. Inst. Uurimused*, 4, 1–207. [In Russian with English summary].

Schallreuter, R. 1980. Ostrakoden aus dem Sularpschiefer (Mittelordoviz) von Schonen (Schweden). *Palaeontographica*, A, **169**, 1–27.

Sidaravičiene, N. 1992. *Ostrakody ordovika Litvy*. Vilnius, 252 pp. [In Russian].

Sidaravičiene, N. 1996. *Lietuvos Ordovikos ostrakodai, stratigrafija*. Geologijos Institutas, Vilnius, 81 pp. [In Lithuanian].

Skoglund, R. 1963. Uppermost Viruan and Lower Harjuan (Ordovician) stratigraphy of Västergötland and Lower Harjuan graptolite faunas of Central Sweden. *Bull. Geol. Inst. Univ. Uppsala*, **42**, 1–55.

Szaniawski, H. 1996. Scolecodonts. In: Jansonius, J. & McGregor, D. C. (eds). *Palynology: Principles and applications,* Vol. 1. AASP, 337–354.

Švanov, V. 1969. *Pesčanye porody i metody izučenija*. Nedra, Leningrad, 248 pp. [In Russian].

Ulst, R. Zh. 1972. Local subdivision chart of the Upper Ordovician in the central East Baltic area. In: *Regional'naja geologija Pribaltiki i Belorussii*. Riga, 7–19. [In Russian with English summary].

Ulst, R. Zh., Gailite, L. K. & Jakovleva, V. I. 1982. *Ordovik Latvii*. Zinatne, Riga, 294 pp. [In *Russian]*.

Valiukevičius, J. 1994. Acanthodian zonal sequence of Early and Middle Devonian in the Baltic Basin. *Geologia, Vilnius*, **17**, 115–125.

Valiukevičius, J. 1998. Acanthodians and zonal stratigraphy of Lower and Middle Devonian in East Baltic and Byelorussia. In: *Sonder-Abdruck aus Palaeontographica*, Abt. A, Bd. 248, Stuttgart, 1–53.

Valiukevičius, J. J., Kleesment, A. E., Kurik, E. J. & Vaitekunene, G. K. 1986. Correlation and organic remains in the deposits of the Narva Regional Stage. In: Brangulis, A. P. (ed.). *Biofacies and fauna of the Silurian and Devonian basins of the Baltic*. Zinatne, Riga, 73–86. [In Russian].

Viira, V. 1974. *Ordovician conodonts of the East Baltic*. Valgus, Tallinn, 140 pp.

Viira, V. & Männik, P. 1999. Distribution of conodonts. In: Põldvere, A. (ed.). *Taga-Roostoja (25A) drill core. Estonian Geol. Sections*, **2**, 9–10.

Vingisaar, P. & Murnikova, T. 1973. New data on mineralogy of some Lower Caradocian metabentonites of Estonia. *Proc. Estonian Acad. Sci. Chem. Geol.*, **22**, 2, 149–158. [In Russian].

Vingisaar, P., Oraspõld, A., Einasto, R. & Jürgenson, E. 1965. *Karbonaatkivimite ühtne klassifikatsioon ja legend*. Tallinn, 49 pp. [In Estonian and in Russian].

APPENDIX 1

DESCRIPTION OF THE VALGA (10) CORE

The description is given in a standardized form. The tables are divided into vertical columns based on the type of information. The values occurring rarely are given in parentheses.

STANDARD UNITS — Chronostratigraphic units.

LOCAL STRATIGRAPHIC UNITS — Stages, substages, formations and members.

CORE BOX NO./FIGURES — Numbers of boxes, location of the intervals of core illustrated (Plates 1–4).

DEPTH/SAMPLES — Depth of the boundaries and sampling levels: C, conodonts; Ch, chitinozoans; S, scolecodonts; O, ostracodes; Ac, acanthodians; M, mineralogical samples; G, granulometric samples; X, X-ray diffractometry samples; I, insoluble residues, T, thin sections. For the intervals with poor core yield, differently interpreted depths are given in parentheses; the corresponding depths are shown by the line connecting the sampled levels.

LITHOLOGY — For legend see next page. The core section is given at a scale of 1:200.

SEDIMENTARY STRUCTURES — Bedding, thickness of beds: micro- (< 0.2 cm), thin- (0.2–2.0 cm), medium- (2–10 cm) and thick-bedded (10–50 cm); massive – visible bedding is missing.

MARL BEDS — The most frequent thicknesses of the marl beds; in parentheses – infrequent thicknesses. Colours were identified on damp core. Contacts between marl and other types of rock may be distinct (D) or indistinct (IND).

MARL PERCENTAGE — The content of marl beds in the described interval was estimated visually.

SHORT DESCRIPTION — The colour of rocks was identified on damp core; the dominant size of crystals (in italics) was estimated visually: cryptocrystalline < 0.005 mm; microcrystalline 0.005–0.01 mm; very finely crystalline 0.01–0.05 mm; finely crystalline 0.05–0.1 mm and medium-crystalline 0.1–1 mm. Clastic fractions (size of particles; also in italics) are described as follows: clay < 0.005 mm; fine silt 0.005–0.01 mm; coarse silt 0.01–0.05 mm; very fine sand 0.05–0.1 mm; fine sand 0.1–0.25 mm; medium sand 0.25–0.5 mm and coarse sand 0.5–1.0 mm. The percentage of allochems, e.g. bioclasts, intraclasts, ooliths and pellets, is also indicated. Main types of rocks are in bold. In descriptions also the rock types according to Dunham (1962) are given (in parentheses).

Selected intervals of the Valga (10) core

(depth increases from left to right)

Fig. 1. **Burtnieki Formation (Härma Member)**; 63.4—65.5 m.

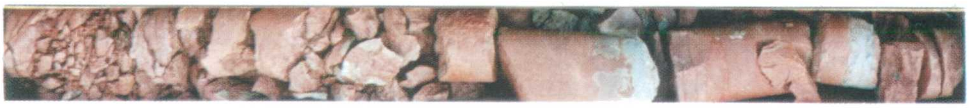


Fig. 2. **Aruküla Formation (Tarvastu Member)**; 85.5—87.0 m.

↑ 99.0

Fig. 3. **Aruküla Formation (Kureküla Member)**; 98.7—101.0 m.

↑ 112.2

Fig. 4. **Aruküla Formation (Viljandi to Kureküla members)**; 109.0—112.6 m.

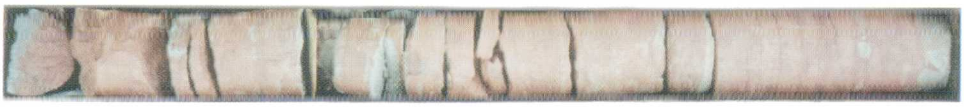


Fig. 5. **Aruküla Formation (Viljandi Member)**; 129.6—130.6 m.

↑ 142.2

Fig. 6. **Gorodenka Formation**; 141.6—142.8 m.

↑ 160.8

Fig. 7. **Leivu Formation**; 160.2—161.2 m.

↑ 171.8

Fig. 8. **Leivu Formation**; 171.2—172.2 m.

Fig. 9. **Leivu Formation**; 184.1—185.2 m.

Plate 2

Selected intervals of the Valga (10) core

(depth increases from left to right)

Fig. 10. **Leivu Formation**; 198.2—199.2 m.

Fig. 11. **Leivu Formation**; 206.3—207.4 m.

Fig. 12. **Vadja Formation**; 223.0—224.0 m.

Fig. 13. **Vadja Formation**; 227.0—228.1 m.

Fig. 14. **Vadja Formation**; 231.8—233.2 m.

Fig. 15. **Pärnu Formation (Tamme Member)**; 254.7—256.5 m.

Fig. 16. **Pärnu Formation (Tori Member)**; 279.6—281.0 m.

Fig. 17. **Mehikoorma Formation**; 289.3—291.0 m.

Fig. 18. **Õhne to Mehikoorma formations**; 298.2—305.3 m.

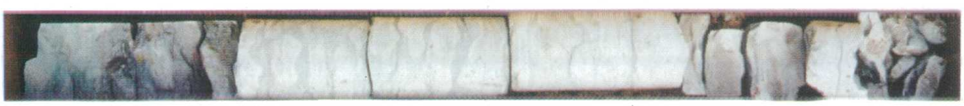


Fig. 19. **Õhne Formation (Rūja to Rozēni members)**; 305.3—306.6 m.

Selected intervals of the Valga (10) core

(depth increases from left to right)

Fig. 20. **Õhne Formation (Puikule to Rūja members)**; 310.9—311.9 m.

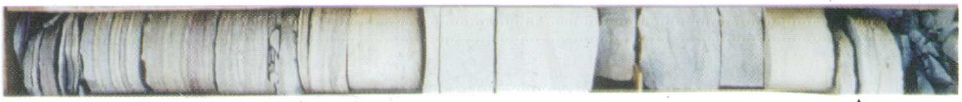


Fig. 21. **Kuldiga to Saldus formations (Ēdole to Broceni members)**; 313.9—314.9 m.

Fig. 22. **Kuldiga Formation (Ēdole Member)**; 317.3—318.3 m.

Fig. 23. **Kuldiga Formation (Ēdole Member)**; 321.3—322.3 m.

Fig. 24. **Kuili Formation**; 325.3—326.3 m.

Fig. 25. **Paroveja to Kuili formations**; 331.3—332.3 m.

Fig. 26. **Jelgava to Paroveja formations**; 332.3—333.3 m.

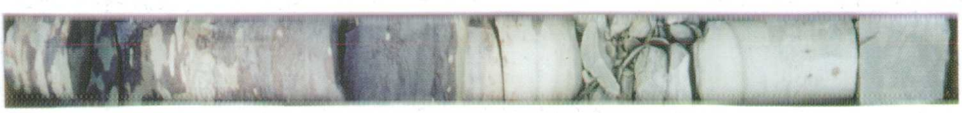


Fig. 27. **Jelgava Formation**; 339.2—340.2 m.

Fig. 28. **Jelgava Formation**; 348.2—349.2 m.

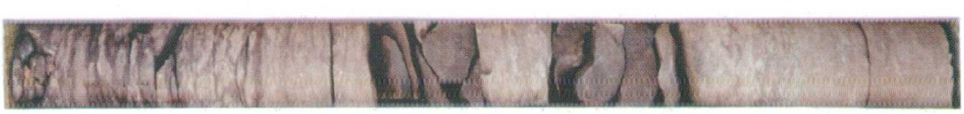


Fig. 29. **Jonstorp Formation**; 353.2—354.2 m.

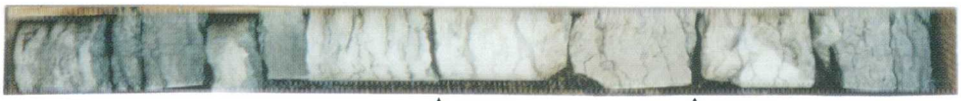
Plate 4

Selected intervals of the Valga (10) core

(depth increases from left to right)

363.4 ↑ ↑ 365.7

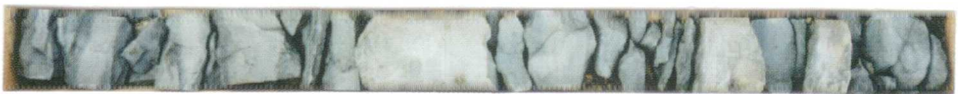
Fig. 30. **Saunja to Jonstorp formations**; 363.1—366.7 m.



↑ 373.2 ↑ 373.5

Fig. 31. **Rägavere to Mõntu formations**; 372.7—373.7 m.

Fig. 32. **Rägavere Formation**; 374.7—375.6 m.



↑ 383.0

Fig. 33. **Mossen Formation (Priekule Member)**; 382.7—383.7 m.

↑ 384.9

Fig. 34. **Mossen Formation (Priekule Member)**; 384.7—385.6 m.

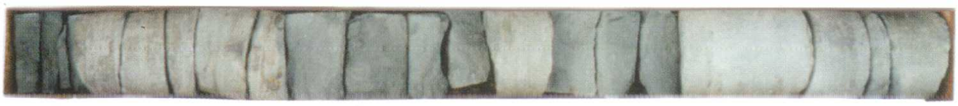


Fig. 35. **Blidene Formation**; 387.6—388.6 m.

Fig. 36. **Adze Formation**; 396.7—397.7 m.

Fig. 37. **Dreimani Formation**; 406.5—407.5 m.

Fig. 38. **Taurupe Formation**; 413.4—414.4 m.

↑ 421.1

Fig. 39. **Stirnas to Taurupe formations**; 420.5—421.5 m.

Appendix 1 continued

LEGEND

- cultivated soil
- till
- limestone
- argillaceous limestone
- dolomitic limestone
- dolostone
- argillaceous dolostone
- silty dolostone
- marl (in general)
- dolomitic marl (in general)
- claystone
- silty claystone
- siltstone
- argillaceous siltstone
- sandstone
- dolomitic sandstone
- K-bentonite band
- breccia

skeletal limestones:

- grains 10 - 25% (wackestone)
- grains 25 - 50% (packstone)
- crypto- and microcrystalline (aphanitic) limestone (a) and dolostone (b)
- fine bioclasts, pyritized
- coarse bioclasts, pyritized
- horizontal bedding; thin- (a), medium- (b) and thick-bedded (c)
- wavy bedding
- nodular
- thin intercalation
- nodules with distinct (a) or indistinct (b) contacts
- discontinuity surfaces
- number of discontinuity surfaces
- mud-cracks
- slickensides
- caverns
- porous
- burrows
- pyritic mottles

- ooliths
- intraclasts
- sandstone globules
- glauconite grains
- pyrite
- galena
- limonite
- dolomite
- calcite
- gypsum
- micas (in general)
- mottled, red-coloured and yellow streaks
- stromatolites
- brachiopods
- trilobites
- cephalopods
- echinoderms
- rugosae
- graptolites
- fishes
- lingulates

DESCRIPTION OF THE VALGA (10) CORE

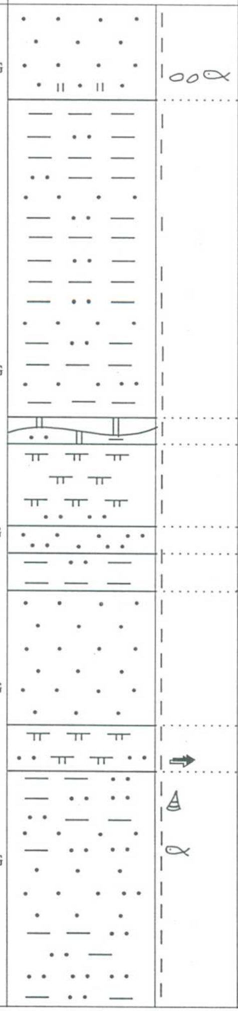
Location: latitude 57° 48.24', longitude 26° 04.65'. Length of the core 424.0 m. Elevation of the top above sea level 46.68 m.

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Pleistocene, Quaternary		1		0.0–1.2						Cultivated soil cover (thickness 0.3 m) is underlain by sandy soil
				1.2–2.0						Pinkish yellow, *very fine* **sand** with little gravel
				2.0–7.7			Irregularly horizontal, microbedded (Core yield 10%)			Greyish brown **clay** and **silt**
				7.7–16.0			! (Core yield 2%)			**Till**, represented by only few cobbles and pebbles
				16.0–35.0		core is missing	! (Core yield 0.5%)			
				35.0–			! (Core yield 5%)			Loamy sand **till**, with pebbles and cobbles of crystalline rocks. In the lower part carbonate clasts

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Pleistocene, Quaternary		1								☞ follow up
Givetian	Burtnieki Stage Burtnieki Formation Härma Member	2		54.0	Ac MG		Horizontal thin-bedded			Greenish grey, sandy, mostly medium-cemented **siltstone**. Basal 0.7 m purplish to greenish grey and reddish brown mottled, with argillaceous interbeds
				55.5			Horizontal bedding			Reddish brown and violet mottled, in the lower part brick-red and greenish grey, silty (especially in the interval of 58.0-59.5 m and in the lower part) **claystone**
			1	63.0	MG		Inclined parallel thin-bedding, in places platy			Brown, with violet shade, in the upper part greenish grey, *very fine-grained* **sandstone**, with reddish brown silty **claystone** interbeds, containing greenish grey pockets. The lower boundary is marked with a 0.1 m thick greenish grey silty sandstone bed
				68.0						

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Eifelian	Aruküla Stage, Aruküla Formation, Tarvastu Member	3		68.0	Ac MG		Indistinctly nodular			Intercalation of reddish brown, with greenish grey partings **siltstone** and greenish grey **sandstone**. **Siltstone** is medium- to strongly cemented, **sandstone** medium-cemented, with strongly cemented globules (diameter 2-3 cm). Upper 0.2 m is silty **claystone**
				69.3			Conglomeratic			Purplish red **quartz sandstone**, with dolomitic cement. Diameter of clasts 1-2 cm
				69.5			Massive or indistinctly bedded			Greenish grey and reddish brown mottled silty **claystone**. Greenish grey interbeds are sandy
				73.0	MG		Indistinctly bedded, in places nodular			Intercalation of reddish brown mottled silty **claystone**, greenish grey to brown **siltstone** and greenish grey or purplish to greenish brown **sandstone**. At 73.6-74.3 m occurs purplish red (with strong dolomitic cement) **siltstone**, with greenish grey pockets and burrows. Branching burrows often look like syneresis cracks. **Sandstone** is medium- to strongly cemented, with strongly cemented sandstone globules
		4		78.5	MG		Indistinct or inclined bedding			Purplish red *fine-grained* **sandstone** containing interbeds with strongly cemented sandstone globules. Muscovite flakes occur along bedding surfaces. Gamma logging showed the presence of **claystone** interbeds
			2	82.5	Ac MG		Massive, in the lower part platy			Reddish brown, in places greenish grey mottled, irregularly cemented, silty **claystone**, with interbeds (thickness to 10 cm) and pockets of greenish grey **sandstone**
		5		88.0	Ac MG		Horizontal, indistinctly bedded			Light greenish grey, medium-cemented **sandstone**. Muscovite flakes occur along bedding surfaces
	Kureküla Mb.			90.0–94.0			Inclined, parallel thin-bedding, in places rubbly			Reddish brown silty **claystone**, containing pockets and interbeds of greenish grey **siltstone** and **sandstone**. Interbeds are common in the middle part

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Eifelian	Aruküla Stage, Aruküla Formation, Kureküla Member	6		94.0–99.0	MG		Horizontal thin-bedded (in places platy), in the lower part in places inclined			Purplish red, in the upper part greenish grey, *fine- and very fine-grained* **sandstone**, medium- to weakly, in the upper 0.25 m strongly cemented. Micaceous flakes occur along bedding surfaces. The interval of 94.25-94.50 m is reddish brown, platy **siltstone**
		7	3	99.0–101.0	AcGM		Wavy bedding, in places platy			Reddish brown, in the lower part varicoloured and silty **claystone**, containing few greenish grey **siltstone** interbeds. In the lower part strongly cemented
				101.0–102.0			Massive			Pale yellow to greenish grey mottled silty **dolostone**, with reddish grey argillaceous interbeds. In **dolostone** occur rare vugs
				102.0–107.0	MG		Indistinctly thin-bedded, sandstone indistinctly inclined			Intercalation of reddish brown, with greenish grey patches, in places yellowish grey mottled, argillaceous **siltstone** and reddish brown *very fine-grained* **sandstone**. **Siltstone** is medium- to strongly cemented, with interbeds of silty **claystone**. Content of sandy material increases downwards. **Sandstone** is medium- to weakly cemented. In the upper part thin silty **claystone** interbeds occur
				107.0–108.0			Indistinctly wavy			Reddish brown **claystone**, with greenish grey pockets and interbeds of **siltstone** and **sandstone**
		8	4	108.0–112.2	AcMG		Wavy thin-bedded			Intercalation of reddish brown **sand- and siltstone**, medium-cemented, with conglomerate interbeds in the upper and the lower part. Diameter of clasts is 1-3 mm. Middle part is a purplish grey **claystone** interbed
	Aruküla Stage, Aruküla Formation, Viljandi Member			112.2–114.0			Massive			Reddish brown **claystone**, in places purplish grey mottled, with some greenish grey silty interbeds
				114.0–115.2	Ac MG		Horizontal, wavy or inclined bedding			Reddish brown, in the upper part greenish grey and clayey, *fine-grained* **sandstone**. On bedding surfaces are mica flakes and clay films. At 114.3-114.5 m occurs yellowish grey **dolostone**, with red **claystone** interbeds
				115.2–117.7			Horizontal (thick-) bedded, in places rubbly			Greyish violet **dolomitic marl**, with reddish brown interbeds. At 116.5-116.6 m occurs greenish grey argillaceous **dolostone**
		9		117.7–120.5			Horizontal (thick-) bedded			Greenish grey, in the upper part argillaceous **siltstone**, with sandstone interbeds. Basal 0.5 m is **claystone**, with greenish grey and reddish brown **siltstone** interbeds



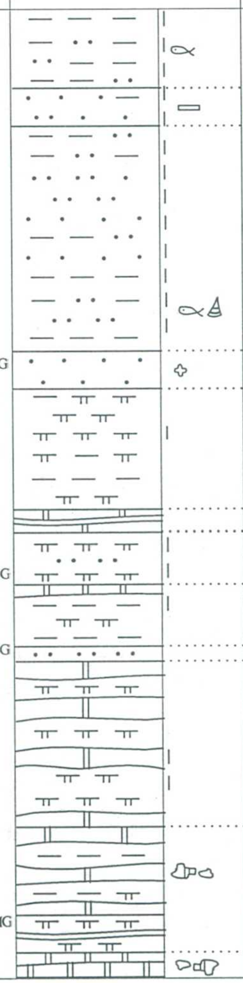
STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Eifelian	Aruküla Stage Aruküla Formation Viljandi Member	9		120.5–123.0	Ac MG		Horizontal thin-bedded			Reddish brown, weakly to medium-cemented **sandstone**. In the lower part dolomite-cemented and with conglomeratic interbeds
		10	5	123.0–131.4	Ac MG		Horizontal and wavy bedding			Reddish brown, with yellowish interbeds and patches, silty **claystone**, with greenish grey **siltstone** and **sandstone** pockets and wavy interbeds (especially abundant in the lower part)
				131.4–132.1			Wavy bedding			Greenish grey to reddish brown mottled **dolostone**, with silty interbeds
		11		132.1–134.3	MG		Horizontal, in places rubbly			Purplish grey, with yellowish patches, in the lower part greenish grey and reddish brown **dolomitic marl**, in the lower part silty
				134.3–135.0			Horizontal thin-bedded or wavy to lenticular			Greenish to yellowish grey, silty, medium-cemented **sandstone**
				135.0–136.0						Reddish brown **claystone**, with greenish grey **siltstone** and **sandstone** pockets and interbeds. Content of sandy material increases downwards
				136.0–139.6	MG		Horizontal thin-bedded			Reddish brown **sandstone**, medium-cemented
	Narva Stage Kernave Substage Gorodenka Formation			139.6–140.8			Massive			Purplish grey **dolomitic marl**, with reddish brown and greenish grey patches, in the lower part silty. At the top and in the middle part are red **claystone** interbeds, at the base occurs a greenish grey silty **claystone** bed
		12, 13	6	140.8–147.0	MG		Horizontal and wavy planar bedding, sandstone in the upper part platy			Intercalation of reddish brown, in places purplish and greenish grey **sand-, silt- and claystone**. Upper 0.5 m is silty **dolomitic claystone**, followed by clayey **siltstone** (thickness 0.3 m) grading downwards into silty **claystone** with **siltstone** pockets (0.6 m). At 142.2-145.0 m occurs silty **sandstone**, in the lower part medium-cemented, with *very fine-grained* **sandstone** pockets. Underlying silty **claystone** (1.0 m) includes interbeds of **siltstone** and **dolomitic marl**. Basal 1.0 m is clayey **siltstone**

STANDARD UNITS: Eifelian

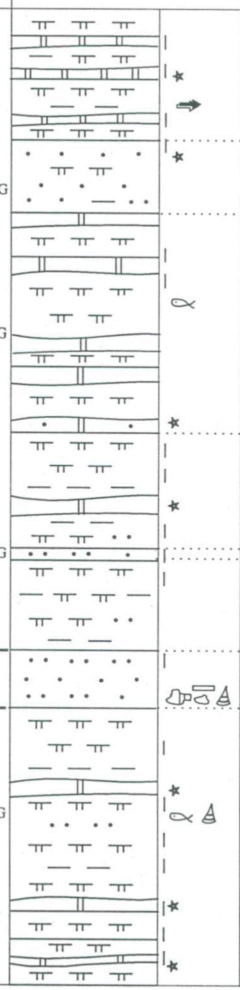
LOCAL STRATIGRAPHIC UNITS: Narva Stage; Kernavė Substage, Gorodenka Formation; Leivu Substage, Leivu Formation

CORE BOX NO.: 13, 14, 15, 16, 17, 18

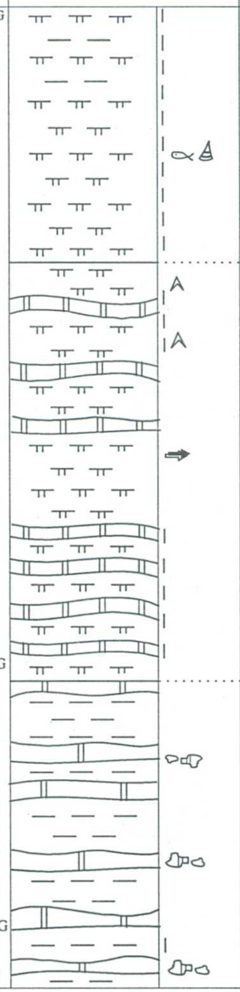
LITHOLOGY



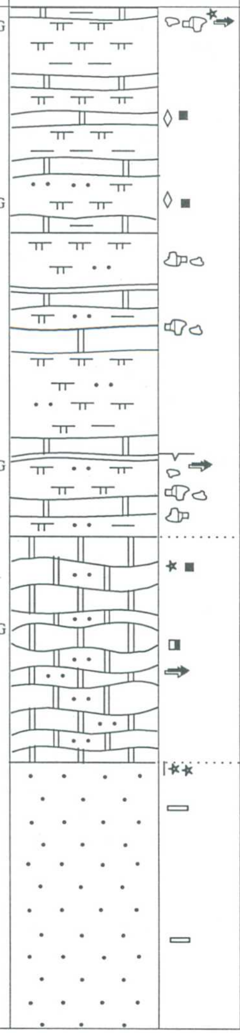
DEPTH (m)	SAMPLES	FIGURES	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
147.0–149.0			Horizontal disrupted thin-bedding			Reddish brown, in places mottled, silty dolomitic **claystone**, with numerous greenish grey **siltstone** interbeds. Upper 0.2 m is violet **dolomitic marl**
149.0–150.0			Horizontal microbedded			Reddish brown, clayey and silty, medium-cemented **sandstone**. On bedding surfaces occur abundant mica flakes and in places clay films
150.0–156.0			Claystone platy, in places massive; siltstone horizontal micro- to thin-bedded			Intercalation of reddish brown, with greenish grey patches and interbeds silty **claystone** and reddish to yellowish brown, medium-cemented sandy **siltstone**. In **claystone** occur few greenish grey clayey **siltstone** interbeds (thickness 1-1.5 cm) and in **siltstone** yellowish brown **sandstone** interbeds. Basal 0.2 m is **dolomitic marl**
156.0–157.0	MG		Wavy bedding			Greenish grey, medium-cemented, *very fine-grained* **sandstone**. In the middle part is a **sandstone** interbed (thickness 20 cm) with strongly cemented globules
157.0–160.2			Indistinctly bedded, in places nodular and rubbly, in the lower part massive; claystone platy			Grey, at 158.2-158.5 m greenish grey and reddish brown mottled, in the upper part argillaceous, **dolomitic marl**. **Claystone** interbed is dark grey to grey
160.2–160.8		7	Wavy to horizontal bedded			Intercalation of dark and greenish grey dolomitic **claystone** and grey argillaceous **dolostone**. In the middle is a 20 cm thick **dolostone** interbed
160.8–162.2	AcMG		Massive, basal part indistinctly bedded			Reddish brown and greenish grey mottled **dolomitic marl**. Basal 0.3 m is grey, argillaceous, with silty interbeds
162.2–163.8	AcMG		Horizontal bedding			Intercalation of pale yellow *aphanitic* **dolostone**, grey **dolomitic marl** and dark grey dolomitic **claystone**. In **dolostone** occur authigenous dolomite-filled cavities (diam. 1-2 mm). In places skeletal debris is found
163.8–164.2			Indistinctly bedded			Grey, strongly dolomite-cemented **siltstone**. Skeletal debris occurs
164.2–168.5			Disrupted wavy bedding or rubbly			Intercalation of grey, in places reddish brown, with greenish grey patches, in the upper part clayey, **dolomitic marl** and grey *aphanitic* **dolostone**
168.5–171.8	MG		Dolostone massive, in places breccia-like, claystone platy and dolomitic marl thin-bedded			Intercalation of light grey **dolostone**, grey **dolomitic marl** and dark grey to blackish grey dolomitic **claystone**
171.8–172.4		8	Wavy thin-bedded or breccia-like			Yellowish grey *aphanitic* **dolostone**, with thin blackish grey **claystone** interbeds

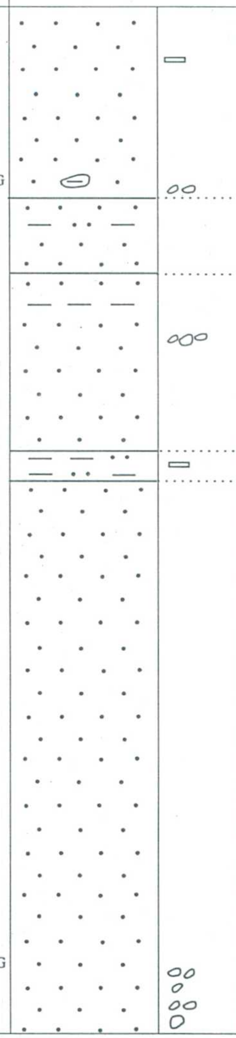


STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Eifelian	Narva Stage Leivu Substage Leivu Formation	18 19		172.4			Wavy thin- to medium-bedded, dolostone in places nodular			Mottled **dolomitic marl**, in places with grey clayey interbeds and thin interbeds of grey to yellowish grey, cavernous, *aphanitic* **dolostone** (with dolomite-filled cavities, and with clay films along bedding surfaces)
				175.9	MG		Wavy, indistinctly thin-bedded			Greenish grey, *very fine-grained* strongly dolomite-cemented **sandstone** with thin **claystone** and mottled **dolomitic marl** interbeds. Basal 0.6 m is clayey and silty
		20 21		177.8	Ac MG		Wavy thin- to medium-bedded, dolostone in places platy			Grey, in places with greyish brown partings and interbeds, **dolomitic marl**. Abundant are yellowish grey and grey **dolostone** interbeds with greenish and blackish grey clay films along bedding surfaces. At 183.1-183.3 m is a sandy **dolostone** bed containing small vugs
			9	183.6			Wavy thin- to medium-bedded, in places rubbly or lenticular			Grey and mottled reddish brown, in the lower part argillaceous and silty, **dolomitic marl**, with yellowish grey **dolostone** and grey to blackish grey **claystone** interbeds
				186.7			Wavy thin-bedded			Light grey, sandy dolomite-cemented **siltstone**, with thin greenish grey **claystone** interbeds
		22		187.0	MG		Wavy bedded or rubbly			Grey, in places varicoloured, in the lower part highly argillaceous, **dolomitic marl**, with few grey dolomite-cemented **siltstone** interbeds
		23		189.4			Wavy thin-bedded, in places breccia-like			Intercalation of greenish grey, in places with pink shade, strongly dolomite-cemented **siltstone** and **sandstone**, and thin **claystone** interbeds. Along bedding surfaces occur mica flakes and clay films. The interval of 189.9-190.1 m is grey **dolomitic marl**
		24 25		190.9	Ac MG		Massive or indistinctly nodular, in places wavy thin-bedded, at 195.5-195.6 m platy			Reddish brown, with purplish shade, and grey mottled **dolomitic marl**, in places argillaceous, with few interbeds of light to yellowish grey **dolostone** (thickness 0.5-7 cm) containing cavities filled with authigenous dolomite. In the interval of 193.50-193.65 m occurs a light grey dolomite-cemented **siltstone** interbed

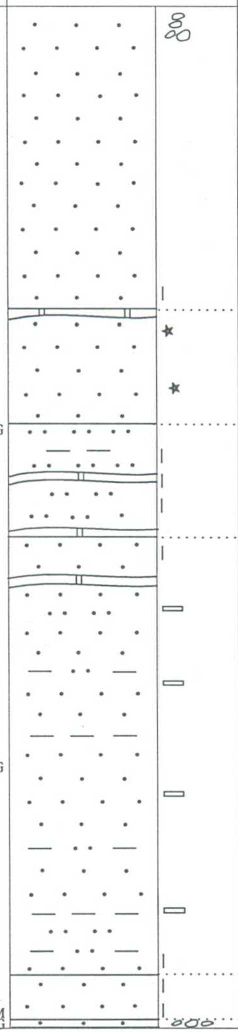


STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Eifelian	Narva Stage; Leivu Substage, Leivu Formation	25, 26	10	198.2	AcMG					☞ follow up
		26, 27, 28	11	204.9	MG		Rubbly, wavy thin- to medium-bedded			Intercalation of grey, in places mottled **dolomitic marl** and light grey *aphanitic* **dolostone**. In **dolomitic marl** occur abundant wavy gypsum (selenite) interbeds (thickness 0.1-3.0 cm) and pockets. In **dolostone** gypsum is present as small pockets and coatings along bedding surfaces. In the interval of 209.3-209.6 m occur thin varicoloured **claystone** interbeds
	Vadja Substage, Vadja Formation	29, 30	12	216.0 – 224.0	MG		Wavy thin- to thick-bedded, with breccia-like beds or disrupted bedding; claystone in places platy			Intercalation of light grey **dolostone** and dark grey **claystone**. **Dolostone** interbeds (thickness 1.0-40.0 cm) are fractured by planes covered by clay films, also penetrated by strecks filled with dolomite crystals. **Claystone** is argillaceous or calcareous. In the lower part in places mottled **dolomitic marl** interbeds occur

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Eifelian	Narva Stage Vadja Substage Vadja Formation	31 32	13 14	224.0	Ac MG MG MG		Wavy medium- to thin-bedded, with breccia-like interbeds or indistinctly nodular; dolostone in places with inclined bedding			Complex intercalation of grey to dark grey, in places silty or argillaceous **dolomitic marl**, yellowish grey to grey **dolostone** and grey to dark grey **claystone**. **Dolomitic marl** contains numerous **dolostone** pebbles and nodules. At 236.0 m occurs a bedding plane with syneresis cracks. In **dolostone** are common irregular cracks covered by dark grey films, and streaks and vugs filled with authigenous dolomite crystals. In places scattered crystals of dolomite and pyrite occur along bedding surfaces
		33		238.0	MG		Wavy thin-bedded, with nodular interbeds			Yellowish grey, silty, *aphanitic* **dolostone**, penetrated by irregular cracks. Bedding surfaces and fracture planes are covered by dark to brownish grey clay films. In the upper part vugs and patches occur, filled with pyrite crystals. In few brownish to dark grey **claystone** interbeds occur slickensides, covered by galena films
	Pärnu Stage Pärnu Formation Tamme Member	34		244.0			Indistinctly bedded, lower part inclined or cross-bedded			Greenish grey, in places pinkish grey, weakly to medium-cemented, *medium- to fine-grained* **sandstone**. Along bedding surfaces occur mica flakes, clay films and silt coatings. In the lower part brownish specks (diameter 1-3 mm) are common. Upper 0.15 m is reddish brown, strongly dolomite-cemented, with few small vugs and grey **claystone** pebbles. Basal 0.05 m is a conglomeratic layer, with **quartz** and **claystone** clasts (diameter up to 1 cm)



STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Eifelian	Pärnu Stage, Pärnu Formation, Tamme Member									☞ follow up
		34	15	256.0	MG		Horizontally thin-bedded; claystone platy			Greenish dark grey, weakly to medium-cemented, *fine-grained* **sandstone**. In the upper part occur dark grey, silty **claystone** interbeds (thickness up to 2 cm)
				258.0			Wavy to lenticular, sandstone micro- to thin-bedded; claystone platy			Brownish grey, *fine-grained* **sandstone**, with greenish grey **claystone** interbeds. At 259.5 m is a thin conglomeratic **sandstone** interbed. In the lower part dominates grey, with brownish patches, weakly cemented **sandstone**
				262.7			Horizontal micro-bedded			Brownish to purplish grey, silty **claystone**. On bed surfaces occur mica flakes
	Tori Member	35		263.5	MG		Horizontal, inclined or cross-bedding			Light grey, in the lower part pinkish grey, weakly cemented, *fine- to medium-grained* **sandstone**. The interval of 276.0-279.0 m contains **claystone** pebbles



STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Eifelian	Pärnu Stage Pärnu Formation Tori Member	35	16						☞ follow up
Emsian	Rēzekne Stage Mehikoorma Formation			286.0		Horizontal thin-bedded			Greenish grey, in the lower part light grey, weakly cemented **sandstone**. At the top is a **dolostone** bed (thickness 10 cm), with wavy sandy interbeds, the **sandstone** below is cavernous and strongly cemented
			17	289.0	MG	Wavy thin- to thick-bedded, in places rubbly			Alternating beds of reddish brown, strongly dolomite- and argillaceous-cemented **siltstone** containing greenish grey argillaceous and grey sandy interbeds. In the upper part is a 0.1 m thick silty **claystone** bed. At 290.5-290.7 m and 291.8-292.0 m are sandy **dolostone** interbeds
		36		292.0		Wavy, indistinctly disrupted bedding; siltstone platy			Light grey, with pink shade, weakly to medium-cemented, *fine-grained* **sandstone**, with grey **siltstone** and dark grey silty **claystone** interbeds. Along bedding surfaces occur mica flakes. At 293.0 m is a **dolostone** bed (thickness 5 cm)
		37	18		Ac MMGG				Grey, with purplish brown patches, strongly cemented **sandstone**. Upper 3 cm and lower 5 cm are purplish brown. Core yield 25%.
				303.6		Wavy parallel bedding			Greenish grey, in the basal part with scattered rusty specks, poorly sorted, dolomite-cemented **sandstone**, with greenish grey **claystone** interbeds. Angular clasts of greenish grey **dolomitic marl** and grey **dolostone** are poorly sorted
				304.8	Ac	Wavy or lenticular bedding			
				305.0	MGGM MG				

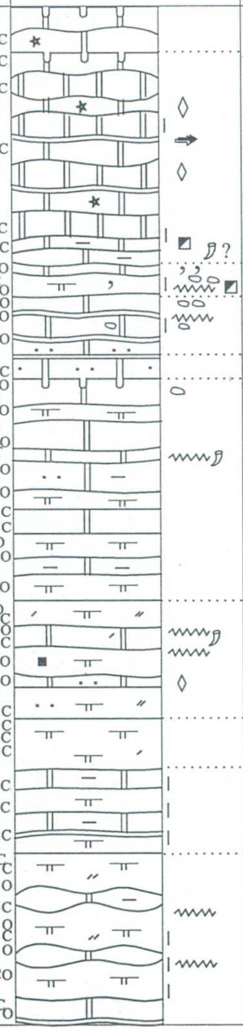
VALGA (10) DRILL CORE

Standard units: Llandovery (305.0–311.7 m); Ashgill (311.7–331.7 m)

Local stratigraphic units: Juuru Stage, Õhne Formation, Rūja Member (Ro* at top); Saldus Fm. (Pu*, Br*, P*); Porkuni Stage, Kuldiga Formation, Ēdole Member; Be*; Pirgu Stage, Kuili Formation

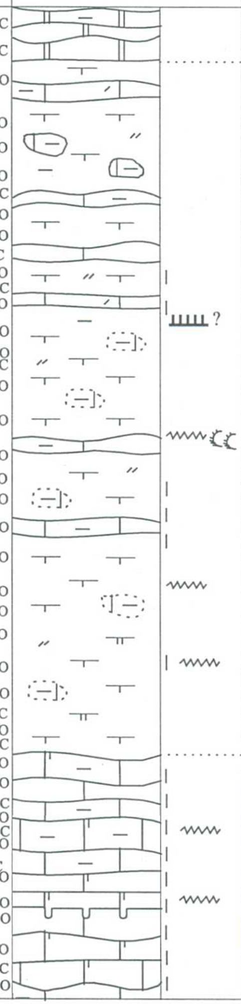
Core box no.: 37, 38, 39, 40, 41, 42

Figures: 18, 19, 20, 21, 22, 23, 24, 25

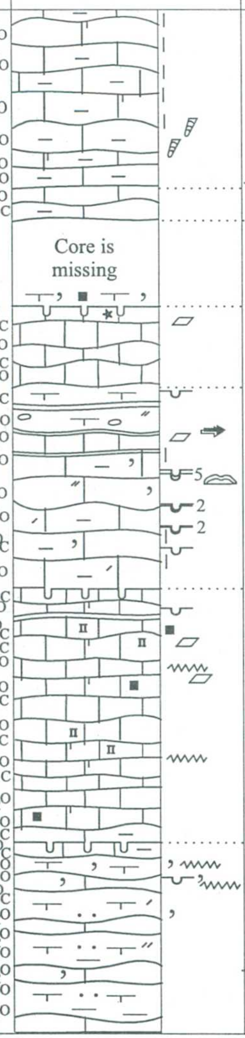


Depth (m)	Sedimentary structures	Marl beds	Marl percentage	Short description
305.0–306.2	Irregularly nodular, in the middle part medium nodular	2-3 (4) cm; IND greenish light grey with red spots or streaks	< 10	Light grey, with beigish tinge (in the upper part greenish grey, in the middle red-brown spots), *very finely crystalline* **dolostone** (grains < 10%)
306.2–	Irregularly nodular to thin-nodular	< 0.5 (1-2) cm D greenish grey to dark grey	< 5	Light grey, with beigish or brown tinge, *micro- to very finely crystalline* **dolostone** (grains < 10%). Nodular limonite crusts are up to 1 cm thick
–311.7		IND		Greenish to dark (below) grey **dolomitic marl**, in the upper part mostly argillaceous, *very finely crystalline* **dolostone.** Burrows are rust-coloured. Limonite nodular crusts are up to 1.5 cm thick
311.7–312.6	Irregularly nodular	1-5 cm; IND greenish or dark grey	40	Intercalation of brownish grey *finely to very finely crystalline* **dolostone** (grains < 10%) and **dolomitic marl**. Below 313.9 m the stone is silty or sandy. Burrows in the upper part are rust-coloured
312.6–314.2	Wavy thin- to microbedded	< 0.2-0.5 (3) cm; D greenish grey	30	
314.2–314.8–	Wavy micro- to medium-bedded, in the middle cross-bedded, in the upper part inclined	Up to 1 cm; IND greenish grey	< 5	Light grey, in places brownish, *finely to medium-crystalline* **dolostone**. Up to 10 cm thick beds contain sand and silt of different grain size
–320.7	Wavy thin- to medium-bedded	0.5-10 (< 0.2) cm; IND soiled grey, dark grey, in the lower part grey D	< 20 < 60	Intercalation of light grey, *very finely crystalline to microcrystalline* **dolostone** and **dolomitic marl**. The lower part is in places more argillaceous. Below 317.0 m intercalate slightly silty up to 3 cm thick **dolostone** beds, argillaceous **dolostone** (4-15 cm) and **dolomitic marl**. Surfaces of burrowed beds are impregnated
320.7–323.8	Wavy medium- (or thin-) bedded	Up to 10 cm; IND grey	< 60	Grey, *micro- to very finely crystalline* **dolomitic marl** (grains 10-25%) with thin interbeds of grey, slightly to medium-argillaceous, silty, *very finely crystalline* **dolostone**
323.8–325.1	Wavy or horizontal thin- or thick-bedded	Up to 40 cm; IND greenish grey	< 80	Greenish light grey to grey **dolomitic marl**
325.1–327.3	Wavy irregularly thin- or medium-bedded	Up to 10 cm; IND mottled reddish brown in places greenish grey	< 40-50	Reddish brown **dolomitic marl** intercalates with argillaceous *very finely crystalline* **dolostone** (grains < 10%). In places occur goethitic spots
327.3–331.7	Wavy medium- to thin-bedded or irregularly nodular	Up to 30 cm, in the lower part 0.5-1 (2) cm; IND, greenish grey D	< 60-80	Greenish grey **dolomitic marl** with nodules of light grey, in places mottled *micro- to finely crystalline* **dolostone**. In the upper part burrows are phosphatized

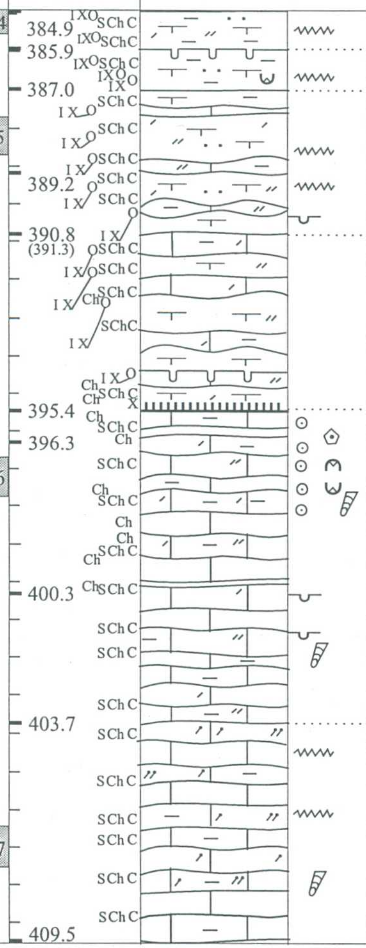
Ro*, Rozēni Member; Pu*, Puikule Member; Br*, Brocēni Member; P*, Piltene Member; Be*, Bernati Member

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Ashgill	Pirgu Stage; Paroveja Fm.	43	25, 26	331.7; 333.1	SChC, Ch, SChC, SChCO		Wavy bedding, irregularly thin-nodular	< 0.2-0.5 (2) cm; D grey	< 10	Grey to dark grey, slightly argillaceous *very finely crystalline to microcrystalline* **dolostone**
	Jelgava Formation	43, 44, 45, 46, 47	27, 28		SChC, SChCO, x		Wavy medium-bedded or thin- to medium nodular, often irregularly nodular	Up to 10 cm IND greenish light grey	> 50	Greenish light grey calcitic and argillaceous **marl**, in the upper part dark grey (in places mottled), some beds are dolomitized. Nodules and interbeds of light grey argillaceous *finely and very finely crystalline* **limestone** (grains < 10%, in places 10-25%) occur. Reddish brown **dolomitic marl** interbeds (348.4-348.9 m and 350.0-350.8 m) are mottled
	Jonstorp Formation	48, 49	29	351.5	SChC, SChCO		Wavy, in places medium-bedded or irregularly thin-nodular	Up to 0.5 cm IND dark brown	< 10 (< 20)	Reddish brown (with some goethitic spots), in the middle part dolomitized, medium to highly argillaceous, *micro- and very finely crystalline* **limestone** (grains < 10%; mudstone)

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Ashgill	Pirgu Stage, Jonstorp Formation	49			SChC O, SChC O, SChC O					☞ follow up
		50		362.6	SChCO, O, SChC O, O, O, OSChC		Medium- to thin-nodular, in places wavy medium-bedded	Up to 0.3 (< 10) cm D or IND greenish grey	< 10	Greenish light grey, in the upper and lower parts with brown tinge, slightly to medium-argillaceous, *finely and very finely crystalline* **limestone** (grains < 10%; mudstone)
	Vormsi Stage, Fjäcka Formation	51	30	363.4		Core is missing	! (Core yield 2%)	Dark grey		Dark grey **marl**, argillaceous. Gamma logging showed the presence of calcitic marl (?) in the upper and lower parts, in the middle occurs **claystone**
Caradoc	Nabala Stage, Saunja Formation	51		365.7	O, SChC, O, SChC, O		Irregularly thin- to medium-nodular, rarely wavy medium-bedded	< 0.2 (1-2) cm; D brownish or greenish dark grey	< 5	Beigish light grey *aphanitic* **limestone** (grains < 10%; mudstone) with calcite-filled primary and secondary veins
	Nabala Stage, Mõntu Formation	52	31	367.9; 373.2	OSChC, SChCO, O, SChC O, SChC O, SChC O, SChC, SChCO		Wavy thin- to medium-bedded, in places thin to medium-nodular	< 0.2-0.5 cm 1-5 cm IND greenish dark grey	40; < 5	Greenish light grey, in places mottled, in some beds medium- to slightly argillaceous, *very finely to finely crystalline* **limestone** (grains < 10%, in places 20%; mudstone). Discontinuity surfaces are phosphatized, limonitized, goethitized or pyritized
	Rakvere Stage, Rägavere Formation	53, 54	31, 32	373.5; 376.9; 378.7	SChC, O, SChC, SChC, O, O, SChC, Ch O, SChC, Ch O, SChC, SChC O		Wavy irregularly thin-bedded, rarely medium-bedded or irregularly thin-nodular	< 0.2 cm, up to 3 cm D greenish or brownish light grey	< 5	Beigish light grey *aphanitic* **limestone** (grains < 10%; mudstone), some beds are dolomitized. Characteristic are burrows and calcite-filled primary and secondary veins. The lower, 10 cm thick interval is very finely crystalline and slightly argillaceous
	Oandu Stage, Mossen Formation, Priekule Member	54, 55	33, 34	379.9; 380.4; 383.0; 383.8; 384.9	IXChSChC O, IXSChC, XI IXO, IXSChC, IXSChCO, IX, SChC IXO, IX, SChC O, IXO, SChCO IX		Thick-nodular or thin-bedded	Up to 2 cm, IND greenish grey	< 60	Greenish grey calcitic and argillaceous **marl** and silty **claystone**. In some beds stone is ferruginous or pyritized. Numerous burrows on bed surfaces are often iron-bearing

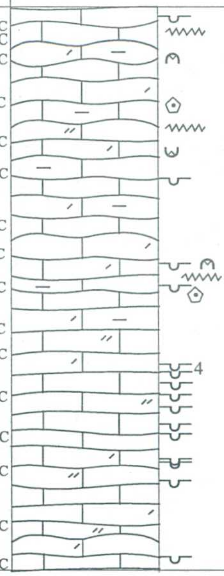


VALGA (10) DRILL CORE



STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Caradoc	?Oandu; Mossen; Pl* | Pr*	56	34	Wavy medium-bedded	Up to 10 cm; IND greenish grey	90	Greenish grey argillaceous **marl**, **siltstone** and **claystone** (grains < 10%), rarely with brownish tinge, shale-like. Burrows are characteristic
	Blidene Fm.		35	Wavy, irregularly medium- to thin-bedded	4-5 cm IND greenish dark grey	90	Brownish to blackish grey splitting shale-like silty **marl** and **claystone** (grains <10%) with burrows
	Keila Stage	57		Wavy thin- to medium-bedded, massive or irregularly medium-nodular	Up to 10 (50) cm IND greenish grey	80-90	Greenish grey argillaceous silty **marl** (grains 10-50%), with limestone nodules. Burrows are rust-coloured. The lower part is less argillaceous, nodules of greenish light grey argillaceous *very finely crystalline* **limestone** occur
				Wavy medium-bedded or thick-nodular	< 0.2 cm 3-7 cm D greenish dark grey	40	Intercalation of **limestone** and **marl**. Light grey, slightly to medium-argillaceous, *very finely and finely crystalline* **limestone** (grains 10-25%, in places up to 50%; wackestone). Bioclasts are mostly pyritized
	Haljala Stage, Idavere Substage, Jõ*; Adze Formation	58, 59	36	Wavy micro-, thin- to medium-bedded	< 0.2-2 cm; IND greenish dark grey to grey	40, 20	Light grey, in some beds with greenish tinge, slightly to highly argillaceous, *finely to very finely crystalline* **limestone** (grains 10-25%, in places 30%; wackestone). Goethitic ooliths are characteristic
Llanvirn	Kukruse Stage; Dreimani Formation	60, 61	37	Wavy medium-bedded or irregularly medium-nodular	< 0.2 cm, 1-2 or 3-5 cm D greenish grey	< 10	Greenish light grey, in some beds slightly to medium-argillaceous, *very finely crystalline* **limestone** (grains 10-25%, in places up to 40%; wackestone). Bioclasts are pyritized

Jõ*, Jõhvi Substage; Pr*, Priekule Member; Pl*, Plunge Member

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	SHORT DESCRIPTION
Llanvirn	Ku* Uhaku Stage / Taurupe Formation Lasna* / Stirnas Fm.	61 62 63 64 65	38 39	409.5 410.6 421.1 422.0 424.4	SChC SChC SChC SChC SChC E SChC SChC SChC SChC SChC SChC SChC SChC SChC SChC SChC		Wavy (micro-) thin- to medium-bedded or irregularly thin-nodular	< 0.2 cm 1-2 cm IND brownish or greenish grey, below 416.2 m in places green	< 10	Greenish light grey, in the lower part light grey, in places slightly to medium-argillaceous, *very finely crystalline* **limestone** (grains 10-25%; wackestone). Pyritized discontinuity surfaces are uneven

Lasna*, Lasnamägi Stage; Ku*, Kukruse Stage

Fossils in Devonian strata of the Valga (10) core

Sample	Sampled interval (m)	Formation	*Ptychodictyon sulcatum* Gross	*Markacanthus alius* Valiukevičius	*Diplacanthus gravis* Valiukevičius	*Cheiracanthus brevicostatus* Gross	*Acanthoides* ? sp. A Valiukevičius	*Acanthoides* ? sp. D Valiukevičius	*Diplacanthus solidus* Valiukevičius	*Acanthoides* ? sp.	*Ptychodictyon rimosum* Gross	*Rhadinacanthus multisulcatus* Valiukevičius	*Cheiracanthus longicostatus* Gross	*Acanthoides* ? sp. B Valiukevičius	*Ptychodictyon distinctum* Valiukevičius	*Diplacanthus carinatus* Gross	*Cheirolepis* sp.	*Minioracanthus laevis* Valiukevičius	Acanthodii indet.	*Markacanthus costulatus* Valiukevičius	*Orvikuina vardiaensis* Gross	*Trochiliscа*	*Rhadinacanthus balticus* Gross	*Diplacanthus* sp.	*Cheiracanthus crassus* Valiukevičius	*Lingulida*	*Acanthoides* ? sp. C Valiukevičius
V10–1	54.5–55.0	Burtnieki	*	*	*	*	*	*																			
V10–3	68.9–69.0	Aruküla			*			*	*																		
V10–6	82.7–82.8	Aruküla						*		*	*																
V10–7	88.0–90.0	Aruküla	*	*	*	*	*	*			*	*	*	*													
V10–9	100.9	Aruküla		*	*	*	*	*			*	*	*		*	*	*										
V10–11	112.0–112.2	Aruküla		*	*	*	*				*	*	*					*									
V10–12	115.1–115.2	Aruküla				*	*																				
V10–13	122.0	Aruküla																	*								
V10–14	130.0–130.2	Aruküla					*																				
V10–19	161.9–162.0	Leivu				*	*	*			*		*							*							
V10–20	163.8–164.0	Leivu				*	*	*			*										*	*					
V10–23	180.8–181.1	Leivu				*	*	*			*		*										*				
V10–25	193.50–193.65	Leivu				*		*			*		*	*							*						
V10–26	198.5	Leivu				*		*			*		*	*	*								*	*			
V10–29	224.6–224.7	Vadja								*															*		
V10–36	298.0	Mehikoorma								*																	
V10–38	304.70–304.75	Mehikoorma																								*	
V10–39	304.75–304.80	Mehikoorma																									*

Identified by Juozas Valiukevičius (Institute of Geology of Lithuania) in collaboration with Anne Kleesment (Institute of Geology at Tallinn Technical University).

APPENDIX 3

Grain-size distribution and dolomitic component of the terrigenous part of Devonian rocks in the Valga (10) core

Sample	Sampled interval (m)	Formation	>0.5	0.5–0.25	0.25–0.1	0.1–0.05	0.05–0.01	0.01–0.005	<0.005	Dolomitic component (%)
			mm / %							
V10–1	54.5–55.0	Burtnieki	0.2	1.9	15.2	23.2	1.1	17.5	40.9	27.30
V10–2	63.0–63.5	Burtnieki	0.1	6.2	46.8	24.7	7.9	10.3	4	1.60
V10–3	68.9–69.0	Aruküla	< 0.1	0.5	29.1	21.9	0.8	12.1	35.6	11.40
V10–4	73.0–73.6	Aruküla	0.3	11.8	76.1	1.7	0.1	10		< 0.1
V10–5	78.5–80.0	Aruküla	0.1	5.6	52.3	10.6	3.4	17.4	10.6	6.40
V10–6	82.7–82.8	Aruküla	< 0.1	0.7	40.7	25	11.4	11.3	10.9	21.80
V10–7	88.0–90.0	Aruküla	0.3	4.1	80	9.2	0.6	3.8	2.1	12.20
V10–8	94.5–95.0	Aruküla	< 0.1	0.3	1.3	73.3	5.5	19.6		10.30
V10–9	100.8–100.9	Aruküla	0.4	0.7	36.5	16	14	14.9	17.5	13.20
V10–10	106.0–106.5	Aruküla	0.1	2.7	38.6	31.2	14.2	8.6	4.6	2.00
V10–11	112.0–112.2	Aruküla	0.1	1.6	66.8	4	3.7	23.8		37.40
V10–12	115.1–115.2	Aruküla	1.2	3.1	51.8	23.6	3.5	9.7	7.1	6.40
V10–13	122.0–122.1	Aruküla	< 0.1	0.2	< 0.1	43.8	29.7	17.1	9.2	17.30
V10–14	130.0–130.2	Aruküla	< 0.1	0.1	7.4	18.4	12.6	34	27.5	1.30
V10–15	134.3–135.0	Aruküla	0.2	0.5	12.6	29.8	15.1	17.3	24.5	21.30
V10–16	138.5–139.0	Aruküla	0.1	1.2	34.7	40.8	12.7	10.5		1.20
V10–17	143.0–143.2	Gorodenka	< 0.1	0.2	0.1	82	6.3	11.4		5.50
V10–18	156.3–156.5	Gorodenka	< 0.1	0.6	22.9	49.5	2.8	19.7	4.5	5.20
V10–19	161.9–162.0	Leivu	< 0.1	< 0.1	0.2	1	0.8	86.2	11.8	26.90
V10–20	163.8–164.0	Leivu	< 0.1	0.1	0.3	1.6	5.4	55.7	36.9	66.70
V10–21	170.8–170.9	Leivu	< 0.1	0.1	0.5	1.9	0.8	37.6	59.1	22.30
V10–22	177.1–177.2	Leivu	0.5	1.4	4.8	49.6	15	22	6.7	21.80
V10–23	180.8–181.1	Leivu	< 0.1	< 0.1	0.1	0.2	2.7	90.2	6.8	50.00
V10–24	186.8–186.9	Leivu	1.2	1	0.1	26.4	40.5	20.9	9.9	13.30
V10–25	193.5–193.7	Leivu	< 0.1	0.2	0.1	4.5	8.4	64.4	22.4	46.40
V10–26	198.5–198.6	Leivu	0.1	0.8	10.5	4.9	0.7	73	10	45.20
V10–27	215.5–216.0	Leivu	0.1	0.1	0.1	0.3	0.6	84	14.8	33.00
V10–28	222.4–222.5	Vadja	–	< 0.1	0.2	0.2	0.8	92	6.8	29.90
V10–29	224.6–224.7	Vadja	0.1	0.2	0.1	0.2	0.1	79.3	20	77.30
V10–30	229.2–229.3	Vadja	–	< 0.1	< 0.1	0.2	0.9	78.3	20.6	80.20
V10–31	236.0–236.1	Vadja	< 0.1	< 0.1	0.1	0.2	0.3	54.7	44.7	49.30
V10–32	240.4–240.5	Vadja	< 0.1	< 0.1	0.1	0.3	0.5	78.1	21	90.60
V10–33	255.5–256.0	Pärnu	1.1	40.7	53	2.9	0.1	2.2		–
V10–34	276.0–279.0	Pärnu	8.2	47.3	42.5	1.1	0.1	0.8		–
V10–35	289.0–289.2	Mehikoorma	< 0.1	0.2	28.2	21.8	5.1	15.6	29.1	1.00
V10–36	298.0–298.2	Mehikoorma	< 0.1	0.3	31.6	41.9	0.4	25.8		–
V10–37	298.2–298.3	Mehikoorma	< 0.1	0.1	6.6	14.6	1.5	42.5	34.7	1.60
V10–38	304.70–304.75	Mehikoorma	< 0.1	4.4	30.6	25.2	3.8	36		51.00
V10–39	304.75–304.80	Mehikoorma	–	1	7.6	9.3	5.8	76.3		70.20
V10–40	304.80–304.95	Mehikoorma	–	0.1	0.2	0.5	2.5	96.7		65.90

Analysed by Anne Kleesment (Institute of Geology at Tallinn Technical University); – not found.

APPENDIX 4

Heavy minerals (fraction 0.1–0.05 mm) in Devonian strata of the Valga (10) core

Sample	Sampled interval (m)	Formation	Biotite (brown)	Biotite (green)	Chlorite	Muscovite	Glauconite	Baryte	Pyrite	Fe-hydroxides	Leucoxene	Anatase	Ilmenite, magnetite	Transparent heavy minerals
			percentage of the heavy fraction											
V10–1	54.5–55.0	Burtnieki	–	9.8	2.8	1.7	0.2	–	0.2	6.4	12.5	–	36.6	29.8
V10–2	63.0–63.5	Burtnieki	–	0.6	–	–	–	–	–	3.2	5.2	–	55.0	36.0
V10–3	68.9–69.0	Aruküla	–	1.4	0.2	–	0.2	–	0.2	22.4	7.3	–	45.0	23.3
V10–4	73.0–73.6	Aruküla	–	0.8	0.4	–	–	< 0.1	–	4.4	11.3	–	58.6	24.5
V10–5	78.5–80.0	Aruküla	–	8.8	0.8	2.2	–	–	1.2	5.0	13.2	–	32.6	36.2
V10–6	82.7–82.8	Aruküla	–	3.8	3.0	1.2	–	–	–	7.8	13.4	–	24.4	46.4
V10–7	88.0–90.0	Aruküla	0.2	0.6	0.4	0.2	–	–	0.4	1.6	5.2	0.8	55.6	35.0
V10–8	94.5–95.0	Aruküla	0.2	71.2	0.2	1.2	–	–	0.2	17.4	1.0	< 0.1	4.2	4.4
V10–9	100.8–100.9	Aruküla	–	4.8	0.2	0.4	< 0.1	–	1.6	24.2	7.0	–	32.6	29.2
V10–10	106.0–106.5	Aruküla	0.6	36.6	0.6	15.8	< 0.1	–	0.2	21.4	2.8	0.8	6.4	14.8
V10–11	112.0–112.2	Aruküla	0.6	0.4	–	0.2	–	–	0.2	3.4	5.4	–	50.2	39.6
V10–12	115.1–115.2	Aruküla	< 0.1	2.4	0.4	0.6	–	–	0.2	1.6	7.0	< 0.1	48.4	39.4
V10–13	122.0–122.1	Aruküla	0.8	27.2	0.6	1.2	–	–	–	20.6	7.8	–	24.4	17.4
V10–14	130.0–130.2	Aruküla	0.7	8.0	0.5	0.7	–	0.7	0.7	15.4	24.1	–	16.4	32.8
V10–15	134.3–135.0	Aruküla	–	6.3	–	2.4	< 0.1	–	0.8	1.6	3.8	–	48.2	36.9
V10–16	138.5–139.0	Aruküla	–	4.8	0.3	1.2	1.2	–	0.6	10.5	23.1	–	32.0	26.3
V10–17	143.0–143.2	Gorodenka	0.6	10.6	0.2	0.2	–	–	0.6	4.6	13.8	< 0.1	44.8	24.6
V10–18	156.3–156.5	Gorodenka	0.4	9.1	0.4	0.2	–	0.2	–	1.6	6.8	–	42.5	38.8
V10–19	161.9–162.0	Leivu	–	0.4	–	0.2	0.2	–	6.8	59.0	1.0	–	23.4	9.0
V10–20	163.8–164.0	Leivu	0.2	5.0	1.2	22.0	0.2	39.2	4.2	6.6	1.6	–	13.2	6.6
V10–22	177.1–177.2	Leivu	1.2	17.0	0.4	4.2	0.4	–	0.2	17.0	6.4	–	20.8	32.4
V10–23	180.8–181.1	Leivu	0.2	1.2	–	–	–	–	2.2	25.0	0.2	–	67.0	4.2
V10–24	186.8–186.9	Leivu	5.4	36.6	1.6	3.0	–	1.8	2.2	11.8	6.6	–	8.6	22.4
V10–25	193.5–193.7	Leivu	–	1.6	0.2	0.2	0.4	–	29.0	15.8	2.8	< 0.1	19.0	31.0
V10–26	198.5–198.6	Leivu	–	0.8	0.4	–	–	–	0.2	0.6	3.6	–	33.4	61.0
V10–27	215.5–216.0	Leivu	–	24.6	3.6	10.9	3.6	–	13.6	26.4	–	–	11.8	5.5
V10–28	222.4–222.5	Vadja	–	0.5	–	–	–	4.2	0.5	14.7	1.0	–	78.6	0.5
V10–29	224.6–224.7	Vadja	–	–	–	< 0.1	–	0.6	79.8	1.6	0.2	–	13.4	4.4
V10–30	229.2–229.3	Vadja	< 0.1	1.8	0.2	–	–	0.2	29.8	28.4	–	–	38.4	1.2
V10–31	236.0–236.1	Vadja	–	0.6	< 0.1	0.2	0.2	–	43.6	24.8	1.0	–	25.5	4.1
V10–32	240.4–240.5	Vadja	–	0.6	–	–	–	1.4	70.0	22.6	–	–	5.2	0.2
V10–33	255.5–256.0	Pärnu	0.6	4.2	1.4	0.2	1.2	0.2	–	16.6	2.8	< 0.1	13.2	59.6
V10–34	276.0–279.0	Pärnu	0.2	1.6	1.8	0.4	1.0	–	–	2.2	1.0	0.2	24.4	67.2
V10–35	289.0–289.2	Mehikoorma	0.4	5.0	1.0	2.0	0.2	–	0.6	2.2	2.0	–	29.6	57.0
V10–36	298.0–298.2	Mehikoorma	–	6.3	1.6	1.0	0.2	–	–	6.4	5.7	–	40.3	38.5
V10–37	298.2–298.3	Mehikoorma	< 0.1	8.8	–	1.6	0.2	–	7.8	10.8	2.2	–	24.4	44.2
V10–38	304.70–304.75	Mehikoorma	0.2	–	0.2	–	0.2	–	–	0.8	2.2	–	29.8	66.6
V10–39	304.75–304.80	Mehikoorma	0.2	0.2	0.2	–	–	–	0.5	5.1	2.1	–	39.2	52.5
V10–40	304.80–304.95	Mehikoorma	–	< 0.1	–	–	–	–	–	6.9	0.4	–	91.6	1.1

Analysed by Anne Kleesment (Institute of Geology at Tallinn Technical University); – not found.

APPENDIX 5

Transparent heavy minerals (fraction 0.1–0.05 mm) in Devonian strata of the Valga (10) core

Sample	Sampled interval (m)	Formation	Garnet	Zircone	Tourmaline	Apatite	Staurolite	Disthene	Rutile	Titanite	Anatase	Brucite	Weathered Ti-min	Corundum	Monazite	Xenotime	Amphibole	Pyroxene	Zoisite
			percentage of transparent heavy minerals																
V10–1	54.5–55.0	Burtnieki	2.6	71.7	5.8	8.0	–	–	8.4	0.9	–	0.4	1.8	–	0.2	–	0.2	–	–
V10–2	63.0–63.5	Burtnieki	6.8	71.4	5.2	11.0	0.4	–	3.2	–	0.2	–	–	–	1.6	–	0.2	–	–
V10–3	68.9–69.0	Aruküla	11.9	50.9	11.2	16.5	0.3	–	6.7	–	–	–	2.1	–	0.4	–	–	–	–
V10–4	73.0–73.6	Aruküla	12.8	62.7	8.8	8.8	0.4	–	3.7	–	–	–	1.6	–	1.2	–	–	–	–
V10–5	78.5–80.0	Aruküla	36.4	36.0	12.6	7.0	2.2	–	2.8	–	0.2	–	1.4	–	1.4	–	–	–	–
V10–6	82.7–82.8	Aruküla	19.3	48.8	11.7	15.3	0.2	–	3.4	–	–	–	0.7	–	0.6	–	–	–	–
V10–7	88.0–90.0	Aruküla	30.2	41.4	8.8	14.0	0.2	0.2	4.4	–	0.2	–	0.2	–	0.4	–	–	–	–
V10–8	94.5–95.0	Aruküla	1.0	13.3	35.2	43.9	–	–	2.8	–	1.0	–	2.1	–	–	–	0.7	–	–
V10–9	100.8–100.9	Aruküla	17.2	38.2	15.8	22.4	0.2	0.2	2.8	–	0.2	–	2.8	–	0.2	–	–	–	–
V10–10	106.0–106.5	Aruküla	3.9	11.8	25.3	47.2	–	–	4.4	–	–	–	7.4	–	–	–	–	–	–
V10–11	112.0–112.2	Aruküla	48.8	26.4	8.8	10.6	0.6	–	3.6	–	–	–	0.8	–	0.4	–	–	–	–
V10–12	115.1–115.2	Aruküla	20.8	25.2	19.4	29.6	–	–	3.8	–	–	–	1.0	–	–	–	–	0.2	–
V10–13	122.0–122.1	Aruküla	16.5	26.0	25.6	21.3	0.4	–	5.1	–	0.4	–	3.9	–	–	–	0.8	–	–
V10–14	130.0–130.2	Aruküla	16.8	18.3	19.1	39.0	–	–	3.7	–	1.0	–	1.8	–	0.3	–	–	–	–
V10–15	134.3–135.0	Aruküla	50.1	21.2	14.4	8.4	1.4	–	1.8	2.1	–	–	0.4	–	0.2	–	–	–	–
V10–16	138.5–139.0	Aruküla	4.6	18.8	24.8	45.2	0.2	–	3.2	–	0.8	–	1.8	–	0.6	–	–	–	–
V10–17	143.0–143.2	Gorodenka	2.2	12.3	23.9	45.7	–	–	6.5	–	1.4	–	7.3	–	0.7	–	–	–	–
V10–18	156.3–156.5	Gorodenka	36.3	20.3	12.3	24.0	–	–	4.3	–	–	–	1.9	–	0.6	0.3	–	–	–
V10–19	161.9–162.0	Leivu	45.8	47.2	4.2	1.4	–	–	–	–	–	–	–	–	–	–	1.4	–	–
V10–20	163.8–164.0	Leivu	69.0	16.6	4.8	6.4	–	–	2.3	–	0.3	–	0.6	–	–	–	–	–	–
V10–22	177.1–177.2	Leivu	35.4	8.3	13.1	39.0	–	–	2.4	–	–	–	1.8	–	–	–	–	–	–
V10–23	180.8–181.1	Leivu	53.3	24.7	5.2	8.0	–	–	0.8	0.4	–	–	1.2	0.4	–	–	4.4	1.2	0.4
V10–24	186.8–186.9	Leivu	50.3	6.5	14.7	24.8	–	–	1.8	–	0.4	–	0.4	–	–	–	1.1	–	–
V10–25	193.5–193.7	Leivu	68.4	3.6	6.0	15.4	–	–	2.0	–	–	–	0.8	3.6	–	–	0.2	–	–
V10–26	198.5–198.6	Leivu	41.4	45.2	5.0	4.0	0.2	–	2.2	–	–	–	1.6	–	0.4	–	–	–	–
V10–27	215.5–216.0	Leivu	33.2	16.7	–	16.7	–	–	–	–	–	–	16.7	–	–	–	16.7	–	–
V10–29	224.6–224.7	Vadja	33.7	56.7	3.8	1.0	–	–	3.8	–	–	–	–	1.0	–	–	–	–	–
V10–30	229.2–229.3	Vadja	41.0	50.0	4.5	–	–	–	–	–	–	–	–	–	–	–	4.5	–	–
V10–31	236.0–236.1	Vadja	26.9	62.6	3.0	3.0	–	–	–	–	–	–	1.5	–	1.5	–	1.5	–	–
V10–32	240.4–240.5	Vadja	50.6	34.9	6.7	4.5	–	–	–	–	–	–	2.2	–	1.1	–	–	–	–
V10–33	255.5–256.0	Pärnu	75.4	13.6	3.6	6.4	–	–	1.0	–	–	–	–	–	–	–	–	–	–
V10–34	276.0–279.0	Pärnu	85.4	9.4	1.6	3.0	–	–	0.4	–	–	–	0.2	–	–	–	–	–	–
V10–35	289.0–289.2	Mehikoorma	80.8	16.2	1.6	0.4	–	–	0.8	–	–	–	0.2	–	–	–	–	–	–
V10–36	298.0–298.2	Mehikoorma	40.8	17.6	13.4	24.2	–	–	3.0	0.2	–	–	0.6	–	0.2	–	–	–	–
V10–37	298.2–298.3	Mehikoorma	75.3	15.6	1.4	5.2	–	–	1.7	–	–	–	–	–	0.6	–	0.2	–	–
V10–38	304.70–304.75	Mehikoorma	65.6	18.2	3.8	11.2	–	–	0.4	–	–	–	0.6	–	0.2	–	–	–	–
V10–39	304.75–304.80	Mehikoorma	86.3	9.8	1.0	1.9	–	–	1.0	–	–	–	–	–	–	–	–	–	–
V10–40	304.80–304.95	Mehikoorma	33.9	45.3	1.9	1.9	–	–	–	–	1.9	–	–	13.2	–	–	1.9	–	–

Analysed by Anne Kleesment (Institute of Geology at Tallinn Technical University); – not found.

APPENDIX 6

Light and heavy minerals (fraction 0.1–0.05 mm) in Devonian strata of the Valga (10) core

Sample	Sampled interval (m)	Formation	Quartz	Orthoclase	Plagioclase	Microcline	Muscovite	Biotite (green)	Biotite (brown)	Weathered mica	Chlorite	Glauconite	Chalcedony	Total per cent	Heavy minerals (%)
V10–1	54.5–55.0	Burtnieki	77.20	18.90	1.20	–	2.10	0.60	–	–	–	–	–	100.0	0.05
V10–2	63.0–63.5	Burtnieki	93.70	6.00	0.30	–	–	–	–	–	–	–	–	100.0	1.75
V10–3	68.9–69.0	Aruküla	89.80	6.90	0.60	–	2.40	0.30	–	–	–	–	–	100.0	0.07
V10–4	73.0–73.6	Aruküla	59.70	37.00	0.30	–	0.90	–	–	0.30	–	1.20	0.60	100.0	0.26
V10–5	78.5–80.0	Aruküla	89.80	5.40	0.30	–	1.20	2.10	–	–	0.30	–	0.90	100.0	0.26
V10–6	82.7–82.8	Aruküla	84.30	11.50	0.30	–	1.20	2.40	–	–	–	–	–	100.0	0.22
V10–7	88.0–90.0	Aruküla	86.80	12.60	0.30	–	–	–	–	–	–	0.30	–	100.0	0.59
V10–8	94.5–95.0	Aruküla	73.00	22.50	–	0.30	0.90	3.30	–	–	–	–	–	100.0	1.07
V10–9	100.8–100.9	Aruküla	88.60	3.90	–	–	2.40	3.90	–	0.30	–	0.30	0.60	100.0	0.56
V10–10	106.0–106.5	Aruküla	87.00	9.60	0.60	–	0.30	2.50	–	–	–	–	–	100.0	0.39
V10–11	112.0–112.2	Aruküla	86.80	11.10	0.90	–	0.30	0.30	–	–	0.60	–	–	100.0	0.44
V10–12	115.1–115.2	Aruküla	65.60	27.80	0.90	–	2.40	3.30	–	–	–	–	–	100.0	0.17
V10–13	122.0–122.1	Aruküla	78.00	16.30	1.50	–	0.60	3.30	–	0.30	–	–	–	100.0	0.07
V10–14	130.0–130.2	Aruküla	54.70	38.40	1.20	–	1.80	3.90	–	–	–	–	–	100.0	0.03
V10–15	134.3–135.0	Aruküla	39.90	29.40	0.90	–	9.00	19.00	0.60	0.60	0.60	–	–	100.0	0.09
V10–16	138.5–139.0	Aruküla	74.80	18.00	0.60	–	1.80	4.50	–	0.30	–	–	–	100.0	0.03
V10–17	143.0–143.2	Gorodenka	83.50	14.10	0.90	0.30	0.30	0.60	–	0.30	–	–	–	100.0	0.03
V10–18	156.3–156.5	Gorodenka	79.90	16.20	1.50	0.30	–	1.20	–	–	–	0.30	0.60	100.0	0.03
V10–19	161.9–162.0	Leivu	46.70	19.20	–	–	25.70	8.40	–	–	–	–	–	100.0	0.32
V10–20	163.8–164.0	Leivu	54.40	35.40	0.30	0.30	7.00	1.70	–	–	0.30	0.60	–	100.0	0.86
V10–21	170.8–170.9	Leivu	66.20	17.00	0.30	0.30	11.50	4.70	–	–	–	–	–	100.0	0.01
V10–22	177.1–177.2	Leivu	71.00	24.50	0.30	0.30	1.80	1.80	–	–	0.30	–	–	100.0	0.07
V10–23	180.8–181.1	Leivu	53.60	20.30	0.50	–	14.40	11.20	–	–	–	–	–	100.0	3.03
V10–24	186.8–186.9	Leivu	55.10	33.00	1.30	0.30	7.20	2.80	0.30	–	–	–	–	100.0	0.03
V10–25	193.5–193.7	Leivu	64.60	26.70	1.90	–	5.10	2.70	–	–	–	–	–	100.0	0.29
V10–26	198.5–198.6	Leivu	77.80	16.20	0.90	0.30	3.90	0.60	–	0.30	–	–	–	100.0	0.77
V10–27	215.5–216.0	Leivu	86.80	7.80	0.90	0.30	3.30	0.90	–	–	–	–	–	100.0	0.25
V10–28	222.4–222.5	Vadja	94.90	2.20	–	–	2.20	0.70	–	–	–	–	–	100.0	7.57
V10–29	224.6–224.7	Vadja	76.10	20.90	–	–	1.50	1.50	–	–	–	–	–	100.0	32.30
V10–30	229.2–229.3	Vadja	77.30	4.20	–	–	9.00	9.00	–	–	–	–	0.50	100.0	3.74
V10–31	236.0–236.1	Vadja	65.50	24.20	–	–	6.90	3.40	–	–	–	–	–	100.0	3.62
V10–32	240.4–240.5	Vadja	79.80	14.20	0.40	–	3.80	0.70	–	–	–	–	1.10	100.0	15.86
V10–33	255.5–256.0	Pärnu	79.20	14.50	0.90	0.30	1.80	2.70	–	–	–	0.60	–	100.0	0.35
V10–34	276.0–279.0	Pärnu	78.50	14.00	0.30	0.30	–	1.80	–	–	–	5.10	–	100.0	3.12
V10–35	289.0–289.2	Mehikoorma	71.80	15.90	0.60	–	7.20	3.90	–	0.30	–	0.30	–	100.0	0.26
V10–36	298.0–298.2	Mehikoorma	81.40	14.70	0.90	–	1.20	1.50	–	–	–	0.30	–	100.0	0.10
V10–37	298.2–298.3	Mehikoorma	36.20	14.60	1.40	–	17.80	28.90	–	0.40	–	0.70	–	100.0	0.07
V10–38	304.7–304.75	Mehikoorma	78.40	15.90	0.90	0.30	2.70	1.80	–	–	–	–	–	100.0	0.37
V10–39	304.75–304.8	Mehikoorma	72.10	11.40	1.50	0.30	8.40	6.30	–	–	–	–	–	100.0	0.60
V10–40	304.8–304.95	Mehikoorma	72.80	14.40	–	–	3.20	9.60	–	–	–	–	–	100.0	1.89

Analysed by Anne Kleesment (Institute of Geology at Tallinn Technical University); – not found.

APPENDIX 7

List of conodont, chitinozoan and scolecodont samples from the Valga (10) core

Sample	Sampled interval (m)	Sample	Sampled interval (m)	Sample	Sampled interval (m)
C96–1	305.70–305.80	C96–24	338.20–338.30	C96–97	382.65–382.75
C96–2	306.30–306.50	C96–25	339.00–339.10	C96–98	383.55–383.70
C96–3	307.00	C96–26	339.60–339.70	C96–99	384.15–384.25
C96–4	308.60	C96–27	340.40–340.50	C96–100	385.10–385.25
C96–5	310.70–310.80	C96–28	341.00–341.10	C96–101	385.70–385.85
C96–6	311.20–311.35	C96–29	341.90–342.00	C96–102	386.30–386.40
JN85	312.00–312.10	C96–30	342.85–343.00	C96–103	387.30–387.40
C96–56	312.10–312.25	C96–31	343.60–343.70	C96–104	387.95–388.05
JN85	312.45–312.55	C96–32	344.25–344.35	C96–105	388.70–388.85
C96–57	312.95–313.10	C96–33	344.85–345.00	C96–106	389.25–389.40
C96–58	313.45–313.60	C96–34	345.55–345.65	C96–107	389.85–389.95
C96–59	314.60–314.70	C96–35	346.30–346.45	C96–108	391.00–391.10
C96–60	315.35–315.45	C96–36	347.20–347.30	C96–109	391.60–391.75
C96–61	315.95–316.05	C96–37	347.90–348.05	C96–110	392.35–392.45
C96–62	316.40–316.55	C96–38	349.00–349.10	JN85	392.50–392.55
JN85	317.35–317.40	C96–39	349.75–349.85	C96–111	393.00–393.15
C96–63	317.45–317.60	C96–40	350.45–350.55	JN85	394.85–394.90
C96–64	318.25–318.35	C96–41	351.20–351.35	OM98–230	394.97–395.15
C96–65	318.75–318.85	C96–42	352.00–352.15	JN85	395.20–395.25
C96–66	319.40–319.55	C96–43	352.75–352.85	JN85	395.50–395.55
JN85	319.80–319.90	C96–44	353.55–353.65	OM98–229	395.80–395.90
C96–67	320.20–320.30	C96–45	354.45–354.55	JN85	396.15–396.22
JN85	320.45–320.55	C96–46	355.20–355.30	OM98–228	396.75–397.00
JN85	320.70–320.80	C96–47	355.90–356.05	JN85	397.50–397.55
C96–68	321.10–321.20	C96–48	357.00–357.15	OM98–227	397.70–397.90
C96–69	321.35–321.50	C96–49	357.55–357.65	JN85	398.45–398.50
JN85	321.60–321.70	C96–50	358.40–358.50	JN85	398.90–398.94
C96–70	321.85–321.95	C96–51	359.20–359.30	OM98–226	399.00–399.10
JN85	322.60–322.70	C96–52	360.30–360.40	JN85	399.40–399.47
C96–71	322.85–322.95	C96–53	361.45–361.55	OM98–225	400.05–400.23
C96–72	323.35–323.50	C96–54	362.10–362.25	JN85	400.17–400.23
JN85	323.60–323.70	C96–55	363.10–363.25	OM98–224	401.15–401.21
C96–73	323.80–323.95	C96–77	366.30–366.43	OM98–223	401.80–402.00
JN85	324.00–324.10	C96–78	367.10–367.20	OM98–222	403.32–403.42
C96–74	324.20–324.35	C96–79	368.25–368.35	OM98–221	403.90–404.07
JN85	324.40–324.50	C96–80	368.70–368.80	OM98–220	405.12–405.22
C96–75	324.60–324.75	C96–81	369.60–369.70	OM98–219	406.08–406.30
C96–76	324.95–325.05	C96–82	370.55–370.70	OM98–218	406.73–406.82
C96–7	325.50–325.60	C96–83	371.10–371.25	OM98–217	407.80–407.97
C96–8	326.00–326.10	C96–84	372.00–372.10	OM98–216	408.88–408.97
C96–9	326.80–326.90	C96–85	372.60–372.75	OM98–215	409.85–410.08
C96–10	327.30–327.40	C96–86	373.35–373.50	OM98–231	410.40–410.48
C96–11	327.60–327.70	C96–87	374.40–374.50	OM98–214	410.80–410.86
C96–12	328.60–328.70	C96–88	374.85–374.95	OM98–213	411.85–412.03
C96–13	329.40–329.50	C96–89	376.10–376.25	OM98–212	412.90–413.05
C96–14	330.40–330.50	JN85	376.60	OM98–211	413.70–413.90
C96–15	331.20–331.30	C96–90	377.20–377.35	OM98–210	415.05–415.12
C96–16	332.00–332.10	JN85	377.70	OM98–209	415.88–416.06
JN85	332.20–332.30	C96–91	378.10–378.25	OM98–208	416.90–417.00
C96–17	332.90–333.00	C96–92	378.95–379.10	OM98–207	417.96–418.04
C96–18	333.60–333.70	JN85	379.60	OM98–206	418.58–418.65
C96–19	334.50–334.60	C96–93	379.65–379.80	OM98–205	419.63–419.86
C96–20	335.15–335.25	C96–94	380.15–380.30	OM98–204	420.80–420.96
C96–21	336.00–336.10	C96–95	381.40–381.55	OM98–203	421.60–421.80
C96–22	336.70–336.80	C96–96	381.95–382.10	OM98–202	423.10–423.20
C96–23	337.30–337.40			OM98–201	424.13–424.31

Collected by Peep Männik (C96–...), Olle Hints (OM98–...) and Jaak Nõlvak (JN85), all from the Institute of Geology at Tallinn Technical University.

Short description of thin sections from the dolostones and marls of the Porkuni Stage

Sampled level (m)	Texture of the micritic component	Quartz grains		Notes
		Diameter (mm)	Relative abundance	
314.9	very finely crystalline to microcrystalline	–	–	pyrite aggregates, microbedding
316.7	microcrystalline to very finely crystalline	<0.05	rare	–
316.9	microcrystalline to very finely crystalline	–	–	numerus pyrite aggregates
317.3–317.4	microcrystalline to very finely crystalline	<0.05 (0.07)	rare	pyrite aggregates
318.0	very finely crystalline to microcrystalline	0.004–0.06	single	pyrite aggregates
318.7	microcrystalline	–	–	in places recrystallized
319.8	microcrystalline	0.004–0.06	rare, poorly sorted	pyrite aggregates, intra- and bioclasts, bioturbated
320.55	microcrystalline	<0.05	rare	pyrite aggregates, burrows
322.2	very finely crystalline to microcrystalline	<0.05	rare	in places recrystallized
322.6–322.7	microcrystalline to very finely (and finely) crystalline	(0.05–0.1)	up to 25%	pyrite aggregates, burrows
324.4–324.5	microcrystalline to very finely (and finely) crystalline	<0.05	rare, subangular	rare bioclasts

Collected by Jaak Nõlvak and Asta Oraspõld, described by Asta Oraspõld (both from Institute of Geology at Tallinn Technical University).

APPENDIX 12

List of ostracode samples from the Valga (10) core

Sample	Sampled interval (m)	Sample	Sampled interval (m)	Sample	Sampled interval (m)	Corrected depth (m)
V–1	311.30–311.40	V–47	344.75–344.85	V–94	380.80–380.90	
V–2	311.90–312.00	V–48	345.40–345.50	V–95	381.10–381.25	
V–3	312.45–312.55	*V–49*	*346.20–346.30*	V–96	381.83–381.94	
V–4	312.75–312.85	V–50	347.00–347.10	V–97	382.20–382.32	
V–5	313.10–313.20	V–51	347.55–347.65	V–98	382.80–382.92	
V–6	313.80–313.85	V–52	348.35–348.45	V–99	383.25–383.37	
V–7	314.85–314.90	V–53	349.05–349.15	V–100	383.78–383.92	
V–8	315.70–315.80	V–54	349.90–350.00	V–101	384.40–384.52	
V–9	*316.50–316.60*	V–55	350.80–350.90	V–102	384.98–385.07	
V–10	317.20–317.30	V–56	351.60–351.70	V–103	385.60–385.70	
V–11	317.70–317.80	V–57	352.25–352.35	V–104	386.00–386.10	
V–12	318.50–318.60	V–58	353.00–353.10	V–105	386.50–386.60	
V–13	319.05–319.15	V–59	353.80–353.90	V–106	386.70–386.80	
V–14	319.65–319.72	V–60	354.72–354.82	V–107	387.48–387.60…	...387.60
V–15	320.35–320.45	V–61	355.37–355.47	V–108	388.20–388.30…	...388.40
V–16	320.95–321.05	V–62	355.87–355.97	V–109	388.83–388.95…	...389.10
V–17	321.65–321.75	V–63	356.65–356.75	V–110	389.55–389.65…	...390.00
V–18	322.30–322.40	V–64	357.50–357.60	V–111	390.20–390.35…	...390.90
V–19	322.90–323.00	V–65	358.52–358.63	V–112	391.13–391.23…	...391.90
V–20	323.60–323.70	V–66	359.40–359.53	V–113	391.80–391.95…	...392.70
V–21	323.95–324.05	V–67	360.45–360.58	V–114	392.60–392.70…	...393.70
V–22	*324.55–324.63*	V–68	361.28–361.38	V–115	394.45–394.52…	...394.50
V–23	*324.90–324.97*	V–69	361.95–362.04	OM98–230	394.97–395.15	
V–24	*325.65–325.73*	V–70	362.37–362.48	OM98–229	395.80–395.90	
V–25	326.40–326.50	V–71	362.80–362.91	OM98–228	396.75–397.00	
V–26	326.95–327.05	V–72	363.15–363.26	OM98–227	397.70–397.90	
V–27	328.00–328.07	V–73	365.83–365.92	OM98–225	400.05–400.23	
V–28	329.00–329.10	V–74	366.74–366.80	OM98–224	401.15–401.21	
V–29	329.75–329.85	V–75	367.50–367.60	OM98–223	401.80–402.00	
V–30	330.60–330.70	V–76	368.28–368.37	OM98–222	403.32–403.42	
V–31	331.80–331.87	V–77	368.84–368.95	OM98–221	403.90–404.07	
V–32	332.60–332.70	V–78	369.25–369.37	OM98–220	405.12–405.22	
V–33	333.75–333.83	V–79	369.88–370.00	OM98–219	406.08–406.30	
V–34	334.40–334.50	V–80	370.70–370.80	OM98–217	407.80–407.97	
V–35	335.05–335.12	V–81	371.30–371.42	OM98–216	408.88–408.97	
V–36	336.13–336.20	V–82	371.92–372.02	OM98–215	409.85–410.08	
V–37	*336.75–336.85*	V–83	372.85–372.96	OM98–214	410.80–410.86	
V–38	*337.60–337.70*	V–84	373.64–373.76	OM98–213	411.85–412.03	
V–39	338.50–338.60	V–85	374.28–374.35	OM98–212	412.90–413.05	
V–40	*339.25–339.35*	V–86	375.05–375.15	OM98–211	413.70–413.90	
V–41	*340.10–340.20*	V–87	375.90–375.97	OM98–209	415.88–416.06	
V–42	340.90–341.00	V–88	376.90–377.00	OM98–207	417.96–418.04	
V–43	341.75–341.85	V–89	377.85–377.92	OM98–205	419.63–419.86	
V–44	342.60–342.70	V–90	378.70–378.80	OM98–204	420.80–420.96	
V–45	343.50–343.58	V–91	379.45–379.60	OM98–203	421.60–421.80	
V–46	344.10–344.20	V–92	379.95–380.08	OM98–201	424.13–424.31	
		V–93	380.35–380.47			

Collected by Tõnu Meidla (V–…; Institute of Geology, University of Tartu) and Olle Hints (OM98–…; Institute of Geology at Tallinn Technical University). Samples in italics were not used in this work.

APPENDIX 14

Results of the X-ray diffractometry of the Ashgill sediments of the Valga (10) core (in per cent)

Sample	Sampled level (m)	Formation	Illite	Smectite	Smectite/ illite	Pyrite	Gypsum	Albite	Ortho-clase	Quartz	Dolomite
10–3139	313.9	Saldus						1.4	3.4	25.6	69.6
10–3351	335.15	Jelgava				43.1	48.7				8.2
10–3359	335.9	Jelgava	29.1		19.4			11.2	18.9	7.2	14.2
10–3398	339.8	Jelgava	23.8	1.8	11.4			5.7	9.8	6.3	41.2

Analysed by Jaan Aruväli (Institute of Geology, University of Tartu).

APPENDIX 15

List of the samples from the Caradoc sediments of the Valga (10) core

Sample	Sampled interval (m)	Corrected depth (m)	Formation
V–91	379.45–379.60	379.60	Rägavere
V–92	379.95–380.08	380.00	Mossen
V–93	380.35–380.47	380.40	Mossen
V–94	380.80–380.90	380.90	Mossen
V–95	381.10–381.25	381.20	Mossen
V–96	381.83–381.94	381.90	Mossen
V–97	382.20–382.32	382.30	Mossen
V–98	382.80–382.92	382.90	Mossen
V–99	383.25–383.37	383.30	Mossen
V–100	383.78–383.92	383.90	Mossen
V–101	384.40–384.52	384.50	Mossen
V–102	384.98–385.07	385.00	Mossen
V–103	385.60–385.70	385.70	Mossen
V–104	386.00–386.10	386.10	Mossen
V–105	386.50–386.60	386.60	Mossen
V–106	386.70–386.80	386.80	Mossen
V–107	387.48–387.60	387.60	Blidene
V–108	388.20–388.30	388.40	Blidene
V–109	388.83–388.95	389.10	Blidene
V–110	389.55–389.65	390.00	Blidene
V–111	390.20–390.35	390.90	Blidene
V–112	391.13–391.23	391.90	Adze
V–113	391.80–391.95	392.70	Adze
V–114	392.60–392.70	393.70	Adze
V–115	394.45–394.52	394.50	Adze

X-ray diffractometry and grain-size analysis were performed
in the Institute of Geology, University of Tartu.