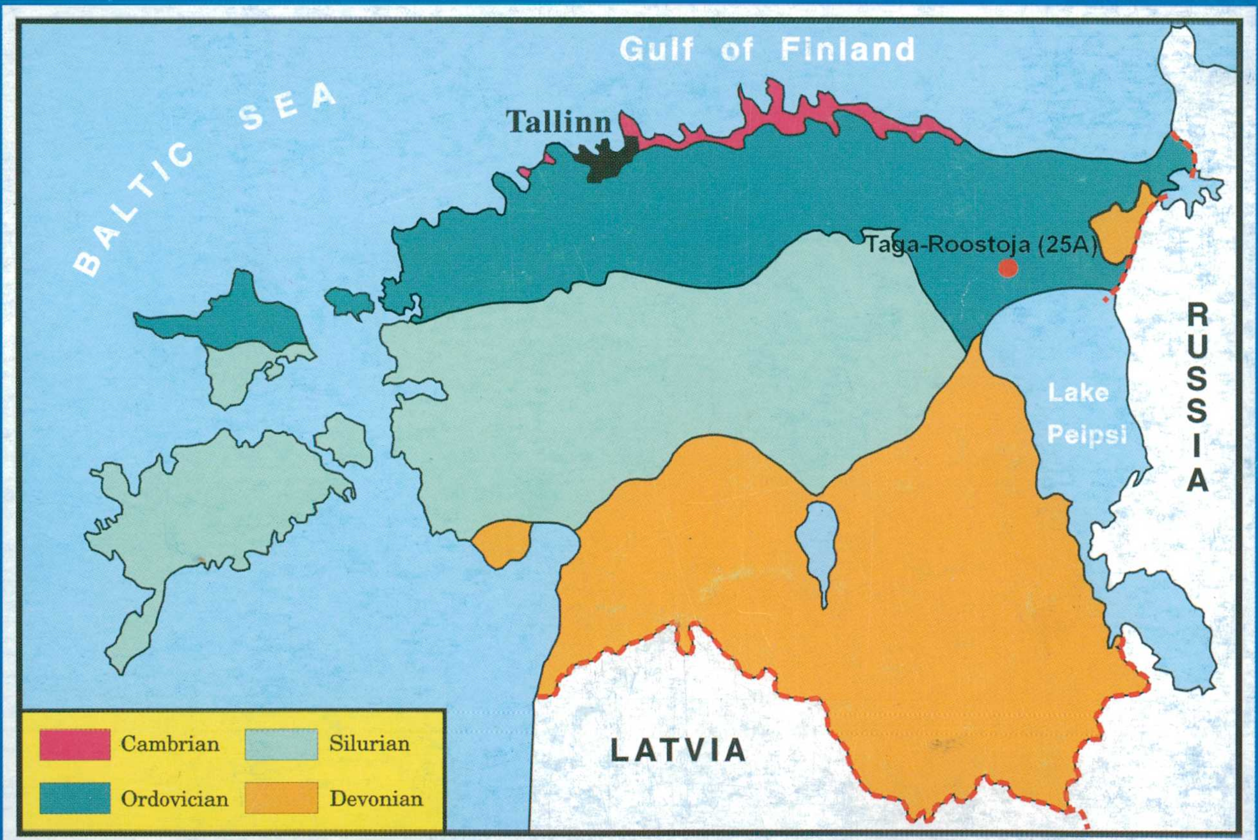
EESTI GEOLOOGIAKESKUS
GEOLOGICAL SURVEY OF ESTONIA

ESTONIAN GEOLOGICAL SECTIONS

BULLETIN 2

TAGA-ROOSTOJA (25A) DRILL CORE



TALLINN 1999

Estonian Geological Sections
Ilmub 1998 aastast

Eesti Geoloogiakeskuse geoloogiline ajakiri. Ilmub ebaregulaarselt, kuid mitte vähem kui üks number aastas. Artiklid on eesti ja inglise keeles.

Toimetus: Kadaka tee 80/82, 51013 Tallinn
Tel. (2) 672 0094
Faks (2) 672 0091
E–post egk@egk.ee

Koostaja: Anne Põldvere
Keeleline toimetaja: Anne Noor
Küljendaja: Madli Luuk
Kaanekujundus: Heikki Bauert

Estonian Geological Sections
Published since 1998

Geological journal of the Geological Survey of Estonia. The journal is published irregularly, at least one number every year. Articles are in the Estonian and English languages.

Editorial office: Kadaka tee 80/82, 51013 Tallinn
Tel. (372) 672 0094
Faks (372) 672 0091
E–post egk@egk.ee

Editor: Anne Põldvere
English text revision: Anne Noor
Layout: Madli Luuk
Cover design: Heikki Bauert

ISSN 1406-3476

EESTI GEOLOOGIAKESKUS
GEOLOGICAL SURVEY OF ESTONIA

ESTONIAN GEOLOGICAL SECTIONS

BULLETIN 2

TAGA-ROOSTOJA (25 A) DRILL CORE

TALLINN 1999

CONTENTS

Preface. *Anne Põldvere* 3
Introduction. *Anne Põldvere* 3
Core description and terminology. *Anne Põldvere* 4
General geological setting. *Anne Põldvere, Kaisa Mens, Heino Koppelmaa* 5
Distribution of conodonts. *Viive Viira, Peep Männik* 9
Distribution of chitinosoans. *Jaak Nõlvak* 10
Geochemistry of rocks. *Jaan Kivisilla* 12
Overview of kukersite oil shale beds. *Anne Põldvere* 18
References 20

Appendix 1. Description of the Taga-Roostoja (25A) core 24
Appendix 2. Thin sections from Palaeoproterozoic rocks of the Taga-Roostoja (25A) core 39
Appendix 3. List of conodont samples from the Taga-Roostoja (25A) core 40
Appendix 4*. Distribution of conodonts in theTaga-Roostoja (25A) core
Appendix 5. List of chitinozoan samples from the Taga-Roostoja (25A) core 41
Appendix 6*. Distribution of chitinozoans in the Taga-Roostoja (25A) core
Appendix 7. Results of semiquantitative emission spectral analyses of major and trace elements in Palaeoproterozoic rocks of the Taga-Roostoja (25A) core 42
Appendix 8. Results of semiquantitative emission spectral analyses of major and trace elements in Ordovician rocks of the Taga-Roostoja (25A) core 43
Appendix 9. Chemical composition of Palaeoproterozoic rocks of the Taga-Roostoja (25A) core (in per cent) 45
Appendix 10. CaO, MgO, CO_2 and insoluble residue in Ordovician rocks of the Taga-Roostoja (25A) core 46

Plates 1-4. Selected intervals of the Taga-Roostoja (25A) core

*foldout

PREFACE

In 1995, detailed complementary study of high-quality cores drilled in the course of geological mapping and prospecting for mineral resources and groundwater supplies was initiated by the Geological Survey of Estonia. The first issue in a series of monographic reports on the most important core sections of Estonia deals with the Tartu (453) drill core located in southern Estonia (Põldvere, 1998). It gives an overview of the lithology and stratigraphy based on the data of ten Estonian and foreign geologists on the distribution of different microfossils. The short review of the geological structure of the section and theoretical discussions presented in the first part of the report are supplemented by appendices on the lithology of the core and laboratory data. Further issues are planned, which would provide comprehensive descriptions of selected unique drill cores and detailed characterization of the geological structure of different regions of Estonia and give a picture of the present state of geological studies.

During the complementary study of a section the core will be relabelled, photographed and its systematic description will be provided, taking the main characteristics of the rock into account. For the problematic parts of the section, additional micropalaeontological analyses will be carried out and different methods for the laboratory examination of clastic sediments and carbonate rocks will be applied. In order to get information about the mineral composition and characteristics of the rock, the lithological description of the core will be supplemented by photo-logs and a generally accepted legend. The source material for this issue is available in an unpublished report (Põldvere *et al.*, 1997), deposited in the Estonian Geological Fund, Kadaka tee 80/82, Tallinn.

INTRODUCTION

The Taga-Roostoja (25A) borehole (latitude 6552.9 km, longitude 5509.9 km) is located in NE Estonia, in the NW part of the East European Platform (Fig. 1), between the settlements of Tudulinna and Iisaku, west of the village of Roostoja. The hole was drilled in autumn 1987, during the complex geological-hydrogeological mapping (at a scale of 1:50 000) of the southern part of the Estonia oil shale deposit (Saadre *et al.*, 1987). The core extracted is housed in the depository of the Geological Survey of Estonia at the settlement of Piirsalu in West Estonia.

The 332.8 m deep Taga-Roostoja borehole penetrates the upper 27 m of the Estonian Palaeoproterozoic section and the 295.3 m thick Vendian, Cambrian and Ordovician sedimentary cover of rocks (Fig. 2). The mentioned rocks are covered by 10.5 m thick loose Quaternary deposits. The Palaeoproterozoic sediments of Estonia are slightly dipping southwards, which causes a similar inclination of Vendian, Cambrian and Ordovician beds. Temporary breaks in sedimentation have not usually brought about changes in the bedding.

Many people have assisted in preparation of this report.The macrolithological characterization (improved using results of various spectral and chemical analyses and thin section data) of the Ordovician part of the core section was compiled by Anne Põldvere (Geological Survey of Estonia). As supplementary material the description of the part from the upper boundary of the Cambrian up to the Kukruse Stage by Tõnis Saadre (Saadre *et al.*, 1987) was used. The description of the Vendian and Cambrian sediments is based on unpublished materials by Kaisa Mens (Institute of Geology at Tallinn Technical University). Thin sections of the Palaeo-

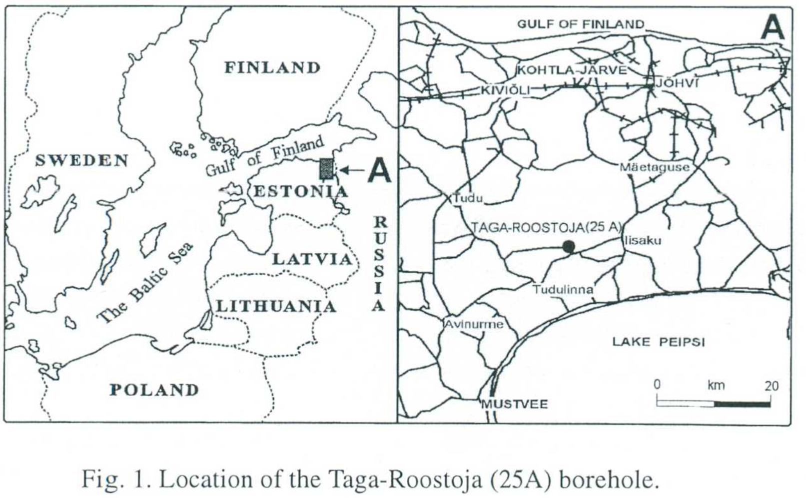


Fig. 1. Location of the Taga-Roostoja (25A) borehole.

proterozoic rocks and chemical analyses were provided by Heino Koppelmaa (Geological Survey of Estonia). Samples for the spectral analyses of Palaeoproterozoic rocks were taken by Jaan Kivisilla (Geological Survey of Estonia) and Ain Põldvere (Geological Survey of Estonia), of Ordovician carbonate rocks (from Haljala to Nabala stages) by Anne Põldvere. Samples for the determination of CaO, MgO, CO_2 and insoluble residue in the Ordovician sediments (Aseri to Nabala stages) were collected by Anne Põldvere.

To improve the stratigraphic subdivision of the Taga-Roostoja section, its Ordovician part was sampled additionally for microfossils. Chitinozoans (from the Billingen to Haljala stages and from the Rakvere to Nabala stages) were identified by Jaak Nõlvak, data on conodonts were improved by Peep Männik and, from the Billingen to Kukruse stages, by Viive Viira (all from the 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 and Anne Põldvere and Elar Põldvere prepared the manuscript in the computer.

Linda Hints (Institute of Geology at Tallinn Technical University) and Peeter Vingisaar (Geological Survey of Estonia) kindly revised the manuscript. Their constructive reviews significantly improved the quality of the report. Mati Niin (Geological Survey of Estonia) made valuable suggestions on terminology for detailed description of Palaeoproterozoic strata. Discussions with Vello Kattai (Geological Survey of Estonia) greatly aided the understanding of the problems of oil shale geology. Useful comments by Tõnu Meidla (Institute of Geology, University of Tartu) were of great help in giving the report a proper form. Thanks are addressed to all colleagues for assistance at several stages of the work.

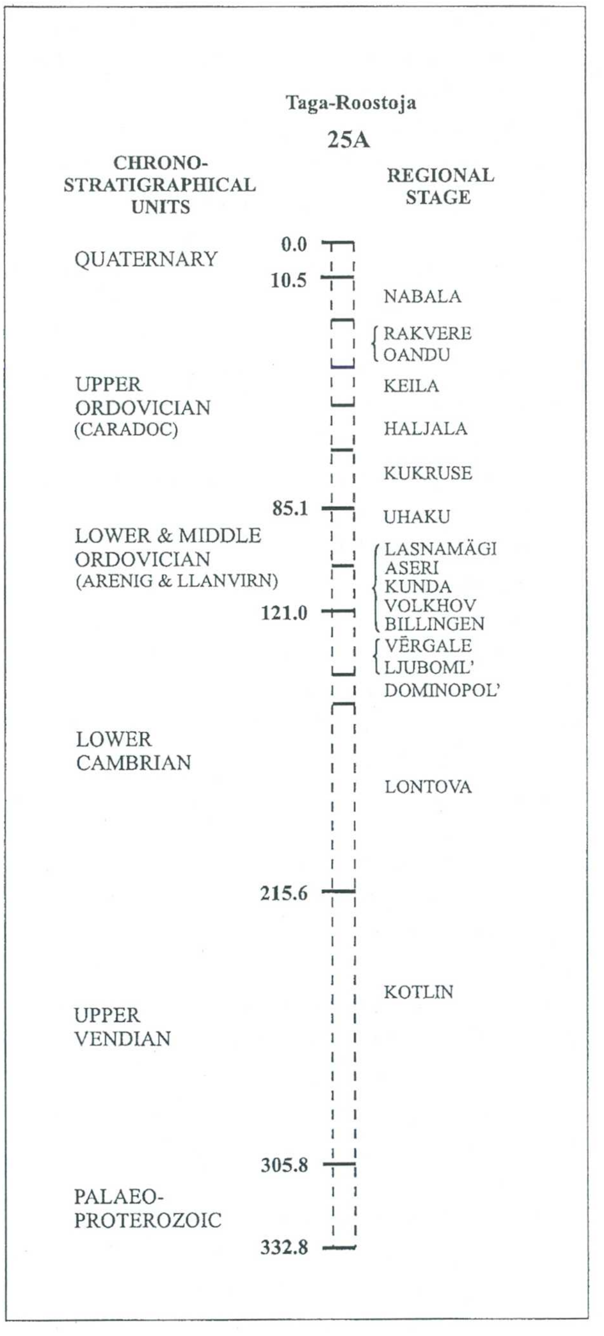


Fig. 2. Generalized stratigraphy of the Taga-Roostoja (25A) core section.

CORE DESCRIPTION AND TERMINOLOGY

The description of the Taga-Roostoja (25A) core is presented in the form of a table including the main lithological features of the rock (Appendix 1). Altogether 62 chemical analyses, 63 semiquantitative emission spectral analyses, 166 analyses of microfossils and 8 thin sections were used for age specification. In order to determine the degree of dolomitization of the carbonate rocks, 3% hydrochloric acid was used during field work. By visual estimations (controlled by chemical analyses), the content of clay, the commonest terrigenous component in carbonate rocks, was assessed as follows (Oraspõld, 1975): slightly argillaceous (insoluble residue 10–15%), medium argillaceous (15–20%) and highly argillaceous (20–25%).

The descriptions of the textures of carbonate rocks are based on the traditional Estonian classification of carbonate rocks (Vingisaar *et al.*, 1965;

Loog & Oraspõld, 1982), where the relative amounts of clastic and micritic components are crucial to identification of the textures. To allow a better understanding of the terminology, the comparison of the Estonian classification with Dunham's classification (Dunham, 1962; Põldvere & Kleesment, 1998) is given in Appendix 1. To avoid misunderstandings, the content of carbonaceous clasts (including bioclasts) is given, if possible, in per cent.

The particles with the diameter above 0.05 mm are described as grains. For the major part of the core, the amount of grains was determined with the magnifying glass on the slabbed surfaces of the core. Of great importance were skeletal remnants of organisms or their fragments (bioclasts). 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 crypto- (crystal sizes < 0.005 mm), micro- (0.005–0.01 mm) and very finely crystalline (0.01–0.05 mm) were 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 and appeared due to the recrystallization of the sediment during diagenesis and catagenesis. 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 words as appositions. The same principles were followed in derivation of descriptive terms for the other characteristics of the rock too.

During sedimentation several external (discontinuity surfaces, ripple marks) and internal structures (layered or nodules) of beds were formed. The variation of these structures in the Taga-Roostoja (25A) core is illustrated in Pls 1–4. Discontinuity surfaces are marked in the core description (Appendix 1).

To characterize the internal structures, 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. Intervals without visually observable bedding are referred to as massive. The bedding may be described as horizontal or wavy. Very often carbonate rocks (especially the varieties containing clay) are characterized by nodular structures, which are divided into seminodular and nodular ones. In case of seminodular structure, carbonate rock contains numerous irregularly diverging laminae or patches of argillaceous material, but only a few distinct nodules. In case of nodular structure, the limestone/marl ratio is roughly 1:1, or marl dominates. 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 sandstones is based on the generally used 5-fractional classification of Pettijohn *et al.* (1987), where the diameter of the finest sand particles is 0.05 mm instead of 0.0625 mm of Pettijohn (1949) and Švanov (1969). In this paper the following fractions and terms are used: 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.

GENERAL GEOLOGICAL SETTING

The Precambrian basement in Estonia consists of two megaunits: the orogenic Svecofennian complex of metamorphic and plutonic rocks and the anorogenic complex of plutonic rapakivi granites and related rocks (Puura *et al.*, 1997). The rocks of the composite synclinal zone of northeastern Estonia belong to the amphibolite facies (Fig. 3). The geological section of the area is characterized by rhythmic alternation of aluminium-rich gneisses and mica gneisses. In places the rocks are enriched with graphite and sulphide, forming so-called black schists. The migmatized gneisses, strongly enriched with quartz-plagioclase-microcline material, are analogues of the Ladoga Series of southern Karelia. Geophysical mapping has shown that this rock complex is over 1 km thick in northeastern Estonia.

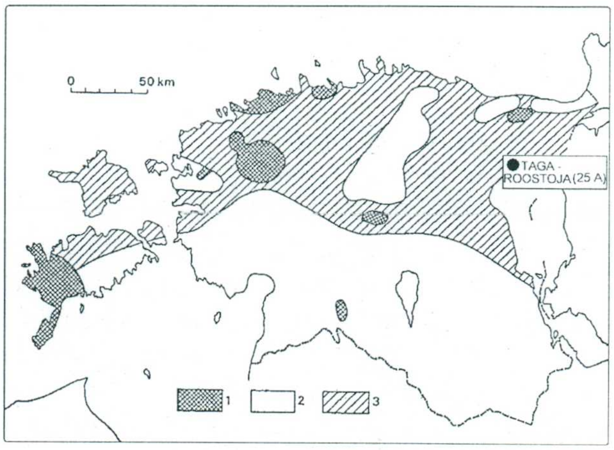


Fig. 3. Metamorphic zonation of the Precambrian basement in Estonia (after Puura *et al.,* 1997). 1, post-metamorphic; 2, granulite facies; 3, amphibolite facies.

In the Taga-Roostoja (25A) core (interval 305.8–332.8 m; Appendix 1, sheet 13; Pl. 4, figs 37–39), Svecofennian orogenic metamorphic rocks of the Alutaguse Zone (northeastern part of Estonia; Puura *et al.*, 1997) are exposed in a thickness of 27 m. Here predominate gneisses containing biotite, cordierite, garnet and sillimanite (Appendix 2), which have been subjected to high-grade metamorphism.

The upper part of Palaeoproterozoic rocks is weathered. On the north coast of Lake Peipsi the thickness of the weathering crust increases from 10 m in the west to 64 m in the east, reaching 16.0 m in the Taga-Roostoja (25A) core. The lower part of the weathering crust consists of montmorillonite, kao-linite and illite, the upper part of kaolinite. In other core sections of the region also more recent hydrothermal evidences (for example, small carbonate veins, in places containing sulphides) can be observed everywhere.

The eroded and weathered surface of the Palaeoproterozoic crystalline basement is overlain by the sedimentary cover beginning with the Vendian rocks of Late Proterozoic age. In Estonia the Vendian sequence is represented only by its uppermost part corresponding to the Kotlin Stage (Mens & Pirrus, 1997a). The thickness of the Kotlin Stage is 90.2 m in the Taga-Roostoja (25A) core (interval 215.6–305.8 m; Appendix 1, sheets 9–12; Pls 3, 4, figs 29–36).

The thickest and stratigraphically the most representative sections are situated in northeastern Estonia. In a westerly direction, the Vendian sections thin out rather rapidly and change in lithology; they are lacking in southwestern Estonia and in some local structures (Fig. 4; Mens & Pirrus, 1997a).

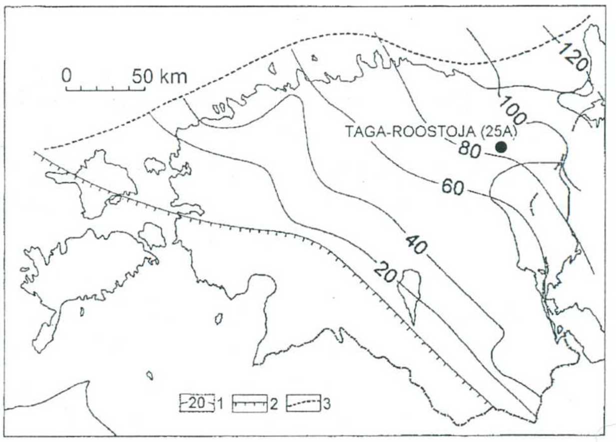


Fig. 4. Distribution of Vendian rocks in Estonia (after Mens & Pirrus, 1997a). 1, isopachs; 2, limit of the present-day distribution of rocks; 3, line of erosion (northern limit of the present-day distribution of successive Cambrian rocks).

The lower boundary of the Kotlin Stage coincides with the base of the sedimentary cover in Estonia and is easy to determine. Differently from many regions of the world, on the East European Platform the whole Vendian sequence is represented by a noncarbonate complex of siliciclastic sediments (Pirrus, 1993). Investigation of the Vendian sediments, especially their authigenic mineral assemblage and sedimentary structures, has allowed of the conclusion that the Kotlin sedimentation took place in brackish environments under cool and humid climatic conditions (Mens & Pirrus, 1974; Pirrus, 1992). Fossils are of uneven distribution and low diversity, occurring mainly in grey clayey rocks in the middle of the stage (Paškevičiene, 1980).

On the basis of differences in rock composition, accompanied by variation in colour, the deposits of the Kotlin Stage are subdivided into three formations. From below, these are the Gdov (sandstones and siltstones; thickness 44.6 m), Kotlin (silty claystones; thickness 22.8 m) and Voronka (sandstones and silty claystones; thickness 22.8 m) formations, forming a succession typical of East Estonia.

In the Taga-Roostoja (25A) drill core the Vendian sequence is overlain by 94.6 m thick Lower Cambrian sediments (interval 121.0–215.6 m; Appendix 1, sheets 5–9; Pl. 3, figs 24–29).

Cambrian rocks are exposed in outcrops along the Baltic Klint, but the data for the study have mostly been obtained from drill cores (Mens & Pirrus, 1997b). The lower boundary of the Cambrian is clear in eastern and central Estonia. It is marked by the appearance of primitive mineralized skeletal fossils and changes in the composition of ichno- and phytofossils and in the mineral composition (Pirrus, 1993; Mens & Pirrus, 1997b).

Lower Cambrian rocks, especially the lowermost beds (so-called pretrilobite Lower Cambrian), are widespread and relatively thick, in places over 80 m. The succession, however, is incomplete in Estonia and varies largely from region to region. These rocks are missing only in southern Estonia and on some peninsulas on the south coast of the Gulf of Finland (Fig. 5).

The depositional conditions changed completely on the East European Platform beginning with the pretrilobite Early Cambrian age. Though the configuration of the sedimentation area and the main direction of the transgression remained unchanged, the rock composition refers to a distinct rearrangement in the hydrochemical regime of the basin: the influence of volcanism stopped, red-coloured sediments disappeared, kaolinite fell out of the clay component (Pirrus, 1993). The sedimentation was dis-

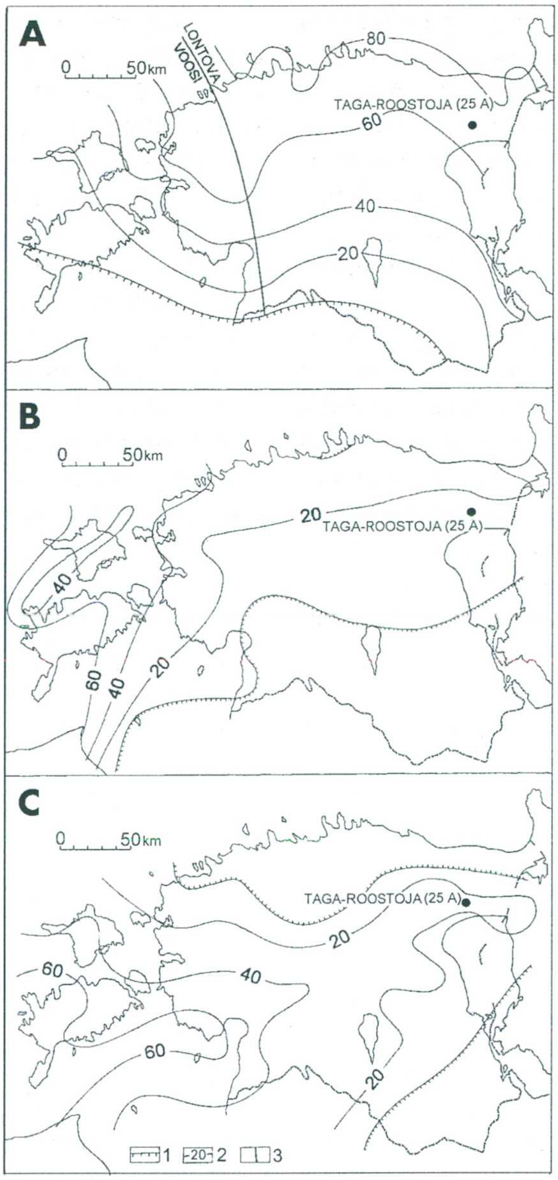


Fig. 5. Distribution and thickness of Lower Cambrian rocks in Estonia. Lontova (A), Dominopol' (B) and Ljuboml'–Vērgale (C) stages (after Mens & Pirrus, 1997b). 1, limit of the present-day distribution of rocks; 2, isopachs; 3, boundary between the Voosi and Lontova formations.

continuous due to periodic transgressions and regressions related to the general tectonic evolution of the platform (Mens & Pirrus, 1997c). The end of the pretrilobite Early Cambrian clay accumulation was marked by the regression in the sedimentary basin and extensive changes in the structural framework. The eastern subsiding area underwent an uplift and a new subsiding area formed in the west (Mens, 1981; Mens & Pirrus, 1997c). Uplift of the territory caused subsequent subaerial weathering of the topmost beds of the Lontova Stage. The contact between the Lontova Formation of the Lontova Stage and Lükati Formation of the Dominopol' Stage is marked by distinct changes in the fossil assemblages and alterations in the sedimentary conditions (Mens & Pirrus, 1997b).

During the following Early Cambrian Epoch shallow-water deposits of the Liivi (Dominopol' Stage) and Aisčiai (Ljuboml'–Vērgale stages) groups accumulated, whereas flooding events intervened with short-term sea level lowstands.

In the Taga-Roostoja (25A) core only three lithostratigraphic units are distinguished: (from base upwards) the Lontova (claystones; thickness 64.0 m), Lükati (siltstones and claystones; thickness 8.6 m) and Vaki (sandstones; thickness 22.0 m) formations, corresponding to the Lontova, Dominopol' and undivided Ljuboml'–Vērgale stages, respectively (Fig. 2).

Lower Cambrian deposits are overlain in the Taga-Roostoja (25A) core by 110.5 m thick Ordovician rocks (interval 10.5–121.0 m; Appendix 1, sheets 1–5; Pls 1–3, figs 1–24). The Ordovician sequence, with a sedimentary gap on the lower boundary and an erosional gap on the upper boundary, comprises the interval from the Billingen to Nabala stages.

The Estonian territory has the central and most important position in the outcrop area of the Baltic Ordovician rocks due to the presence of the complete sequence of the Ordovician System with its both lower and upper boundaries accordingly conforming to the Cambrian and Silurian systems (Männil, 1990). This circumstance allowed of a relatively stable detailed local classification for Ordovician rocks which afterwards obtained the status of a regional standard for most of the East European Platform (Männil, 1990). In recent years numerous Ordovician regional stratigraphic schemes have been compiled (Männil, 1990; Männil & Meidla, 1994; Nõlvak, 1997). For practical reasons, in the present paper the emended, newest correlation chart of 1997 is mainly used (Nõlvak, 1997).

During the Ordovician, the nowadays Baltoscandian area constituted the northern part of an epicontinental marine basin (Fig. 6), surrounded from the north, east and south by the Fennosarmatian land (Männil, 1966; Põlma, 1982; Jaanusson, 1995; Nestor & Einasto, 1997). The territory of Estonia is divided between the North Estonian and Central Baltoscandian confacies (Fig. 6). On the basis of the general character of carbonate sedimentation in the Ordovician, two epochs are recognized in the post-Tremadoc Ordovician in the East Baltic (Põlma, 1982; Kaljo *et al.*, 1996). In the Caradoc, near the Keila–Oandu boundary reefs appeared, and the deposition of pure lime mud was initiated in shelf areas (Einasto, 1995). The sediments which formed in shallow-water conditions occur in the nowadays outcrop area, while those formed in deeper environments are distributed in central and southern Estonia (e.g. in the Tartu (453) core; Põldvere *et al.*, 1998).

The lower boundary of the Ordovician is not easy to determine lithologically as it lies within the relatively homogeneous Kallavere Formation. Biostratigraphically, the Cambrian–Ordovician transition in Estonia is fairly well studied (Mens *et al.*, 1993; Mens & Pirrus, 1997b). The base of the Ordovician, traced by the first appearance of *Cordylodus lindstromi*, *C. intermedius* and *C. proavus* or nematophorous graptolites (Heinsalu & Viira, 1997), falls into the so-called *Obolus* Sandstone. Thus, the *Obolus* Conglomerate, so far used as a good lithological marker, remains in the Upper Cambrian (Puura & Viira, 1999). In the Taga-Roostoja (25A) core, however, sediments of the Pakerort and Varangu stages (mostly Tremadoc terrigenous sediments) are missing. The Lower Cambrian sediments are directly overlain by dolomites of the Billingen Stage (Pl. 2, fig. 19). The existing Ordovician core log is subdivided into 13 formations, which are characterized by differently dolomitized limestones, dolostones and marls. The Ordovician rocks are overlain by a 10.5 m thick Quaternary cover, formed of Pleistocene glaciolacustrine deposits (Fig. 2; Appendix 1, sheet 1).

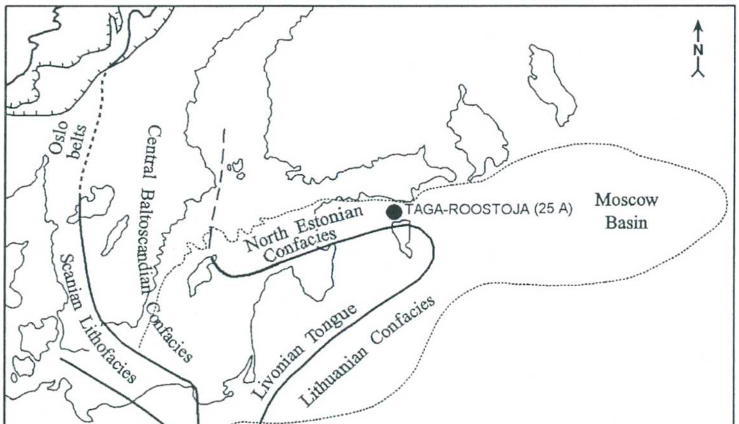


Fig. 6. Baltic Ordovician confacies belts (after Jaanusson, 1995, modified from Nõlvak, 1997).

DISTRIBUTION OF CONODONTS

A total of 90 samples, with the size from 0.5 to 1 kg, were studied for conodonts from the Taga-Roostoja (25A) core (Appendix 3). All samples yielded conodonts with the colour alteration index of about 1. The number of specimens in samples was highly variable. The richest samples came from the interval from the Aseri to Kukruse stages. Conodonts of particularly good preservation and high species diversity were found in the Aseri and Lasnamägi stages. Conodonts from the Taga-Roostoja (25A) section are referred to 32 genera and 57 species (Appendix 4). The collection is stored at the Institute of Geology at Tallinn Technical University.

The Ordovician conodont zonation of Baltoscandia was introduced by Lindström (1971) and Bergström (1971) and was subsequently modified by Löfgren (1978, 1985), Stouge (1989), Bagnoli & Stouge (1997), and Zhang (1997, 1998). In the Taga-Roostoja (25A) section 16 zones and subzones were established.

The two lowermost samples, from the depths of 120.6–120.8 m and 120.2–120.4 m, represent the *Oepikodus evae* Zone which is characteristic of the uppermost Billingen Stage. *O. evae* has been identified in the lower part and *Periodon flabellum* in the upper part of this zone. The following two zones in conodont succession – *Baltoniodus triangularis* and *B. navis* – are not known in this section, but they may occur in the unsampled interval (1.2 m) above the mentioned samples. The next two samples (from 118.9–119.0 m and 118.75–118.90 m) contained the index species of the *Paroistodus originalis* Zone characterizing the middle part of the Volkhov Stage. In the interval of 118.4–118.5 m the conodont fauna changed remarkably. Most noteworthy is the appearance of the prioniodontid genus *Lenodus*, the oldest representative of the so-called platform conodont apparatus with the amorphognathiform Pa element. The index species of the *Lenodus antivariabilis* Zone was found in the interval of 117.85–118.50 m. The identification of *L. antivariabilis,* and succeeding *L. variabilis* and *L. pseudoplanus,* must be taken with caution because most of the studied, generally rare specimens were broken. At the lower boundary of the *L. antivariabilis* Zone, *Scalpellodus gracilis* and long-ranging *Semiacontiodus cornuformis* appeared. *Scalpellodus gracilis* in this section is regarded *sensu lato* and may include also the elements of *Scalpellodus latus* (Wamel). These two taxa are morphologically similar and well-preserved material is needed to distinguish between them. The *L. variabilis* Zone was established at 115.22–117.85 m. The *L. pseudoplanus* Zone has been erected on Estonian material (Viira, 1974) and was recently included into the zonation by Zhang (1998). In the Taga-Roostoja (25A) section this zone corresponds to the interval of 110.95–114.50 m. From the same stratigraphic level rare specimens of *Microzarkodina ozarkodella*, the zonal species of the *M. ozarkodella* Subzone, were found. This zone was originally described by Löfgren (1978) and questioned by Stouge (1989), but included in the zonal scheme of Zhang (1998).

The sample from 109.95–110.1 m showed the first appearance of stratigraphically useful fauna (Appendix 4). This fauna consists of rapidly evolving successive species of the genus *Eoplacognathus* (now referred to three genera by Zhang, 1998). On the basis of the evolution of species of these genera, Bergström (1971) subdivided the Middle Ordovician of Baltoscandia into zones and subzones. In the Taga-Roostoja (25A) section the following zones (subzones) are represented: *Eoplacognathus suecicus*, *Yangtzeplacognathus foliaceus*, *Baltoplacognathus reclinatus*, *Baltoplacognathus robustus* and *Eoplacognathus lindstroemi* (Bergström, 1971). The index species of these zones (subzones), *E. suecicus* excluded, were found here in short intervals (in 1–2 samples). At the lower boundary of the *E. suecicus* Zone the first representatives of the genus *Panderodus* appeared, which range in Baltoscandia in the Aseri Stage and upwards (Viira, 1974; Löfgren, 1978). In the interval of this zone *Sagittodontina kielcensis*, known from the Mojcza section of Poland (Dzik, 1994), was found for the first time in Estonia. The fauna of the *E. suecicus* Zone in the Taga-Roostoja (25A) section is quite diverse, including *Protopanderodus varicostatus*, *Drepanodus reclinatus*, *Walliserodus iniquus*, *Triangulodus alatus*, *Erraticodon* sp., *Oslodus semisymmetricus*. *Pygodus serra*, the index species of the *P. serra* Zone, is represented by the "haddingodus" element found only in one sample from 104.65–104.75 m. In the interval of 99.58–101.92 m, between the *Baltoplacognathus robustus* and *Eoplacognathus lindstroemi* subzones, the *Yangtzeplacognathus protoramosus* Subzone was established. Originally, this zone was erected in South China by Zhang (1998) and supposed to correspond to the interval from the upper part of the *Baltoplacognathus reclinatus* Subzone to the *Eoplacognathus lindstroemi* Subzone in the Baltic area. In the present study the *Yangtzeplacognathus protoramosus* interval is preliminarily regarded in the rank of subzone, all the more that it seems to form part of the *Eoplacognathus* s.l. lineage in the Baltic. *Baltoniodus prevariabilis* is the dominating species in the *Eoplacognathus suecicus* Zone–*E. lindstroemi*

Subzone interval, that is in the Aseri and Lasnamägi stages. The occurrence of *Complexodus pugionifer* (at 93.60–98.75 m) is noteworthy because it is the second platform species in this section found for the first time in Estonia. Originally this species was described from Podolia (Drygant, 1974) and later established also in Poland (Dzik, 1976, 1994) and Great Britain (Bergström & Orchard, 1985). In all regions it occurs somewhere in the *Pygodus anserinus* Zone. In the range interval of *Complexodus pugionifer* noticeable gradual changes took place in the morphology of some species which led to the appearance of new taxa. *Baltoniodus prevariabilis* was replaced by *B. variabilis* at 97.7–97.8 m and *Drepanoistodus basiovalis* by *D. suberectus* at 99.58–99.65 m. In the interval of 96.0–97.0 m the cornuform element of *Semiacontiodus cornuformis* became shorter and stouter, so that upwards also occasional *S. bulbosus* (Löfgren) could be identified. The 20 m interval above the level of about 96.0–99.0 m contained homogeneous conodont fauna dominated by *Baltoniodus variabilis*. Other taxa were mainly represented by simple cone conodonts. At 77.85–77.97 m *Amorphognathus tvaerensis* made its first appearance, which marks the lower boundary of the *A. tvaerensis* Zone, the first zone based on the *Amorphognathus* evolutionary lineage. According to the original description of the *A. tvaerensis* Zone, three subzones – *Baltoniodus variabilis, B. gerdae* and *B. alobatus* – were recognized in this zone (Bergström, 1971). The upper boundary of the *A. tvaerensis* Zone was defined by the disappearance of *A. tvaerensis* and the appearance of *A. superbus*. In the Taga-Roostoja (25A) section the last specimens of *A. tvaerensis* came from the interval of 60.6–60.8 m (Appendix 4). The following interval (up to 49.5–49.6 m) contained no *Amorphognathus*. Higher, only unidentified fragments of elements of this genus were found. However, the uppermost specimens of *Baltoniodus alobatus* occurred in the sample from 57.5–57.7 m. It is noteworthy that above this level the number of conodonts per sample decreased considerably and several new taxa (e.g. *Pseudooneotodus* aff. *beckmanni*, *Dapsilodus*? *mutatus*) appeared. Due to the lack of *Amorphognathus* above 60.6–60.8 m, the position of the upper boundary of the *A. tvaerensis* Zone in the Taga-Roostoja (25A) section is problematic. Also, due to the poor preservation of the Pa element of *Baltoniodus* in the *A. tvaerensis* Zone, the boundaries between the *Baltoniodus variabilis*, *B. gerdae* and *B. alobatus* subzones could not be established precisely. The strata above the level of disappearance of *B. alobatus* did not contain any diagnostic conodonts.

DISTRIBUTION OF CHITINOZOANS

From the Taga-Roostoja (25A) core 76 samples were studied for chitinozoans between the depths of 21.2–27.9 m and 65.8–121.0 m (Appendix 5). Of these, 42 samples (mainly those used also for conodont study) were processed at the Institute of Geology at Tallinn Technical University, 21 samples were prepared at the Geological Survey of Estonia and 13 samples from the beds between 65.9 m and 67.6 m were provided by Garmen Bauert. The collection of chitinozoans is stored at the Institute of Geology at Tallinn Technical University.

The sample size varied from 0.3 to 1 kg, being commonly over 0.5 kg. Eleven samples were barren, or only some indeterminable fragments were found. In almost all cases the main reason for the unproductiveness of samples is secondary dolomitization of the rock which has destroyed organic-walled microfossils, except some rare acritarchs, in the lowermost Ordovician, between 118.7 m and 121.0 m. Relatively bad preservation of chitinozoans, also caused by dolomitization, is characteristic of all beds of the Billingen to Kunda stages as well as of a bit higher beds, up to the level of 108.9 m. Altogether, 57 chitinozoan taxa were distinguished, which are presented in Appendix 6. Their stratigraphical distribution is analysed in accordance with the chitinozoan biozonal scheme (Nõlvak & Grahn, 1993) and following the real changes in the vertical distribution of chitinozoans in this section (see Appendix 6).

The first rare chitinozoans in the Taga-Roostoja (25A) core were recorded in the samples from 117.85–117.95 m and 118.20–118.28 m. Although this portion of the section is poorly fossiliferous, some specimens of the zonal species *Conochitina cucumis* were found. The total range of that form coincides with the zone corresponding to the Langevoja Substage in the uppermost Volkhov Stage (Appendix 1, sheet 5; Appendix 6; Grahn, 1984; Nõlvak & Grahn, 1993).

Just above the 117.85 m level (see Appendices 5, 6), a new and relatively diversified association of chitinozoans appeared, among others *Cyathochitina hunderumensis* and *Conochitina decipiens*. The former was first described from the Granby impact crater (Grahn *et al.*, 1996) and has been found in other localities of Sweden, also in one sample from the lowermost Kunda Stage in the Rapla borehole section in Central Estonia (Jaak Nõlvak unpubl.), but not in North Estonian sections. *Cyathochitina hunderumensis* together with *Conochitina decipiens* allows us to correlate the corresponding beds with the Hunderum Substage of the Kunda Stage (Appendix 1, sheet 5; Appendix 6). The absence of these chitinozoans in the northernmost sections is in accordance with the well-known fact that the lowermost substage of the Kunda Stage is missing (see Männil, 1966) in North Estonia. *Conochitina decipiens* has worldwide distribution: it occurs in the peri-Gondwana sections and in Canada, South China, Brazil, Bolivia (see Heuse *et al.*, 1999), in most reliable cases in the beds of the same time interval, in the late Arenig.

The early Middle Ordovician *Cyathochitina regnelli* Zone could be distinguished in the Taga-Roostoja (25A) section only tentatively, because the zonal species itself was found only in one sample (Appendix 6). In the type locality of that zone, in the Tallinn section (Grahn, 1984), there is a gap in the lower Kunda Stage, therefore the appearance level of *Cyathochitina regnelli* is still unclear. The reasons for low frequency and the range of that species can be elucidated by further more detailed investigation of the sections where the lowermost Kunda beds are present. Consequently, the upper boundary of the *Cyathochitina regnelli* Zone can be drawn in the Taga-Roostoja (25A) section above 112.4 m and below the appearance of *Cyathochitina sebyensis* at 108.1 m, most probably at the level of the gap in sedimentation (111.1 m).

The next stratigraphically important zone is the *Laufeldochitina striata Zone*, the appearance of which marks the topmost beds of the Aseri Stage (Nõlvak & Grahn, 1993). As noticed earlier, the lower part of the zone may contain rare specimens of the index species *L. striata*, but the total range of this species defines the zone. The level of its appearance in the Taga-Roostoja (25A) section (Appendix 6), above the discontinuity surface at 106.8 m, can be controlled by the disappearance of *Belonechitina crinita* above that level and by the presence of some characteristic chitinozoans such as *Lagenochitina tumida* s.l., *Tanuchitina tallinnensis*. The data available allows of the conclusion that the lower boundary of the Lasnamägi Stage can be drawn higher than the discontinuity surface at 106.8 m, between the levels of 106.65–106.75 m and 105.60–105.75 m sampled by us.

The *Cyathochitina sebyensis* Subzone, the beds of which correspond to late Aseri–early Lasnamägi time in the type locality in Sweden (Nõlvak & Grahn, 1993), is represented by two samples: from 107.95–108.10 m and 106.80–106.90 m. Most probably these beds belong to the upper Aseri Stage in this section.

The fact that *Pterochitina retracta* and *Belonechitina pellifera* appear a little higher (above the appearance level of the next zonal species *Conochitina clavaherculi*) than was known earlier (see Nõlvak & Grahn, 1993, fig. 6) proves the possible absence of the lower beds of the Lasnamägi Stage in the Taga-Roostoja (25A) section if we correlate it with the Suhkrumägi section (see Grahn, 1984). Also, the absence of the beds corresponding to the uppermost part of the *Cyathochitina sebyensis* Subzone supports this conclusion, and the Lasnamägi Stage seems to be represented in the Taga-Roostoja (25A) section in a very restricted thickness (less than 2 m). The approximate level for the beginning of the Uhaku Stage is supposed to be between the levels of 104.65–104.75 m and 103.65–103.75 m, above the disappearance of *Belonechitina pellifera* (Appendix 6).

Higher subzones can be easily drawn by their definitions (Nõlvak & Grahn, 1993). The *Conochitina tuberculata* Subzone corresponds to the part of its range between the last occurrence of *Conochitina clavaherculi* and the first occurrence of *Eisenackitina rhenana*. The appearance level of the latter coincides very clearly with the lower boundary of the Kukruse Stage, which correlates with the lower boundary of the kukersite layer A at a depth of 85.1 m. The upper boundary of the Kukruse Stage coincides with the boundary between the *Laufeldochitina stentor* and *Lagenochitina dalbyensis* zones.

The boundary between the *Laufeldochitina striata* and *L. stentor* zones lies between the depths of 93.60–93.70 m and 90.55–90.65 m. The level of the change of these two species is in accordance with earlier data (see Männil, 1986) and coincides roughly with the lower boundary of the Erra Member of the Kõrgekallas Formation, the beds belonging to the upper part of the Uhaku Stage (Appendix 1, sheet 4; Appendix 6).

In general, the distribution and diversity of chitinozoans in the Uhaku and Kukruse stages in the Taga-Roostoja (25A) core is in good accordance with earlier data from numerous North Estonian sections (Ralf Männil, Jaak Nõlvak, unpubl.; Bauert & Bauert, 1998), even in some details such as the order of the appearance and disappearance of *Conochitina* sp. 1 and *Conochitina* sp. 2 (*C. savalaensis* nom. nud. and *C. viruana* nom. nud. in Männil, 1986; fig. 2.1.1), etc.

A very clear boundary can be drawn between the *Laufeldochitina stentor* and *Lagenochitina dalbyensis* zones. It coincides with the upper boundary of the *Eisenackitina rhenana* Subzone at a depth of 66.5 m (Appendix 6). There is a big gap in the stratigraphical record on the boundary of the Kukruse and Haljala stages marked by numerous discontinuity surfaces (see also Nõlvak, 1972). Two chitinozoan zones are missing in the lowermost part of the Haljala

Stage (see Nõlvak & Grahn, 1993; Nõlvak, 1997, 1999; Nõlvak *et al.*, 1999). It means that the boundary level can be established precisely. Thereby the range of the *E. rhenana* Subzone coincides exactly with the stratigraphical extent of the Kukruse Stage.

From the topmost part of the Taga-Roostoja (25A) core seven samples were investigated. All samples were barren, except the one that yielded taxa typical of the Nabala Stage (21.20–21.30 m, Appendix 5). The main reason seems to be secondary dolomitization, which is very characteristic of the uppermost Ordovician rocks also in other sections in a wider area (Nõlvak, 1987), not depending on the precise age of the outcropping beds (Rakvere Stage or Nabala Stage). This area in northeastern Estonia was, most probably, covered by Devonian rocks before the last Quaternary glaciation. Devonian rocks have directly influenced the underlying beds, which is observed in the effect of recrystallization on the preservation of organic-walled microfossils: heavy dolomitization destroyed those totally, especially in less argillaceous limestones. This well-known fact applies also to the uppermost Silurian beds, which nowadays lie below the Devonian rocks in many borehole sections in Central Estonia.

In general, the order of changes in the distribution of chitinozoans relatively clearly follows the one established by earlier data. Some levels, though, need more detailed sampling, especially the very restricted portion of beds belonging to the Lasnamägi Stage, but also those of the Aseri Stage. These beds are more complete in the Taga-Roostoja (25A) section, against the stratigraphically very restricted sections of northwestern Estonia. The need for more detailed data could also be stressed by the fact that in more southward sections of the Livonian Tongue (Central Baltoscandian Confacies Belt) (Fig. 6) these beds are represented by redbeds which do not contain acid-resistant microfossils as, for example, in the Tartu (453) core (see Põldvere *et al.*, 1998).

The changes in the chitinozoan succession in the investigated part of the Taga-Roostoja (25A) section clearly support the recognition of the lower boundaries of some stratigraphical units (e.g. the bases of the Kunda, Lasnamägi, Uhaku, Kukruse and Haljala stages).

GEOCHEMISTRY OF ROCKS

In order to determine general changes in the chemical composition of rocks and elucidate the problems connected with stratigraphical correlation, the semiquantitative arc emission spectral analysis of the Palaeoproterozoic, and Vendian, Cambrian and Ordovician rocks and sediments was widely applied at the Geological Survey of Estonia in the years 1967–90. To enhance the reliability and comparability of the results, a collection of natural reference samples was compiled (Kivisilla, 1970, 1982) and the relevant system of mathematical processing of data was created (Kivisilla, 1975). For widening the spectrum of the elements determined and obtaining more reliable results the samples were analysed in parallel by two different modifications of the arc emission spectrometry method: burning the probe in the crater of the electrode and strewing the probe into the arc-light (Kivisilla *et al.*, 1975). Thanks to the application of these methods, the reliability of the results of the spectral analyses of trace elements appeared to be fully comparable with those obtained by the so-called quantitative methods (XRF, AAS) used at that time.

The geochemical study of the Taga-Roostoja (25A) core is based on 63 samples, 21 of which come from the Palaeoproterozoic basement (depth interval of 312.0–332.7 m) and 42 from the Ordovician carbonate rocks (depth 10.5–66.0 m). The samples were treated at the laboratory of the Estonian Geological Survey in 1987, applying the method of semiquantitative arc emission spectral analysis. The source data for the analyses are presented in Appendices 7 and 8, respectively. Considering mainly the results of spectral analyses, the distribution of selected major and trace elements was studied, taking also the results of the chemical analyses into account (Appendices 9, 10).

The Palaeoproterozoic rocks are dominated by cordierite gneisses and amphibolites (Appendix 1, sheet 13; Pl. 4, figs 37–39). Traces of weathering are observable up to a depth of 321.8 m.

According to the geochemical regionalization, the Palaeoproterozoic strata exposed in the Taga-Roostoja (25A) core belong to the Chalcophylic District of Northeastern Estonia. In general, these strata are enriched with chalcophylic elements (S, Zn, Pb, Mo), also with Si and K, but deficient in lithophylic elements (Ca, P, Ba, Sr) (Kivisilla, 1991). The chalcophylic character of rocks is also evidenced by the occurrence of a weak Cu–Mo–Ag anomaly in the section considered (Appendix 7; samples 253210, 253227, 253317). Evidently, the anomaly is of secondary origin, because relatively high contents of these elements are observed in all three rock types (amphibolite, gneiss and migmatite granite) exposed in this core. The maximum contents of these elements (Cu 250, Mo 6 and Ag 0.25 ppm) occur in garnet-cordierite gneiss (at 321.0–322.0 m) on its contact with the granite vein. By eliminating these anomalous contents from further calculations, we found the average chemical compositions of different rock types (Table 1), which allow of several conclusions on their geochemistry.

The whole geochemical spectrum of the rocks of the core (Fig. 7) corresponds in general to that of the Earth's continental crust, differing from the latter in the deficiency of Ca, Na, Sr and Sn and in the excess of K and Ga, observable in all rock types.

Migmatite granites as felsic rocks are enriched with Si, (Al), Na, K, and trace elements Pb, Ba (both obviously related to K-feldspar) and Th; the contents of other components (especially Fe, Mg, Ca, Sc, Ti, V, Cr, Mn, Co, Ni, Zn, but also Sn, Y, Yb, B) are 1.5–5 times higher in amphibolites than in granites (Fig. 7).

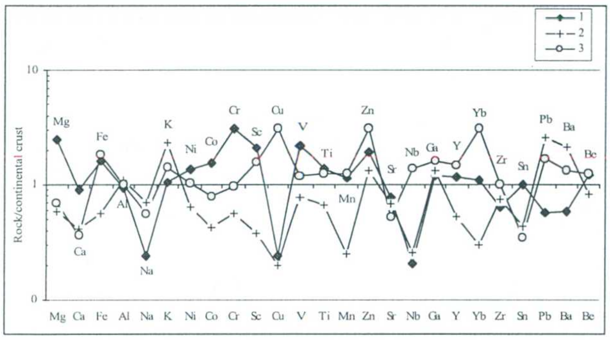


Fig. 7. Chemical composition of amphibolites (1), migmatite granites (2) and mica gneisses (3) of the Taga-Roostoja (25A) core, given as the ratio to the average values in the continental crust.

Garnet-cordierite gneisses are impoverished in Ca and Sr as compared to amphibolites and granites (Fig. 7) (the argillaceous sediments that served as parent rock for gneisses have obviously become void of these elements due to the decomposition of plagioclases and the following outwash of Ca and Sr). The contents of other elements (Cu, Zn, Zr, Nb, Y, Yb, Li) in gneisses are higher than in amphibolites and granites, or intermediate (Ti, V, Cr, Co, Ni, Pb, Ba) between them.

The comparison of the average contents of elements in these rock types with the corresponding background values in northeastern Estonia (Table 1, III) shows the geochemical similarity of the Taga-Roostoja (25A) core with the rocks of the surrounding area.

In comparison with the global averages of basaltoids, the amphibolites of the Taga-Roostoja (25A) core as well as of the whole northeastern Estonia are enriched with Mg, K, Cr, Zn, Ga, Sn, Pb, Ba and Be, and impoverished in Ca, Al, Na, Ni, Co, V, Ti, Mn, Sr and Nb. The Taga-Roostoja (25A) amphibolites, however, are richer in K, Y, Yb and Be, but poorer particularly in Cu, but also in Ca, Fe, Sn, Pb, Ba than the surrounding rocks. The chemical analyses have shown that the contents of rock-forming elements in amphibolite are very close to those in the amphibolites of the Alutaguse Zone; higher values have been recorded only for Al, Mg and Ca, and lower values for Si (cf. Appendix 9 and Table 1, line 3).

The unusually low Cu (3.5–10 ppm) in the Taga-Roostoja (25A) amphibolites, low contents of other femic elements (Ca, Sr, Mn, Ni, Zn) and higher values of the elements of the terrigenous component (Zr, Y) indicate the sedimentary origin of amphibolites so much the more because amphibolites associate with sedimentary garnet-cordierite gneisses.

Granite as well (one anomalous sample excluded) shows relatively low Cu, Mn, Sr and Sn contents as compared to the Alutaguse Zone, but 1–1.5 times higher contents of femic elements (Fe, Mg, Ca, Ti, V, Cr, Co, Ni, Zn) and Ba.

As compared to the local background values of mica gneisses, the gneisses considered are somewhat richer in many siderophylic (Fe, Sc, Ti, Cr, Co, Ni, Cu, Zn) and some felsic (Ba, Be, Nb, Y, Yb) elements. The chemical analyses have revealed the contents of rock-forming elements in gneisses very close to the averages of the mica gneisses of the Alutaguse Zone; only Ca and Na contents are a bit higher (cf. Appendix 9 and Table 1, line 10). In comparison with the global averages of shales, the gneisses of the Taga-Roostoja (25A) core as well as of the entire Alutaguse Zone tend to become poorer in Ca, Ni, V and Sn and richer in Mg, Fe, Na, Zn, Ga, Zr and Pb.

The comparison of fresh amphibolites and gneisses with the corresponding weathered varieties (Table 1, Fig. 8) has revealed a typical regularity occurring during the weathering of basement rocks: enrichment of weathered rocks with boron in particular, to a lesser degree with potassium, in case of amphibolites also with Ba, Be, Co and Fe, and their impoverishment in almost all other elements considered, especially in Mn, Ca, Na and Sr. The outwash of the last three elements is probably due to decomposition of plagioclase.

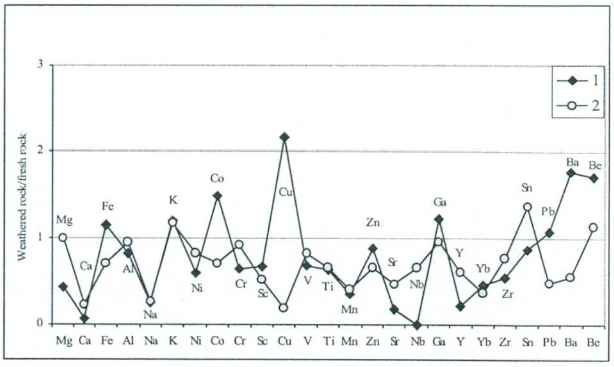


Fig. 8. Migration of elements during weathering in amphibolites (1) and mica gneisses (2) of the Taga-Roostoja (25A) core, given as the ratio of average values of weathered rock to fresh rock.

Table 1. Average chemical composition of weathered (I) and fresh (II) basement rocks of the Taga-Roostoja (25A) core, regional averages (III) of the corresponding rock groups in the Alutaguse Zone (Koppelmaa & Kivisilla, 1997), global averages (IV) of the corresponding rock groups (Turekian & Wedepohl, 1961) and global average of the continental crust (V; after Wedepohl, 1995)

No.	Rock group	n	SiO_2	Al_2O_3	Fe_2O_3t	MgO	CaO	Na_2O	K_2O	Sc	Ti	V	Cr	Mn	Co	Ni	Cu	Pb	Zn	Sn	Ga	Zr	Nb	Y	Yb	Be	Sr	Ba	B
			%							ppm																			
			Amphibolites																										
1	I	2	*45*	*11.5*	*11.5*	*4.0*	*0.4*	*0.2*	*3.0*	*22*	*3500*	*145*	*250*	*315*	*55*	*45*	*13.0*	*9.0*	*110*	*2.0*	*22*	*70*		*6.0*	*1.0*	*5.0*	*45*	*600*	*200*
2	II	5	52	14.0	10.0	9.2	4.9	0.8	2.5	33	5600	212	386	890	37	76	6.1	8.4	124	2.3	18	128	4	28.0	2.2	2.9	260	340	25
3	III	94	50	12.0	12.5	9.3	9.5	0.9	1.7	25	5700	210	370	1200	32	110	100.0	11.0	140	4.0	21	97		10.0		1.1	330	440	
4	IV		49	14.7	12.4	7.63	10.64	2.43	1.00	30	13800	250	170	1500	48	130	87.0	6.0	105	1.5	17	140	19	21.0	2.1	1.0	465	330	5
			Migmatite granites																										
5	II	2	70	16.5	3.5	2.2	2.3	2.3	5.5	6	2750	75	70	190	10	35	5.0	38.0	85	1.0	20	150	5	12.5	0.6	2.0	225	1250	15
6	III	1002	72	13.2	2.7	0.7	1.8	2.2	5.2		2200	49	33	430	5	17	29.0	42.0	58	3.4	22	160		16.0	1.3	1.5	340	560	
7	IV		74	13.6	2.0	0.27	0.71	3.48	5.06	7	1200	44	4	390	1	5	10.0	19.0	39	3.0	17	175	21	40.0	4.0	3.0	100	840	10
			Mica gneisses (incl. garnet-cordierite gneisses)																										
8	I	8	*59*	*14.3*	*8.1*	*2.6*	*0.4*	*0.5*	*4.0*	*13*	*3250*	*96*	*110*	*390*	*14*	*47*	*14.5*	*12.0*	*130*	*1.1*	*23*	*154*	*17*	*21.0*	*2.2*	*3.4*	*82*	*425*	*78*
9	II	4	59	15.2	11.5	2.6	2.0	1.8	3.4	25	5000	118	120	960	19	57	76.0	25.0	200	0.8	24	200	26	35.0	6.1	3.0	175	775	16
10	III	1482	62	16.5	8.6	3.0	2.5	1.7	3.4	12	3600	110	97	650	14	37	45.0	27.0	140	2.8	25	200		26.0	2.4	2.0	330	570	
11	IV		59	15.1	6.8	2.49	3.09	1.29	3.20	13	4600	130	90	850	19	68	45.0	20.0	95	6.0	19	160	11	26.0	2.6	3.0	300	580	100
12	V		61.5	15.1	6.28	3.7	5.5	3.2	2.4	16	4080	98	126	775	24	56	25	14.8	65	2.3	15	203	19	24	2	2.4	333	584	11

Notes:

1. Given values (I–III) calculated on the basis of semiquantitative emission spectral analysis; n, number of samples.
2. Values in italics – weathered rocks.
3. Empty cells – component not determined or content below the detection limit.
4. Fe_2O_3 t – total iron as Fe_2O_3 (Fe_2O_3 t=Fe_2O_3+1.111FeO).
5. Global averages (Turekian & Wedepohl, 1961): No. 4, basaltic rocks; No. 7, low-calcium granitic rocks (Mg, Cr, Co, Ni, after Vinogradov, 1962); No. 11, shales.

The samples of sedimentary rocks come from locally dolomitized argillaceous limestones and (in the upper part of the section) dolomites (Appendix 1, sheets 1–3; Pls 1, 2, figs 1–10), stratigraphically ranging from the Tatruse Formation of the Idavere Substage to the Saunja Formation of the Nabala Stage (Table 2).

Table 2. Stratigraphy of the Haljala to Nabala stages in the Taga-Roostoja (25A) core

Stage	Substage	Formation	Member	Interval in core
Nabala		Saunja		10.5–15.8
		Paekna		15.8–23.7
Rakvere		Rägavere	Tudu	23.7–27.7
			Piilse	27.7–37.2
Oandu			Tõrremäe	37.2–37.8
Keila		Kahula	Saue	37.8–42.4
			Pääsküla	42.4–45.9
			Kurtna	45.9–50.2
Haljala	Jõhvi		Madise	50.2–51.7
			Pagari	51.7–54.4
			Aluvere	54.4–58.7
	Idavere		Vasavere	58.7–62.6
		Tatruse		62.6–66.5

Table 3 presents the average contents of main major and trace elements in 13 stratigraphic units distinguished on the basis of the analysis of these samples. For comparison purposes, the average contents of the same elements recorded in the same units from the Tallinn–Kõrvemaa subsurface mapping area, west of the Taga-Roostoja (25A) borehole (Koppelmaa *et al.*, 1982; Kiipli *et al.*, 1984), and the average global contents of these elements in carbonate rocks (Turekian & Wedepohl, 1961) are given in Table 3.

The content of insoluble residue in carbonate rocks of the Taga-Roostoja (25A) core (as well as in those from the Tallinn–Kõrvemaa area) is 1.4–4 times as high as the global average (Table 3). Only in limestones of the Rakvere Stage the amount of insoluble residue is lower, making 44% of the calculated global average in the Tudu Member and 79% in the Piilse Member. The dependence between the main components of carbonate rocks (CaO, MgO, CO_2, IR) is shown in Fig. 9.

Greater insoluble residue values are accompanied by higher contents of the main elements occurring in clay and accessory minerals (Si, Al, Fe, Ti, Sc, Cr, Cu, Zr, Yb, La) (see, e.g., Fig. 10), but the contents of certain elements (V, Mn, Co, Ni, Pb, Sr, Ba, La) do not correlate with insoluble residue (see, e.g., Fig. 11). The contents of several of the last mentioned elements in carbonate rocks of the Taga-Roostoja (25A) core are notably lower than the global averages. However, we should mention that the contents of trace elements associated with clay and accessory minerals in the rock are not in one-to-one correspondence with the amount of insoluble residue: arranging the rock types with different clay contents in ascending order of insoluble residue content, we see that the rise in the element content of the rock falls behind the increase in the insoluble residue (see, e.g., Fig. 10).

The CaO/MgO ratio is notably higher in the carbonate rocks considered (10–40) than the global average (5.43). It is particularly high (40–41) in limestones of the Rakvere Stage where the insoluble residue is minimal (3.2% in the Tudu Member and 6.4% in the Piilse Member). Owing to the low insoluble residue, these rocks show also the lowest contents of Si, Al, Fe, Cr, Co, Ni, Cu and Ga (Table 3).

Comparison of the trends in the change of the contents of chemical elements in the Taga-Roostoja (25A) core and Tallinn–Kõrvemaa area (Table 3) revealed the same regularity: the limestones of the Rakvere Stage as the purest ones exhibited everywhere the lowest values of Si, Al, Fe, Cr, Co, Ni, Cu and Ga. In general, the V content was markedly higher and the Sr, Ga and La contents lower in the Taga-Roostoja (25A) core (this may partly be due to certain fluctuations in the results of analyses carried out at different times).

The dolomite and dolomitized limestone of the Saunja Formation with the MgO content reaching 19.66%, exposed in the upper part of the section, stand out clearly among other carbonate rocks. Dolomitization of limestone has obviously caused also an increase in Mn, Pb, Zn and Ag. The maximum

Table 3. Average contents (arithmetic means) of components in carbonate rocks of the Taga-Roostoja (25A) core (1–13) and the Tallinn–Kõrvemaa area (14–26) compared with global averages (27) of sedimentary carbonates (Turekian & Wedepohl, 1961)

No. Formation/ Member	n_1	n_2	MgO	CaO	CO_2	IR	SiO_2	Al_2O_3	Fe_2O_3t	Sc	Ti	V	Cr	Mn	Co	Ni	Cu	Pb	Zn	Ag	Sr	Ba	Zr	Ga	Y	Yb	La
			%							ppm																	
1 Saunja	*2*	3	*19.2*	*28.5*	*43.9*	*6.0*	3.8	1.0	1.1	2.3	330	22	7	1170	3	8	4.3	33		0.10	40	80	47		9	0.6	17
2 Paekna	*8*	8	*2.8*	*42.1*	*36.4*	*16.0*	7.8	2.2	0.9	4.8	1300	31	24	580	6	13	6.4	6		0.06	200	250	77	3	20	1.0	28
3 Tudu	*2*	2	*1.3*	*52.2*	*42.6*	*3.6*	2.5	0.9	0.4	2.0	500	16	10	600	2	5	4.5		30		200	190	32	2	9		20
4 Piilse	*5*	5	*1.3*	*50.8*	*41.2*	*5.1*	1.8	1.1	0.4	3.0	690	16	8	430	2	5	3.6			0.06	270	82	45	2	11	0.6	21
5 Tõrremäe	*2*	1	*0.8*	*48.0*	*38.9*	*9.4*	4.0	1.3	1.0	2.0	400	12	6	600	4	7	4.0	8		0.06	120	70	60	3	10	1.0	20
6 Saue	*2*	3	*3.4*	*40.4*	*35.3*	*17.1*	13	3.2	1.4	3.7	1500	23	18	500	6	10	6.7	10		0.06	220	120	100	3	20	1.0	27
7 Pääsküla	*2*	2	*2.1*	*45.2*	*37.7*	*12.5*	9	2.0	1.2	3.0	1500	25	15	700	5	10	7.0	6		0.06	250	120	100	3	18	1.0	22
8 Kurtna	*5*	4	*1.8*	*37.9*	*32.0*	*23.7*	20	3.2	1.5	4.0	1400	21	22	420	5	12	7.5	7		0.06	210	140	95	4	20	1.5	18
9 Madise	*2*		*3.0*	*38.0*	*33.9*	*21.4*																					
10 Pagari	*3*	1	*2.5*	*34.1*	*30.1*	*28.5*	13	3.0	1.5	4.0	2000	40	20	600	8	10	10.0	6		0.06	200	150	100	6	15	1.5	20
11 Aluvere	*5*	3	*2.0*	*39.2*	*33.1*	*21.8*	11	2.2	0.7	3.3	1300	13	13	530	2.7	6	6.7			0.06	200	100	80	3	20	0.7	22
12 Vasavere	*3*	2	*1.1*	*30.8*	*25.6*	*39.6*	20	2.5	1.0	5.0	1500	18	18	500	4.5	9	6.0				200	100	105	4.5	22	1.5	22
13 Tatruse	*6*	2	*1.6*	*45.7*	*38.2*	*11.2*	9.2	1.6	1.6	3.5	1000	15	15	700	5.5	12	5.5	7	13	0.06	190	80	75	2.5	22	1.2	22
14 Saunja		44	2.4	43			1.7	0.3	0.6		430	4.2		370		5.1	2.5	7.5			370	49	36				26
15 Paekna		62	0.9	42			6.5	1.8	0.9	3.0	1100	13.0	21.0	390	3.2	10.0	4.4	7.0			230	95	61	4.7	12		32
16 Tudu		23	0.6	44			2.4	0.8	0.5		570	3.6	5.5	330		5.3	2.6	6.5			240	52	45				30
17 Piilse		29	1.4	40			2.8	0.9	0.6		620	5.6	6.4	460		5.9	2.7	6.8			300	56	42	0.0			34
18 Tõrremäe		14	0.7	44			6.2	2.2	1.3	3.4	1000	7.0	12.0	430	3.8	10.0	5.8	20.0			240	84	62	4.2	12	0.5	30
19 Saue		14	1.6	40			14	3.1	1.7	3.7	1500	12.0	23.0	460	5.1	9.5	7.4	10.0			340	190	110	8.1	14	1.2	32
20 Pääsküla		15	1.0	41			6.8	1.9	0.9	2.6	1000	7.0	15.0	400	3.3	8.2	4.8	6.0			280	120	70	3.4	11		26
21 Kurtna		22	1.1	40			12	3.2	1.0	3.6	1300	13.0	19.0	500	4.0	10.0	6.6	7.0			340	220	100	5.3	17	1.4	32
22 Madise		6	1.3	39			11	2.8	1.4	4.2	1300	18.0	23.0	540	4.4	14.0	7.3	5.9			300	180	86	5.4	22	1.4	37
23 Pagari		6	2.2	31			13	3.6	2.2	4.8	1600	21.0	39.0	520	6.6	17.0	8.7	6.4			300	165	120	9.2	14	1.2	41
24 Aluvere		6	1.4	42			14	3.6	1.0	4.0	1200	9.6	26.0	520	3.5	9.5	8.0	7.9			340	180	90	8.0	18	1.4	36
25 Vasavere		4	0.6	38			9.4	3.4	1.2	5.4	1400	9.6	20.0	490	3.2	9.0	5.6	8.3			240	140	110	7.8	27	1.3	34
26 Tatruse		4	0.7	45			4.8	1.6	1.0	2.8	1400	11.0	14.0	640	3.4	10.0	5.2	8.1			230	98	100	3.4	23	0.6	26
27 Global average			7.79	42.3		(8.14)	5.14	0.79	0.54	1	400	20	11	1100	(7.0)	20	4	9	20	0.0X	610	(190.0)	19	4	30	0.5	X

Notes:

1. Figures in italics – results of chemical analyses; others – results of semiquantitative emission spectral analyses.
2. Empty cells – component not determined or content below the detection limit.
3. Global average of insoluble residue (IR) for carbonates calculated as 100%–$MgCO_3$–$CaCO_3$.
4. Global averages of Co, Ba, La are taken from the column "Deep sea carbonate sediments", other figures from the column "Sedimentary rocks: carbonates"(Turekian & Wedepohl, 1961).
5. Fe_2O_3 t – total iron as Fe_2O_3 (Fe_2O_3 t=Fe_2O_3+1.111FeO).
6. n, number of samples (n_1, chemical analyses; n_2, semiquantitative emission spectral analyses).

contents of these elements (Mn 1500, Pb 60, Zn 100, Ag 0.2 ppm) occur in the interval of 14.5–15.8 m, on the endocontact of dolomitized rocks with undolomitized or slightly dolomitized rocks. Apart from the mentioned elements, the dolomitic rocks of the Saunja Formation are richer in Si, Al, Fe, V, Mn, Ni and Cu in the Taga-Roostoja (25A) core than the corresponding but not dolomitized rocks in the Tallinn–Kõrvemaa area. From this we may conclude that, as a result of the replacement of limestone by dolomite, apart from Mg, the rock becomes enriched also with Fe, Mn, Ni, Cu, Pb, Zn and Ag, but highly impoverished in Ca and Sr. Higher contents of Si and Al in the Saunja Formation of the Taga-Roostoja (25A) core may be due to a somewhat greater clay content of the rocks in comparison with the Tallinn–Kõrvemaa area.

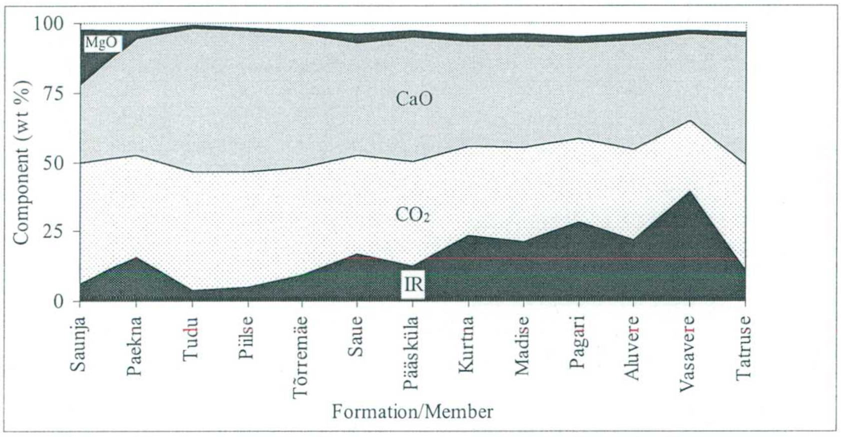


Fig. 9. Composition of main lithostratigraphic units of carbonate rocks of the Taga-Roostoja (25A) core sorted in ascending order of depth.

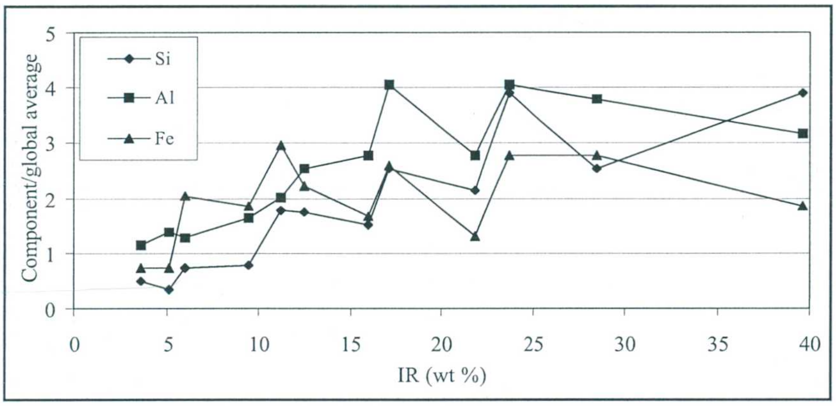


Fig.10. Average contents (arithmetic means) of some chemical elements in main lithostratigraphic units of carbonate rocks of the Taga-Roostoja (25A) core sorted in ascending order of insoluble residue (IR) value and plotted in element vs. IR diagram.

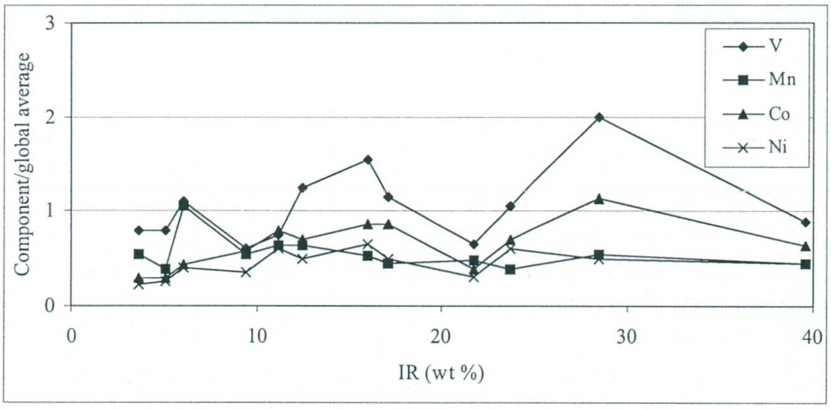


Fig. 11. Average contents (arithmetic means) of some chemical elements in main lithostratigraphic units of carbonate rocks of the Taga-Roostoja (25A) core sorted in ascending order of insoluble residue (IR) value and plotted in element vs. IR diagram.

OVERVIEW OF KUKERSITE OIL SHALE BEDS

The Taga-Roostoja (25A) borehole is located in the southern part of the Estonia oil shale deposit which is one of the largest in the world, with the total resources exceeding 5 x 10^9 tonnes of oil shale (official balance as of 1 January 1999). The deposit has been mined continuously since 1919. The maximum annual output was 29.7 million tonnes in 1980 (Bauert & Kattai, 1997). The southern part (570 km^2) of the Estonia deposit has little prospect of becoming an oil shale mining area (Fig. 12), mainly due to the gradual southward increase in the thickness of the overburden and the lowering of calorific value of oil shale seams (Saadre *et al.*, 1987; Bauert & Kattai, 1997).

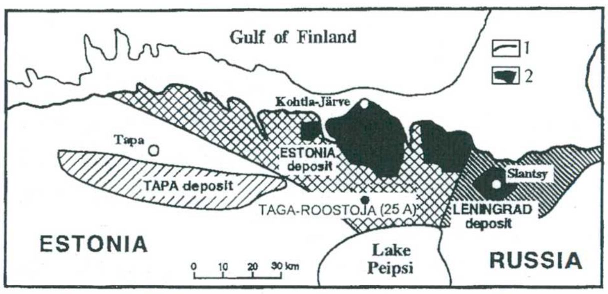


Fig. 12. Location of oil shale deposits in the Baltic Oil Shale Basin (after Bauert & Kattai, 1997). 1, recent erosional boundary of kukersite oil shale; 2, mined-out areas and fields of active mines.

The kukersite oil shale beds in the Taga-Roostoja (25A) core are lithostratigraphically confined to the Kõrgekallas (thickness 14.6 m) and Viivikonna formations (thickness 18.6 m). Both formations are subdivided into several members, of which the Pärtliorg, Erra, Kiviõli, Maidla and Peetri members contain kukersite beds (Table 4; Appendix 1, sheets 3, 4; Pl. 2, figs 11–16). The currently accepted stratigraphic nomenclature of the kukersite beds found in the Kõrgekallas and Viivikonna formations follows the historical traditions of more than 60-year-long study by various authors and is not uniform throughout the sequence (Bauert & Kattai, 1997). The kukersite beds in the Pärtliorg and Erra members are indexed with lowercase letters; capital letters are used to designate kukersite beds in the Kiviõli Member and in the lower part of the Maidla Member, whereas for the rest of the Viivikonna Formation, Roman numerals are used (Table 4).

The oil-shale-bearing beds, indexed in a traditional way, consist of kuckersineous limestone and kukersite, intercalating with argillaceous limestone and lime marl (insoluble residue < 45%). The limestone is generally bioclastic-micritic (grains 10–25%), more rarely micritic (grains < 10%) or micritic-bioclastic (grains 25–50%). The rock structure varies from nodular to seminodular, or to wavy bedding. Frequent are discontinuity surfaces and burrows.

Table 4. Kukersite oil shale beds of the Kõrgekallas and Viivikonna formations in the Taga-Roostoja (25A) core

Formation	Member	Kukersite bed	Interval of kukersite beds (m)	Thickness of beds (m)
Viivikonna	Peetri	VII	66.50–67.55	1.05
		VI	67.55–67.80	0.25
		V	68.35–68.90	0.55
		IV	69.00–69.70	0.7
		III	70.15–71.40	1.25
	Maidla	II	72.60–73.25	0.65
		I	73.70–74.20	0.5
		P	74.50–74.95	0.45
		N+O	75.55–76.86	1.31
		M	77.00–77.40	0.4
		L	77.75–78.35	0.6
	Kiviõli	K_2	78.45–78.60	0.15
		K_1	78.70–78.90	0.2
		H_2	79.45–80.10	0.65
		H_1	80.10–80.45	0.35
		G	80.70–81.20	0.5
		F_4	81.60–82.00	0.4
		F_3	82.15–82.35	0.2
		$D+E+F_1+F_2$	82.45–83.55	1.1
		C	84.00–84.30	0.3
		B	84.40–84.60	0.2
		A'	84.85–84.95	0.1
		A	85.00–85.10	0.1
Kõrgekallas	Erra	n	85.30–85.60	0.3
		m_2	86.80–86.90	0.1
		m_1	87.30–87.50	0.2
		l	88.10–88.40	0.3
		k	88.80–88.90	0.1
		h	90.00–90.20	0.2
		g	90.80–90.90	0.1
		d	91.00–91.20	0.2
		c	91.30–91.50	0.2
	Pärtliorg	b_5	91.65–91.70	0.05
		b_4	92.00–92.15	0.15
		b_3	92.40–92.50	0.1
		b_2	92.70–92.85	0.15
		b_1	93.00–93.25	0.25
		$a_1+a_2+a_3+a_4$	94.80–96.70	each 0.02

The lower part of the Pärtliorg Member of the Kõrgekallas Formation shows the occurrence of up to 0.02 m thick levels of slightly kuckersineous, irregularly thin-nodular limestone corresponding to oil shale layers a_1–a_4 that wedge out here (Table 4). The contacts between these levels are transitional. Higher there occur five 0.05–0.25 m thick kuckersineous limestone beds (b_1–b_5) of a similar structure. In these beds some kukersite is found sporadically in the limestone as well as in marl interbeds.

The 0.1–0.3 m thick beds of brownish grey kuckersineous limestone of the Erra Member of the Kõrgekallas Formation (Pl. 2, figs 15, 16) contain interbeds of argillaceous kukersite and kukersite-bearing marl (c–n; Table 4). Limestone is mostly argillaceous, medium- or thin-bedded or irregularly medium- to thin-nodular but some marl is recorded as well.

In the lower, Kiviõli Member of the Viivikonna Formation the commercial kukersite oil shale bed is a composite of individual kukersite seams A, A', B, C, D, E, F_1 and F_2, comprising also some 0.05–0.45 m thick limestone interbeds A'/B, B/C, C/D, D/E, E/ F_1 (Pl. 2, figs 13–15). Seams A, B and D are the richest in yellowish brown, light, easily splitting kukersite abounding in skeletal debris and whole fossils. The other kukersite seams contain small lens-shaped layers of limestone. Seams A' and F_2 are greyish brown and argillaceous. The kukersite seams alternate with limestone beds of variable thickness, which may be light grey or beigish grey in colour, nodular, often argillaceous and contain kukersite in different amounts. Beds A'/B and C/D are thicker. The former is represented by argillaceous limestone, the latter by bluish grey hard limestone, so-called double limestone which serves as a good marker level. Usually the limestone contains fine, regular burrows of bottom-dwelling worms, which are filled with brownish kukersite. The total thickness of the commercial bed in the core is 1.55 m (83.55–85.1 m).

The seven kukersite seams (F_3–K_2; Table 4) distinguished in the upper part of the Kiviõli Member are nodular or show wavy bedding. The content of kukersite is here 20–30%. The interlayers are represented by argillaceous limestone with marl interbeds. Directly under seam G occurs a 5 cm thick bed of kuckersineous marl containing valves of the brachiopod *Kullervo panderi*.

In the middle part of the Viivikonna Formation, in the Maidla Member, the content of kukersite is lower (Pl. 2, fig. 12). There are distinguished six kukersite seams (L–II), ranging from 0.4 to 1.31 m in thickness (Table 4). The kukersite interbeds (20–30% of the section) occur in slightly kuckersineous, wavy, medium-bedded and nodular limestone. In the upper part of the member seminodular structure is predominating.

The Peetri Member which forms the upper part of the Viivikonna Formation shows an increase in kukersite. In the lower part of the member there occurs the 1.25 m thick kukersite seam III (Table 4) which is the potential commercial bed of the Tapa deposit (Pl. 2, fig. 11). The content of kukersite in this wavy-bedded and thick-nodular seam is 50–70%. In other beds (Table 4) the kukersite percentage is 25–40. The limestone is argillaceous and prevailingly medium-bedded.

The oil shale from the southern part of the Estonia deposit contains 7–39% organic matter, 20–52% fine-grained clastic materials and 32–71% calcite skeletal debris and carbonates (Basanec *et al.*, 1983). The main indicators of the oil shale quality are its calorific value (up to 3719 kcal/kg), oil yield (0.25–24.09%) and density (1.51–2.31 g/cm^3). These parameters depend directly on organic matter content (Morozov *et al.*, 1986).The chemical composition of the organic matter contained in oil shale is almost stable: 77.3% C, 9.8% H, 10.8% O, 0.4% N and 1.7% S (Urov & Sumberg, 1992).

REFERENCES

Bagnoli, G. & Stouge, S. 1997. Lower Ordovician (Billingenian–Kunda) conodont zonation and provinces based on sections from Horns Udde, north Öland, Sweden. *Boll. Soc. Paleont. Ital.*, **35**, 2, 109–163.

Basanec, E. M., Taratorina, M. L., Morozov, O. V., Uusmaa, A. V., Radik, E. A., Morozova, L. M. & Popov, E. R. 1983. Otčet o predvaritel'noj razvedke južnoj časti Èstonskogo mestoroždenija gorjučih slancev (zapasy po sostayaniyu na 1. 01. 83 g.). UG ÈSSR. Unpublished report of the Geological Survey of Estonia, Tallinn, 311 pp. [In Russian].

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.

Bauert, H. & Kattai, V. 1997. Kukersite oil shale. In: Raukas, A. and Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 313–327.

Bergström, S. M. 1971. Conodont biostratigraphy of the Middle and Upper Ordovician of Europe and eastern North America. *Geol. Soc. Amer. Mem.*, **127**, 83–162.

Bergström, S. M. & Orchard, M. J. 1985. Conodonts of the Cambrian and Ordovician Systems from the British Isles. In: Higgins, A. C. & Austin, R. L. (eds.). *A stratigraphical index of conodonts*. Ellis Horwood Ltd., Chichester, 32–67.

Drygant, D. M. 1974. New Middle Ordovician conodonts from the north-western Volyn. *Paleontol. Sbornik*, **11**, 54–58. [In Russian].

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. 1976. Remarks on the evolution of Ordovician conodonts. *Acta Palaeont. Polonica*, **21**, 4, 395–455.

Dzik, J. 1994. Conodonts of the Mojcza Limestone. *Palaeont. Polonica*, **53**, 43–128.

Einasto, R. 1995. On the role of the Livonian Tongue in the evolution of the Baltic Continent. In: Meidla, T., Jõeleht, A., Kalm, V. & Kirs, J. (eds). *Geology of Livonia*. University of Tartu, Estonian Geological Society, Tartu, 23–32. [In Estonian with English summary].

Grahn, Y. 1984. Ordovician Chitinozoa from Tallinn, Northern Estonia. *Rev. Palaeobot. Palynol.*, **43**, 5–31.

Grahn, Y., Nõlvak, J. & Paris, F. 1996. Precise chitinozoan dating of Ordovician impact events in Baltoscandia. *J. Micropaleont.*, **15**, 21–35.

Heinsalu, H. & Viira, V. 1997. Oeland Series (Lower Ordovician). Pakerort Stage. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 52–58.

Heuse, T., Grahn, Y. & Erdtmann, B. D. 1999. Early Ordovician chitinozoans from the East Cordillera of southern Bolivia. *Rev. Micropaleont.*, **42**, 43–55.

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

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.

Kiipli, T., Kivisilla, J., Vingisaar, P. & Taalmann, V. 1984. Evolution of the chemical composition of Estonian Ordovician and Silurian limestones. *Proc. Estonian Acad. Sci. Geol.*, **33**, 3/4, 120–127. [In Russian with English summary].

Kivisilla, J. 1970. O neobhodimosti primenenija kollekcii estestvennyh standartov pri polukoličestvennom spektral´nom analize litogeohimičeskih prob. *Tezisy dokladov VII naučnoj konferencii geologov Pribaltiki i Belorussii.* Tallinn, 251–255. [In Russian].

Kivisilla, J. 1975. Sistema programm "Basal´t" dlja matematičeskoj obrabotki massovoj geohimičeskoj informacii na ÈVM. In: *Opyt i metodika geohimičeskih issledovanij i poiskov mestoroždenij poleznyh iskopaemyh v kristalličeskom fundamente Belorussii i Pribaltiki.* Minsk, 65–69. [In Russian].

Kivisilla, J. 1982. O sozdanii edinoj dlja Pribaltiki i Belorussii metrologičeskoj sistemy analitičeskih rabot pri litogeohimičeskih issledovanijah. In: *Geohimičeskie metody korreljacii.* Minsk, 15–19. [In Russian].

Kivisilla, J. 1991. Main features of geochemical specialization of the crystalline basement of Estonia. *Bull. Geol. Surv. Estonia*, **1/1**, Tallinn, 23–24.

Kivisilla, J., Petersell, V., Vares, V. & Orlova, K. 1975. Dostovernost´ massovoj geohimičeskoj informacii pri glubinnom geologičeskom kartirovanii kristalličeskogo fundamenta Èstonii. In: *Opyt i metodika geohimičeskih issledovanij i poiskov mestoroždenij poleznyh iskopaemyh v kristalličeskom fundamente Belorussii i Pribaltiki.* Minsk, 61–64. [In Russian].

Koppelmaa, H., Gromov, O., Kivisilla, J., Klein, V., Lodjak, T., Mardla, A., Niin, M., Puura, V. & Suuroja, K. 1982. Otčet o glubinnom geologičeskom kartirovanii ploščadi Tallinn–Kõrvemaa (Severnaja Èstonia) m-ba 1:500 000 za 1979–1982 gody. UG ÈSSR. Unpublished report of the Geological Survey of Estonia, Tallinn, 298 pp. [In Russian].

Koppelmaa, H. & Kivisilla, J. 1997. *Geological map of the crystalline basement of North-Eastern Estonia.* Scale 1:200 000. Explanation to the map. Geological Survey of Estonia, Tallinn, 37 pp.

Lindström, M. 1971. Lower Ordovician conodonts of Europe. *Geol. Soc. Amer.,* **127**, 21–62.

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

Löfgren, A. 1978. Arenigian and Llanvirnian conodonts from Jämtland, northern Sweden. *Fossils and Strata,* **13**, 129 pp.

Löfgren, A. 1985. Early Ordovician conodont biozonation at Finngrundet, south Bothnian Bay, Sweden. *Bull. Geol. Inst. Univ. Uppsala*, **10**, 115–128.

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

Männil, R. 1986. 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. 1990. The Ordovician of Estonia. In: Kaljo, D. & Nestor, H. (eds). *Field Meeting Estonia 1990. An excursion guidebook.* Institute of Geology, Estonian Academy of Sciences, Tallinn, 11–20.

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. Correlation charts and explanatory notes. *IUGS Publ.*, **28**, A, 52 pp.

Mens, K. 1981. Haanja–Mõniste struktuuri arengust vendi ja kambriumi läbilõigete alusel. In: Pirrus, E. (toim.). *Settekivimid ja tektoonika*. Eesti NSV Tead. Akad., Tallinn, 45–63. [In Estonian].

Mens, K. & Pirrus, E. 1974. Vendskie otloženija Pribaltiki i litogenetičeskie osobennosti ih formirovanija. In: *Tezisy dokladov soveščanija po verhnemu dokembriju (rifeju) Russkoj platformy*. Moskva, 84–88.

Mens, K. & Pirrus, E. 1997a. Sedimentary cover. Vendian. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 35–38.

Mens, K. & Pirrus, E. 1997b. Sedimentary cover. Cambrian. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 39–51.

Mens, K. & Pirrus, E. 1997c. Vendian–Tremadoc clastogenic sedimentation basin. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 184–191.

Mens, K., Viira, V., Paalits, I. & Puura, I. 1993. Upper Cambrian biostratigraphy of Estonia. *Proc. Estonian Acad. Sci. Geol.*, **42**, 4, 148–159.

Morozov, O. V., Morozova, L. M., Radik, E. A., Dančenko, V. I., Popov, E. R., & Taratorina, M. L. 1986. Otčet o detal'noj pazvedke šahtnogo polja "Permiskjula" Èstonskogo mestoroždenija gorjučih slancev za 1982–1985 gody (zapasy po sostojaniju na 01. 01. 1986 g). UG ÈSSR. Unpublished report of the Geological Survey of Estonia, Tallinn, 329 pp. [In Russian].

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. 1972. Kukruse ja Idavere lademe piirikihtide iseloomustus Lipu profiilis. *Loodusuurijate Seltsi Aastaraamat*, **61**, 39–59. [In Estonian].

Nõlvak, J. 1987. Nabalaskij gorizont. In: Puura, V. (ed.). *Geologija i poleznye iskopaemye Rakvereskogo fosforitonosnogo rajona*. Tallinn, Valgus, 65–66. [In Russian with English summary].

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

Nõlvak, J. & Grahn, Y. 1993. Ordovician chitinozoan zones from Baltoscandia. *Rev. Palaeobot. 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**, 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].

Paškevičiene, L. T. 1980. *Akritarhi pograničnyh otloženij venda i kembrija zapada Vostočno-Evropejskoj platformy*. Nauka, Moskva, 1–75.

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.

Pirrus, E. 1992. Freshening of the late Vendian basin on the East European Craton. *Proc. Estonian Acad. Sci. Geol.*, **41**, 3, 115–123.

Pirrus, E. 1993. Sedimentological and paleogeographic aspects of the Vendian–Cambrian transition on the East European platform. *Proc. Estonian Acad. Sci. Geol.*, **42**, 4, 141–147.

Puura, I. & Viira, V. 1999. Chronostratigraphy of the Cambrian–Ordovician boundary beds in Baltoscandia. Acta Univ. Carolinae, Geol., **43**, 1/2, 5–8.

Puura, V., Klein, V., Koppelmaa, H. & Niin, M. 1997. Precambrian basement. In: Raukas, A. & Teedumäe, A. (eds). *Geology and mineral resources of Estonia*. Estonian Academy Publishers, Tallinn, 27–34.

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., Saadre, T. & Mens, K. 1997. Tugiläbilõigete täienduurimine. II etapp. Unpublished report of the Geological Survey of Estonia, Tartu, 205 pp. [In Estonian].

Põldvere, A., Meidla, T., Bauert, G., Bauert, H. & Stouge, S. 1998. Ordovician. In: Männik, P. (ed.). *Tartu (453) drillcore. Estonian Geol. Sections*, 1, 11–17.

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].

Saadre, T., Stumbur, H., Põldvere, A., Morgen, E., Mardim, T., Nõmmsalu, V., Luht, H., Kala, E. & Suuroja, K. 1987. Otčet o kompleksnoj geologo-gidrogeologičeskoj s'emke m-ba 1:50 000 ploščadi Èstonskogo mestoroždenija gorjučih slancev (južnaja čast'), provedennoj v 1984–1987 gg. Listy O-35-31-V,G; O-35-32-V. Unpublished report of the Geological Survey of Estonia, Keila, 412 pp. [In Russian].

Stouge, S. 1989. Lower Ordovician (Ontikan) conodont biostratigraphy in Scandinavia. *Proc. Estonian Acad. Sci. Geol.*, **38**, 2, 68–72.

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

Turekian, K. K. & Wedepohl, K. H. 1961. Distribution of the elements in some major units of the earth's crust. *Geol. Soc. Amer. Bull.*, **72**, 2.

Urov, K. & Sumberg, A. 1992. *Harakteristika gorjučih slancev i slancepodobnyh porod izvestnyh mestoroždenij i projavlenij*. Valgus, Tallinn, 62 pp. [In Russian].

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

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

Vinogradov, A. P. 1962. Srednee soderžanie himičeskih élementov v glavnyh tipah izveržennyh gornyh porod zemnoj kory. *Geohimija*, N **7**, 641–664. [In Russian].

Wedepohl, K. H. 1995. The composition of the continental crust. *Geochim. Cosmochim. Acta*, **59**, 7, 1217–1232.

Zhang, J. 1997. The Lower Ordovician conodont *Eoplacognathus crassus* Chen & Zhang, 1993. *GFF*, **119**, 61–65.

Zhang, J. 1998. Conodonts from the Guniutan Formation (Llanvirnian) in Hubei and Hunan Provinces, south-central China. *Acta Univ. Stockholmiensis, Stockholm Contrib. Geol*, **46**, 161 pp.

APPENDIX 1

DESCRIPTION OF THE TAGA-ROOSTOJA (25A) 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 and formations.

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; E, chemical samples CaO, MgO, CO_2, IR; K, chemical samples; S, spectral analyses; T, thin sections.

LITHOLOGY — Legend see on the next page. 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.

ACCESSORY MINERALS AND OOLITHS — The amount of these particles was identified visually.

SHORT DESCRIPTION — The colour of rocks was identified on damp core; the dominant size of crystals (in italics) was estimated visually: cryptocrystalline (size of crystals) < 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 (also in italics) are described as follows: clay (size of particles) < 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 Taga-Roostoja (25A) core
(depth increases from left to right)

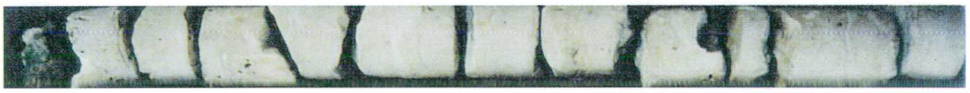


Fig. 1. **Saunja Formation**; 12.1–13.3 m.

↑15.8

Fig. 2. **Paekna to Saunja formations**; 15.2–16.3 m.

Fig. 3. **Paekna Formation**; 18.7–19.7 m.

Fig. 4. **Rägavere Formation**; 23.8–24.8 m.

Fig. 5. **Rägavere Formation**; 33.2–34.2 m.

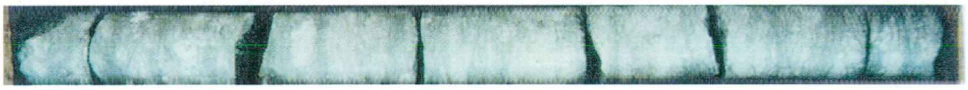


Fig. 6. **Kahula Formation**; 38.6–39.6 m.

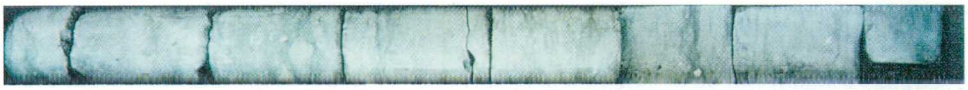
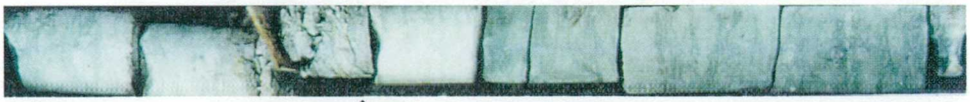


Fig. 7. **Kahula Formation**; 42.7–43.7 m.



↑50.2

Fig. 8. **Kahula Formation**; 49.7–50.8 m.

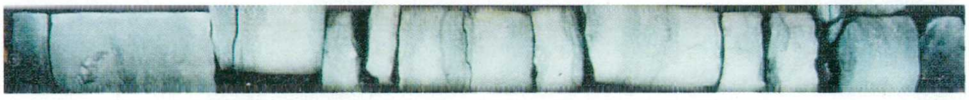


Fig. 9. **Kahula Formation**; 58.8–60.1 m.

Selected intervals of the Taga-Roostoja (25A) core

(depth increases from left to right)

Fig. 10. **Tatruse to Kahula formations**; 61.9–63.3 m.

Fig. 11. **Viivikonna Formation**; 70.4–71.4 m; kukersite bed III.

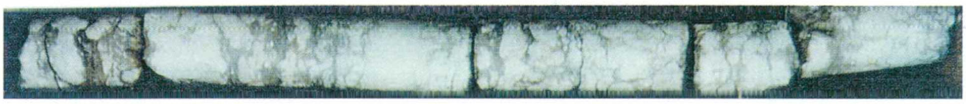


Fig. 12. **Viivikonna Formation**; 75.55–76.6 m; kukersite beds N+O.

Fig. 13. **Viivikonna Formation**; 82.45–83.7 m; kukersite beds D–F.

Fig. 14. **Viivikonna Formation**; 83.7–84.9 m; kukersite beds B & C.

Fig. 15. **Kõrgekallas to Viivikonna formations**; 84.9–86.2 m; kukersite beds n, A & A'.

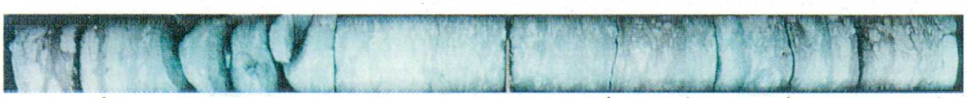


Fig. 16. **Kõrgekallas Formation**; 90.0–91.2 m; kukersite beds d, g & h.

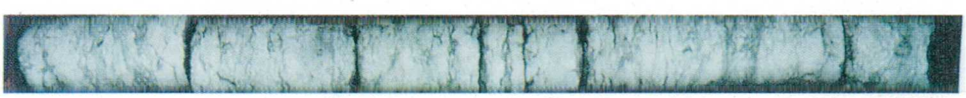


Fig. 17. **Kõrgekallas Formation**; 97.2–98.2 m.

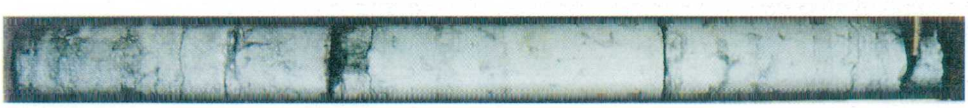


Fig. 18. **Väo Formation**; 102.3–103.4 m.

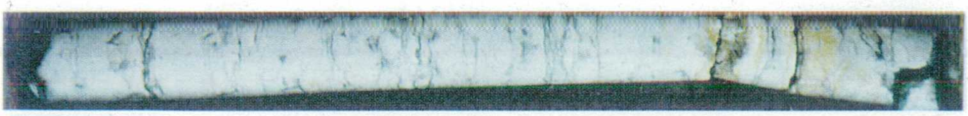


Fig. 19. **Kandle Formation**; 108.4–109.4 m.

Selected intervals of the Taga-Roostoja (25A) core

(depth increases from left to right)

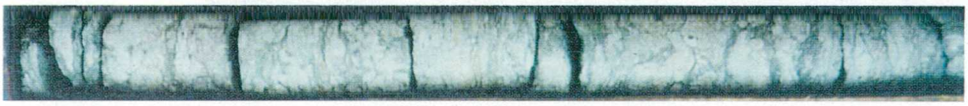


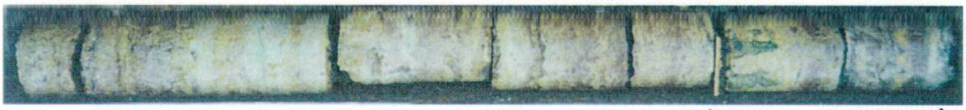
Fig. 20. **Kandle Formation**; 113.2–114.2 m.

117.2 ↑↑ 117.2

Fig. 21. **Sillaoru to Loobu formations**; 117.2–118.2 m.

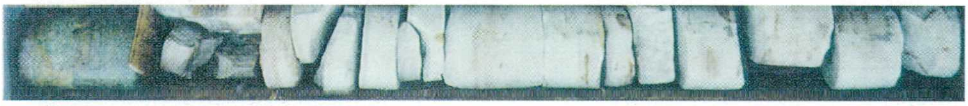
↑ 118.9

Fig. 22. **Toila to Sillaoru formations**; 118.2–119.2 m.



↑ 120.1 120.4↑

Fig. 23. **Toila Formation**; 119.2–120.4 m.



↑120.6 ↑ 121.0

Fig. 24. **Vaki to Leetse formations**; 120.4–122.2 m.

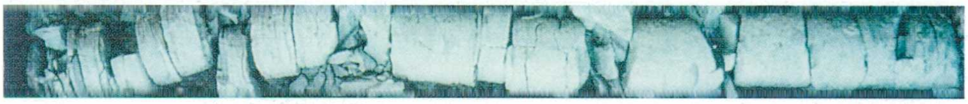


Fig. 25. **Lükati Formation**; 149.5–150.6 m.

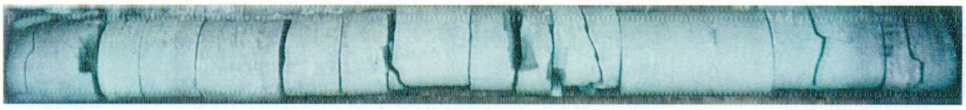


Fig. 26. **Lontova Formation**; 164.0–165.0 m.

Fig. 27. **Lontova Formation**; 183.6–184.6 m.

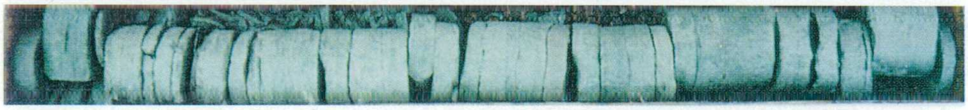


Fig. 28. **Lontova Formation**; 208.8–209.8 m.

↑215.6

Fig. 29. **Voronka to Lontova formations**; 214.2–219.2 m.

Selected intervals of the Taga-Roostoja (25A) core

(depth increases from left to right)

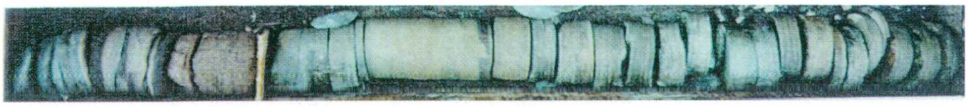


Fig. 30. **Voronka Formation**; 233.9–238.4 m.

Fig. 31. **Kotlin Formation**; 238.4–239.4 m.

Fig. 32. **Kotlin Formation**; 252.2–253.2 m.

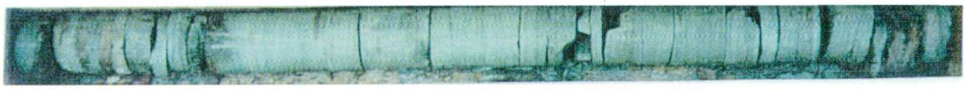


Fig. 33. **Kotlin Formation**; 260.2–261.2 m.

↑266.6

Fig. 34. **Gdov Formation**; 264.8–266.8 m.

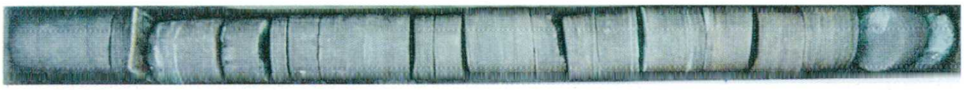


Fig. 35. **Gdov Formation**; 277.0–278.0 m.

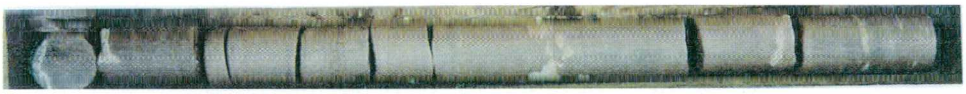


Fig. 36. **Gdov Formation**; 296.4–297.4 m.

Fig. 37. **Palaeoproterozoic**; 318.9–319.9 m.

Fig. 38. **Palaeoproterozoic**; 328.1–329.1 m.

Fig. 39. **Palaeoproterozoic**; 330.2–331.2 m.

Appendix 1 continued

LEGEND

- cultivated soil
- limestone
- argillaceous limestone
- dolomitic limestone
- sandy limestone
- dolostone
- argillaceous dolostone
- calcitic marl
- dolomitic marl
- claystone
- silty claystone
- siltstone
- argillaceous siltstone
- sandstone
- K-bentonite band

skeletal limestones:

- grains 10-25% (wackestone)
- grains 25-50% (packstone)

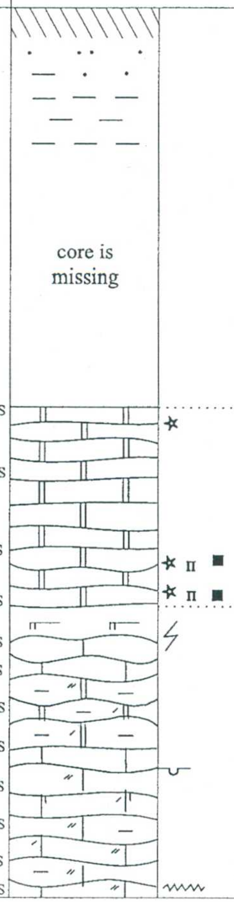
- crypto- and microcrystalline (aphanitic) limestone
- fine bioclasts, pyritized
- coarse bioclasts, pyritized
- horizontal bedding; thin- (a), medium- (b) and thick-bedded (c)
- wavy bedding
- nodular
- thin intercalation
- lenses of another rock
- discontinuity surfaces
- ripple marks
- veins
- slickensides
- porous
- caverns
- burrows
- pyritic mottles
- quartz grains
- feldspar grains
- glauconite grains
- ooliths
- intraclasts

- kerogen
- kukersite interbeds
- pyrite
- siderite
- calcite
- micas (in general)
- mottled, red-coloured and yellow streaks
- bryozoans
- stromatoporoids
- brachiopods
- cephalopods
- echinoderms
- trilobites
- weathering crust
- biotite gneiss
- weathered gneiss
- amphibolite
- granite
- cordierite
- garnet
- sillimanite
- migmatized rocks

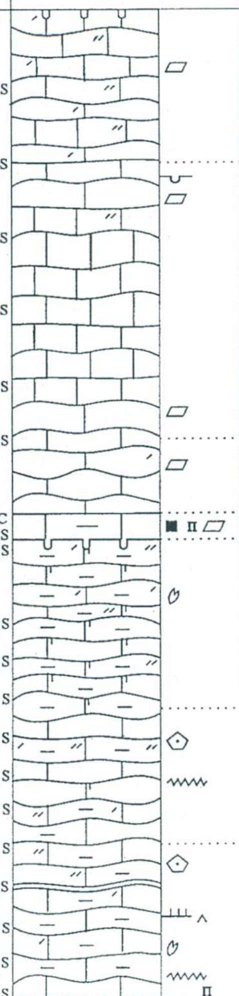
DESCRIPTION OF THE TAGA-ROOSTOJA (25A) CORE

APPENDIX 1, SHEET 1

Location: latitude 6552.9 km, longitude 5509.9 km. Length of the core 332.8 m. Elevation of the top above sea level 43.5 m.

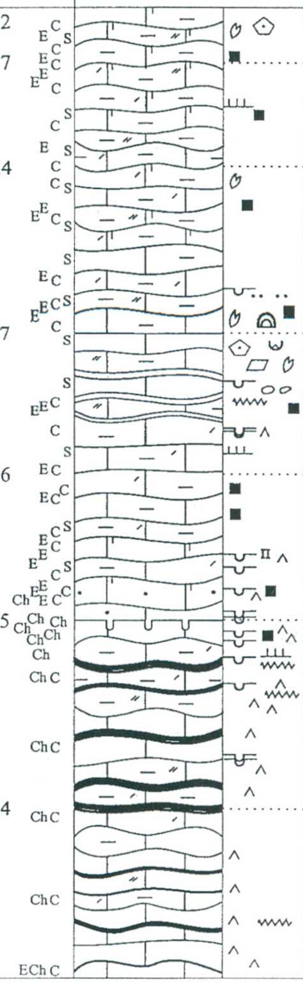


STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS		CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Pleistocene, Quaternary			1		0.0		core is missing					0.0-0.8 m - cultivated soil cover. 0.8-1.3 m - yellowish grey silty **sand**; 1.3-1.7 m - multicoloured argillaceous **sand**; 1.7-2.0 m - blackish grey **sand**; 2.0-3.5 m - variable-grey varved **clay**
Caradoc	Nabala Stage	Saunja Formation	2	1, 2	10.5	S, S, E, S, E, S, E, S		Wavy thin- to medium-bedded	< 1 cm D brownish dark grey	< 5		Grey, with brownish tinge, *very finely crystalline* **dolostone** (grains < 10%)
		Paekna Formation	3, 4	3	15.8 23.7	S, S, E, E, S, E, S, E, S, E Ch, S, E Ch, S, E Ch Ch S		Medium-nodular or wavy medium- (thin-) bedded	0.3-2 cm (4 cm) IND dark grey D	5-10 < 5		Grey, *very finely and finely crystalline,* partly dolomitized argillaceous **limestone** (grains 10-25%, in places up to 30%; wackestone). Upper 0.6 m is dolomitic **marl**

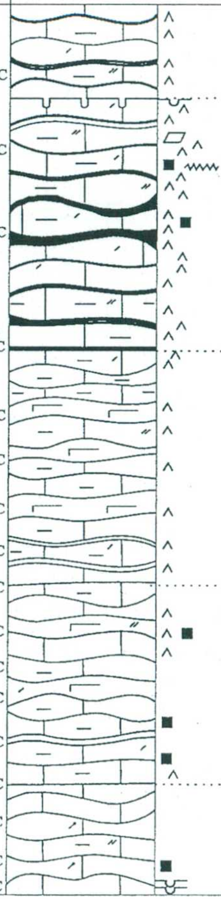
STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Caradoc	Rakvere Stage, Rägavere Formation	4, 5	4	23.7	E E Ch, S, E Ch Ch S		Wavy thin- to medium-bedded	< 0.2 cm 0.5-1 cm D brownish dark grey	< 5		Light grey, with yellow tinge, *crypto- and microcrystalline or very finely crystalline* **limestone** (grains 10-30%; wackestone) with calcite-filled primary and secondary veins
		6, 7	5	27.7	E, S, S, S		Wavy thick- to medium-bedded, in places thin-bedded	< 0.2 cm 0.5 (3) cm D brownish grey			Light grey, with brown tinge, in the upper 2 m *crypto- and microcrystalline* and in the lower part *very finely crystalline* **limestone** (grains < 5%, in places up to 30%; mudstone) with calcite-filled primary and secondary veins
	Oandu Stage	7		35.1	E E C C S		Wavy to thin-seminodular	< 0.2-0.3 cm D dark grey	< 5	Sulphide minerals	Light grey, *very finely crystalline and microcrystalline* **limestone** (grains < 10%, in places 20-30%; mudstone)
				37.2	E E C C S		Wavy medium-bedded	< 1 cm IND greenish dark grey	< 5	Pyrite	Light grey, slightly argillaceous, *very finely crystalline and microcrystalline* **limestone** (grains < 10%, in places > 10%; mudstone)
	Keila Stage, Kahula Formation	8	6	37.8	C S, E C S, E C S, S		Wavy medium- to thin-bedded	< 0.2 cm 0.5-3 cm IND greenish dark grey	20		Greenish grey, slightly to highly argillaceous, *finely crystalline* dolomitic **limestone** (grains 10-25%, in places 30%; wackestone)
		9	7	42.4	E C S, E C S, S		Wavy thin- to medium-bedded, irregularly nodular	< 0.2 cm 0.3-3 cm IND greenish dark grey	< 10		Light grey, with green tinge, slightly to medium argillaceous, *very finely to finely crystalline* **limestone** (grains 10-25%, in places 40%; wackestone)
		10	8	45.9–50.2	E C S, E E C S, E C S, E C S		Wavy medium- to thin-bedded, irregularly nodular	< 0.2 cm 0.3-3 cm IND greenish dark grey	< 10		Light grey, with green tinge, slightly to highly argillaceous, *very finely to finely crystalline* **limestone** (grains 10-25%; wackestone)

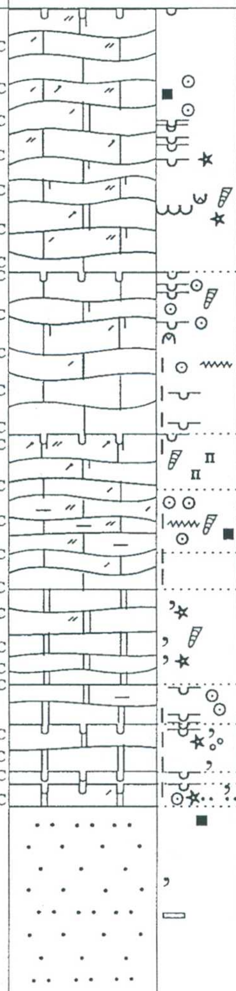
TAGA-ROOSTOJA (25A) DRILL CORE

APPENDIX 1, SHEET 3



STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Caradoc	Haljala Stage, Jõhvi Substage	11	8	50.2; 51.7	Wavy medium- to thin-bedded, irregularly nodular	< 0.2 cm 0.3-1 cm IND greenish dark grey	< 10		Grey, with green tinge, slightly to medium argillaceous, *very finely crystalline* dolomitized **limestone** (grains 10-20%; wackestone)
	Haljala Stage, Jõhvi Substage	12		54.4	Wavy thin-bedded or nodular	< 0.2 cm 0.3-1 (4) cm IND greenish dark grey	< 10		Grey, with green tinge, slightly to highly argillaceous, *finely crystalline* dolomitized **limestone** (grains 10-20%; wackestone)
	Haljala Stage, ? , Kahula Formation				Wavy thin- to medium-bedded or nodular	< 0.2 cm 0.3-1 cm IND greenish dark grey	< 5		Grey, with green tinge, slightly to medium argillaceous, *finely crystalline,* in places dolomitized **limestone** (grains < 20%, in places < 10%; mudstone and wackestone)
	Haljala Stage, Idavere Substage, Kahula Formation	13	9	58.7	Wavy thin- to medium-bedded or nodular	< 0.2 cm 0.3-5 cm D greenish dark grey	> 5		Light grey, with green tinge, slightly argillaceous, *very finely and finely crystalline* **limestone** (grains 10-30%, in places < 10%; mudstone and wackestone)
	Haljala Stage, Idavere Substage, Tatruse Fm.	14	10	62.6	Wavy thin- (micro-) to medium-bedded	< 0.2 cm 0.3-0.5 cm D dark grey	< 5	Pyrite	Light grey, slightly argillaceous, *very finely to finely crystalline,* in places dolomitized **limestone** (grains 10-25%; wackestone). Discontinuity surfaces are phosphatized or pyritized
	Kukruse Stage, Viivikonna Formation	15	11	66.5	Wavy (thick-) medium-bedded to seminodular	< 0.2 cm 0.3-2 (3) cm D dark grey or brownish dark grey	< 20		Greenish or beigish light grey, slightly to medium argillaceous, *very finely crystalline* **limestone** (grains 10-25%; wackestone) with interbeds of kuckersineous limestone or kukersite and with numerous burrows. Discontinuity surfaces are pyritized
	Kukruse Stage, Viivikonna Formation	16	12	71.4	Irregularly medium- to thin-nodular and wavy medium-bedded	< 0.2 cm 0.3-1 cm D dark grey or brownish dark grey	> 10		Light grey, intercalated by slightly argillaceous or kuckersineous (kukersite) beds, *very finely crystalline* **limestone** (grains 10-25%; wackestone). In places whitish burrows occur

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Caradoc	Kukruse Stage, Viivikonna Formation	17	12		ChC						☞ follow up
		18	13, 14, 15	78.45	ChC, ChEC, Ch C, ChEC		Wavy medium-bedded or irregularly thick- to thin-nodular	< 0.2 cm 1-5 cm D dark grey or brownish dark grey	< 10	Pyrite	Light grey and beigish light grey, with kuckersineous (kukersite) or some slightly argillaceous interbeds, *very finely crystalline* **limestone** (grains 10-25%; wackestone). Characteristic are kukersite-filled burrows
Llanvirn	Uhaku Stage, Kõrgekallas Formation	19, 20	16	85.1	ChC, ChC, ChC, ChC		Wavy medium- to thin-bedded, irregularly medium- to thin-nodular	< 0.2 cm 0.3-5 (10) cm D (IND) greenish dark grey	40-60 30-50		Light grey, in places slightly (to highly) argillaceous, *very finely crystalline* **limestone** (grains < 10%, in places > 10%; mudstone) and **marl**. In some beds stone is slightly kuckersineous
		21		91.5	ChEC, ChC, ChEC, ChC, ChC		Irregularly thin-nodular, in places wavy medium- to thin-bedded	< 0.2 cm 0.3-1 cm IND greenish dark grey	< 30 < 10	Pyrite	Intercalation of light grey, in places with green tinge, slightly to medium argillaceous, *very finely crystalline* **limestone** (grains < 10%, in places < 20%; mudstone) and **marl**. In some beds stone is slightly kuckersineous
		22	17	96.7 99.7	ChC, ChC, ChEC, ChChCC		Wavy thin- to medium-bedded and thin-seminodular	< 0.2 cm 0.3-1 cm D dark grey	< 10	Pyrite	Light grey, intercalated by kuckersineous and slightly argillaceous beds, *very finely or finely to very finely crystalline* **limestone** (grains 2-20%; mudstone and wackestone). Discontinuity surfaces are phosphatized



DEPTH (m)	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
99.7–106.8	Wavy medium-bedded or irregularly thick- to thin-nodular	< 0.2 cm 0.3-1 cm D dark grey	< 5	Pyrite, goethitic ooliths	Light grey to darkish grey, differently dolomitized, *finely crystalline* **limestone** (grains 10-30%; wackestone) with **dolostone** interbeds. Discontinuity surfaces are phosphatized Light grey, with greenish tinge, in the upper part differently dolomitized, *finely (very finely to medium) crystalline* **limestone** (grains < 10%, in places > 10%; mudstone). Below a depth of 109.0 m limonitized discontinuity surfaces (?) form yellow streaks and burrows are characteristic
106.8–111.1	Wavy medium- to thick-bedded, irregularly thin-nodular	< 0.2 cm 0.3-0.5 cm D dark grey	< 5	Goethitic ooliths	Bluish grey, *finely crystalline* dolomitized **limestone** (grains 2-20%; mud- and wackestone) with phosphatized streaks Greenish light grey, medium to slightly argillaceous, *finely to very finely crystalline* **limestone** (grains 2-20%; wacke- and mudstone)
111.1–112.6	Wavy medium- to thin-bedded	< 0.2 to 1 cm; D greenish dark grey	< 5		Greenish light grey, with intensively yellow streaks, *finely to very finely crystalline* **limestone** (grains < 10%; in places > 10%; mudstone)
112.6–114.3	Wavy thin- to medium-bedded, irregularly nodular	< 0.2 to 1.5 cm; D greenish dark grey	< 5	Goethitic ooliths 5 (40)%	Grey to dark grey, *medium to finely crystalline* **dolostone** (grains < 5%). Caverns are covered with secondary crystals
114.3–115.3	Wavy thin- to medium-bedded	< 0.2 cm; D greenish dark grey	< 5		Soiled dark grey, *medium crystalline* **dolostone** (grains < 5%). Caverns are covered with secondary crystals
115.3–117.8	Wavy thin- to medium-bedded	< 0.2 to 1 cm; IND dark grey	< 5	Glauconite < 20%	Mottled greenish grey, *finely to medium crystalline* **dolostone** (grains < 5%). Discontinuity surfaces are limonitized. The lower boundary is marked by a very distinct discontinuity surface with amphora-shaped borings
117.8–118.9	Wavy medium, to thick-bedded	< 0.2 to 1 cm; IND dark grey	< 2	Goethitic ooliths < 50%	
118.9–120.4	Horizontal thick-bedded	< 0.2 cm; D dark grey	< 2	Glauconite	
120.4–121.0	Wavy bedding	< 0.2 cm; D brownish grey	< 1		Mottled reddish brown, *finely to medium crystalline* **dolostone** (grains < 5%). Discontinuity surfaces are limonitized
121.0–	Horizontal bedding	< 0.2 cm; D greenish dark grey, in upper part grey	< 1	Glauconite > 10%, goethitic ooliths	Greenish to brownish grey, limonitized, *finely to medium crystalline* dolomitized **limestone** or **dolostone** (grains < 5%). Below 120.8 m beigish light grey, limonitized, *medium to finely crystalline* **dolostone** (grains < 5%) occurs

STANDARD UNITS: Llanvirn; Arenig; Lower Cambrian

LOCAL STRATIGRAPHIC UNITS: Uhaku Stage; Lasnamägi St.; Väo Formation; Aseri Stage; Kunda Stage; Aluoja Substage; Kandle Formation; Hun*; V*; Loobu Fm.; Volkhov St.; La*; Sil*; B*; Vääna*; Toila*; L*; Ljuboml' & Vergale stages; Vaki Formation

CORE BOX NO.: 22, 23, 24, 25, 26, 27, 28

FIGURES: 18, 19, 20, 21, 22, 23, 24

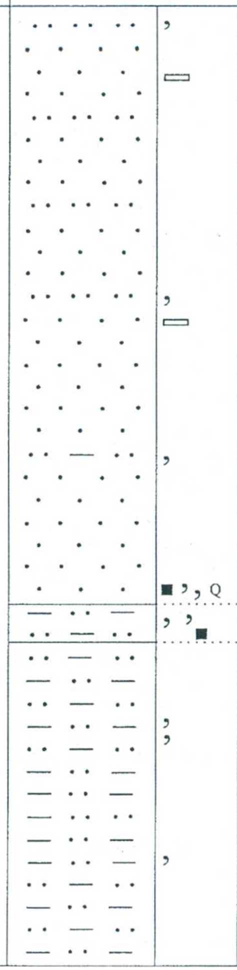
DEPTH (m): 99.7, 104.2, 106.0, 106.8, 111.1, 112.6, 114.3, 115.3, 117.8, 118.9, 120.1, 120.4, 121.0

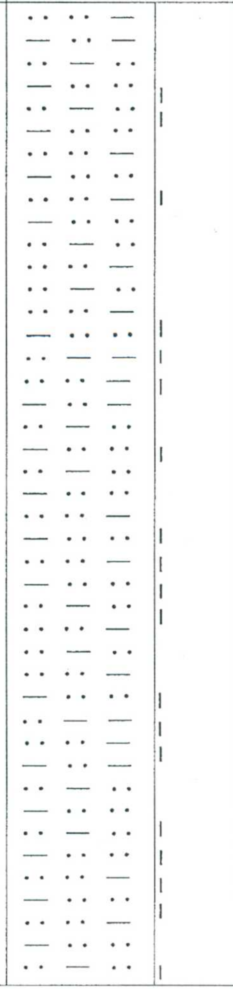
SAMPLES: E, ChC, ChEC, ChC, ChEC, ChEC, ChC, ChC, ChEC, ChEC, ChC, ChC, Ch ChC ChC, ChC, ChC, ChC, ChC Ch ChC, ChC, ChC, ChC Ch C, ChC ChC ChC, ChC Ch ChC ChC, ChC ChC

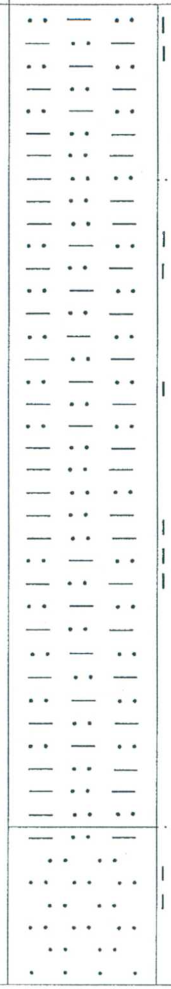
☞ follow down

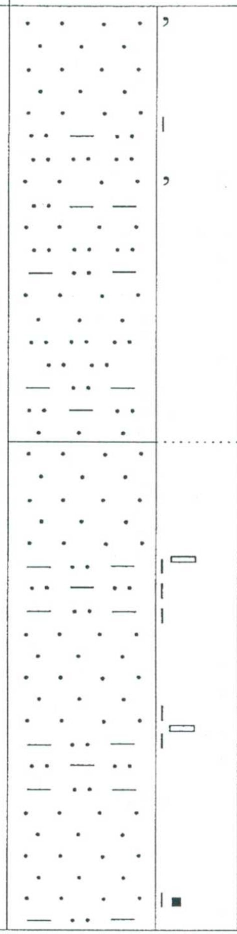
B*, Billingen Stage; Vääna*, Vääna Substage; La*, Langevoja Substage; Hun*, Hunderum Substage; V*, Valaste Substage; L*, Leetse Formation; Toila*, Toila Formation; Sil*, Sillaoru Formation

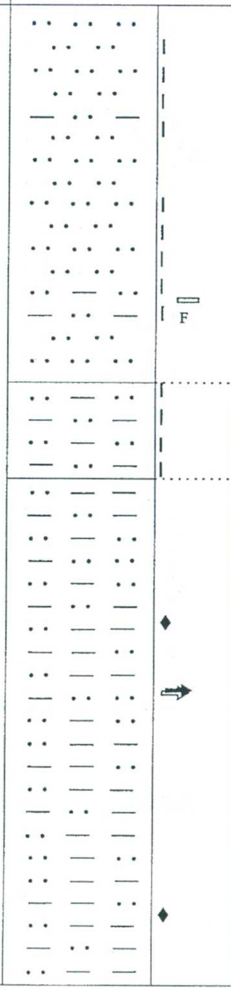
STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Lower Cambrian	Ljuboml' & Vërgale stages Vaki Formation	28		142.0			Massive			Muscovite, glauconite, pyrite Green biotite	Light grey, *very fine- to fine-grained,* medium-cemented (in the upper part strongly cemented) **sandstone** with thin interbeds of mottled, *coarse-grained* siltstone, argillaceous siltstone and silty claystone. Trace fossil *Skolithos* occurs. Core yield 25%
				143.0			Horizontal thin-bedded			Pyrite, glauconite	Intercalation of light grey **siltstone** and greenish light grey **silty claystone**. On bed surfaces are trace fossils, pyrite nodules and sand-sized quartz grains. Core yield 50%
	Dominopol' Stage Lükati Formation	29 30	25	151.6			Horizontal thin- (medium-) and thick-bedded			Glauconite	Intercalation of greenish grey **silty claystone** and grey **siltstone**. Some beds are cemented by poikilotopic carbonate. The upper part is weathered and bed surfaces are ochreous. *Volborthella tenuis* and *Luekatiella* occur. Core yield 95%

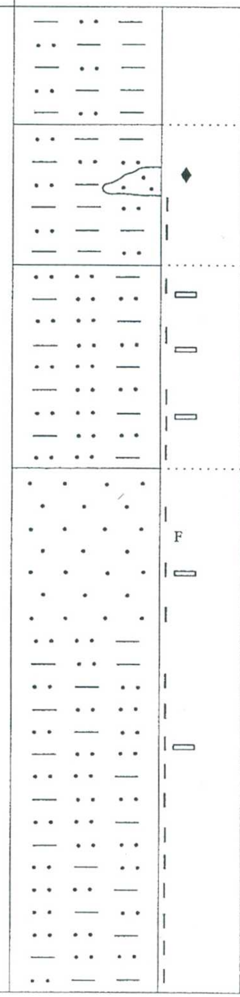


STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Lower Cambrian	Lontova Stage Lontova Formation	31 32 33 34 35 36	26	151.6			Massive				Mottled **silty claystone** with greenish grey, reddish brown and purplish interbeds, streaks and spots. In some places microinterbeds of silt occur. *Platysolenites* and pyritized trace fossils are characteristic. Pyritized excavations are 3 mm wide in the lower part and up to 5-6 mm wide in the upper part. Core yield 85%

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Lower Cambrian	Lontova Stage; Lontova Formation	36									☞ follow up
		37, 38, 39, 40	27	182.6			Massive				Greenish grey **silty claystone**, in the upper part with purplish, mottled, in some places thin interbeds of very fine-grained sandstones. On bed surfaces pyritized trace fossils (width up to 1-2 mm) are found. *Platysolenites* fragments occur. Core yield 70%
		40, 41		199.8			Massive			Glauconite (light green)	Intercalation of **silty claystone**, **siltstone** and **sandstone.** Greenish grey, in places purplish, **claystone** with silty microinterbeds and pyritized trace fossils. Glauconite-containing **sandstone** beds (thickness 0.02-0.2 m, in the lower part up to 1 m) are differently cemented. Siltstone interbeds are micro- to thin-bedded or lenticular. *Platysolenites antiquissimus* and *Sabellites cambriensis* occur. Core yield about 85%

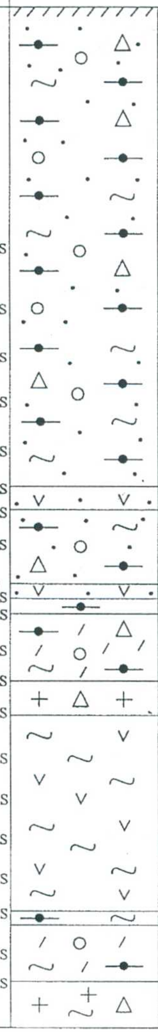
STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Lower Cambrian	Lontova Stage Lontova Formation	41 42 43	28								☞ follow up
Upper Vendian	Kotlin Stage Voronka Formation	44	29	215.6 228.5			! (Core yield 5%)			Muscovite, pyrite	Gamma-logging of the well showed the presence of quartzose **sandstone**. According to the data from neighbouring boreholes, it can be whitish grey, medium- to weakly-cemented and *very fine- to fine-grained*. In core only thin interbeds of mottled, reddish or purplish brown silty claystone and clayey siltstone occur. Pyrite crystals are surrounded by aureoles of reduction. Core yield 5%

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Upper Vendian	Kotlin Stage; Voronka Formation	44	30	228.5			Massive			Muscovite Biotite, feldspar	Indistinct intercalation of **siltstone** and **silty claystone**. Mottled (in the upper part reddish brown, in the lowermost part changeable greenish light grey and purplish brown) **siltstone** is massive. Thin-laminated **claystone** interbeds are ochreous in some places. In the lower part occurs a 10 cm thick sandstone layer with a small quantity of feldspars. Core yield 35%
	Kotlin Formation	45	31	238.4			Horizontal micro- to thin-bedded			Siderite	Mottled, silty **claystone.** Due to weathering the laminated stone is yellowish green and ochreous (goethite). In the upper part (1.5 m) the rock is reddish brown and siderite nodules are common. In the lower part bleached whitish grey, ochreous yellow-mottled and, more rarely, purplish brown, laminated claystone occurs. Core yield 100%
		45 46 48 49	32	241.0			Horizontal micro- to thin-bedded (laminated)			Siderite	Grey **claystone**, in places silty. On bed surfaces are dark to brownish grey microbeds of organic matter, siderite nodules (vertical diameter 1 cm; lenticular or of irregular shape) and slickensides (underwater origin). Core yield 55%

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS		CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Upper Vendian	Kotlin Stage	Kotlin Formation	49		257.5							☞ follow up
			50	33	261.2			Horizontal thin-bedded or massive			Siderite	Grey, thin-laminated **silty claystone** with lenticular interbeds of silt and poorly sorted sandy-gravelly material. Some siderite nodules occur. Core yield 100%
		Gdov Formation	51	34	266.6			Lenticular or wavy thin- to thick-bedded			Mica	Greenish grey **siltstone** with purplish brown clayey interbeds. Brownish grey lenticular fine-grained sandstone layers are characteristic. Micas occur in remarkable quantities. Core yield 70%
			52, 53	35				Horizontal thin- to medium-bedded or massive			Mica, feldspars	In the core only **clayey siltstone** and **silty claystone** interbeds exist. In the upper part the rock is grey, in the lower part reddish brown and more massive. Beigish or brownish light grey **sandstone** (by gamma-logging data 40% of the section) is *fine-grained*, weakly cemented, containing 5-10% feldspars. Underlying sandstone is intensely reddish or purplish brown, particles are sub-angular and iron minerals occur. On bed surfaces mica and very coarse grains of sand are recorded. Core yield 35%

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Upper Vendian	Kotlin Stage Gdov Formation	53 54	36				Massive				☞ follow up
		55		304.5 305.8		Q F	Massive			Quartz, feldspars	Mottled reddish brown, unsorted **clayey-sandy-gravelly deposits** (mixtite) consisting of silty claystone, siltstone and angular or sub-angular sand-gravel (quartz, feldspars, crystalline basement) material. The clayey matrix consists mostly of kaolinite. In the lowermost part the grain size is up to 10 mm. Single light grey lenses and thin interbeds of siltstone and sandstone are characteristic. Core yield 100%

STANDARD UNITS	LOCAL STRATIGRAPHIC UNITS	CORE BOX NO.	FIGURES	DEPTH (m)	SAMPLES	LITHOLOGY	SEDIMENTARY STRUCTURES	MARL BEDS	MARL PERCENTAGE	ACCESSORY MINERALS AND OOLITHS	SHORT DESCRIPTION
Palaeoproterozoic	Alutaguse Zone	55, 56		305.8–318.4	S S S S S		Dip angle 60-75°				*Coarse-grained* **garnet-cordierite gneiss**, irregularly banded, migmatized, weathered, kaolineous and permeated with iron oxides
				318.4–319.0	S		Dip angle 65°				*Medium-grained* **amphibolite**, schistose and weathered
		57	37	319.0–321.0	S S		Dip angle 65-80°				*Coarse-grained* **garnet-cordierite gneiss**, irregularly banded, migmatized and weathered
				321.0–321.4	S S		Dip angle 60°				*Medium-grained* **amphibolite**, schistose and weathered
				321.4–321.8	S		Dip angle 70°				*Coarse-grained* **garnet-cordierite gneiss**, migmatized and weathered
				321.8–323.6	T S, S		Dip angle 60-75°				*Coarse-grained* **garnet-cordierite gneiss** with sillimanite, irregularly banded and strongly migmatized
				323.6–324.5	T S		Dip angle 70-80°				*Coarse-grained* **migmatite granite** with garnet and cordierite crystāls
		58, 59	38	324.5–329.8	T, S, T S, S, K T S		Dip angle 60-85°				*Fine- to medium-grained* **amphibolite**, schistose or banded and slightly migmatized
				329.8–330.1	K T S						*Fine-grained* **biotite gneiss** with garnet
			39	330.1–331.7	S, T		Dip angle 65-75°				*Coarse-grained* **garnet-cordierite gneiss** with sillimanite and andalusite, migmatized
				331.7–332.8+	T S		Dip angle 60-70°				*Coarse-grained* **migmatite granite** with cordierite



Thin sections from Palaeoproterozoic rocks of the Taga-Roostoja (25A) core

Thin section*	Rock name	Mineralogical composition (%)	Texture	Notes
253227	coarse-grained garnet-cordierite-biotite gneiss	Q 20; Pl 25; Mi 20; Bt 15; Cord 15; Gr 5; Mu, Sil, Zrc, Op, Graph	granoblastic	
253245	fine- to medium-grained garnet-biotite gneiss	Q, Pl, Bt, Gr, Cord, Zrc, Chl	porphyroblastic	contact with migmatite granite
253252	fine- to medium-grained amphibolite (biotite-amphibole gneiss)	Q, Pl (Byt), Hbl, Bt, Zrc, Op	nematoblastic	foliated structure
253264	fine- to medium-grained amphibolite	Q, Pl, Hbl, Bt, Op	nemato-granoblastic	
253290	medium-grained amphibolite	Q 6; Hbl 70; Pl (Byt) 17; Bt 7; Ap, Op	granoblastic	
253300	fine-grained cordierite-biotite gneiss	Q 20; Pl 45; Mi 5; Bt 20; Gr 10; Zrc; Op	porphyroblastic	Gr porphyroblasts with abundant inclusions of Q and Bt, Ø <1 cm
253313	coarse-grained cordierite-biotite gneiss	Q 30; Pl 25; Mi 15; Bt 15; Cord 10; And 3; Chl 2, Zrc, Op, Graph	granoblastic	grains of And isometric, partially replaced by mica
253320	coarse-grained migmatite granite	Q, Pl, Mi, Bt, Cord, Zrc	granoblastic	

* The first two figures in the sample number denote the number of the borehole, other figures show the sampling depth in decimetres.

Abbreviations used: And, andalusite; Ap, apatite; Bt, biotite; Byt, bytownite; Chl, chlorite; Cord, cordierite; Gr, garnet; Graph, graphite; Hbl, hornblende; Mi, microcline; Mu, muscovite; Op, opaque; Pl, plagioclase; Q, quartz; Sil, sillimanite; Zrc, zircon.

APPENDIX 3

List of conodont samples from the Taga-Roostoja (25A) core

Sample	Sampled interval (m)	Regional stage	Sample	Sampled interval (m)	Regional stage
A250348	34.80–35.00	Rakvere	A250869	86.90–87.00	Uhaku
A250351	35.10–35.30	Rakvere	A250881	88.10–88.20	Uhaku
A250370	37.00–37.20	Rakvere	A250894	89.40–89.55	Uhaku
A250373	37.30–37.40	Oandu	A250905	90.55–90.65	Uhaku
A250378	37.80–38.00	Keila	A250915	91.50–91.63	Uhaku
A250383	38.30–38.50	Keila	A250927	92.70–92.85	Uhaku
A250404	40.40–40.60	Keila	A250936	93.60–93.70	Uhaku
A250413	41.30–41.50	Keila	A250945	94.55–94.65	Uhaku
A250435	43.50–43.70	Keila	A250956	95.60–95.70	Uhaku
A250442	44.20–44.40	Keila	A250966	96.60–96.70	Uhaku
A250462	46.20–46.40	Keila	A250977	97.70–97.80	Uhaku
A250474	47.40–47.50	Keila	A250986	98.65–98.75	Uhaku
A250480	48.00–48.20	Keila	A250995	99.58–99.65	Uhaku
A250495	49.50–49.60	Keila	A250997	99.75–99.85	Uhaku
A250506	50.60–50.80	Haljala	A251007	100.75–100.85	Uhaku
A250513	51.30–51.50	Haljala	A251018	101.82–101.92	Uhaku
A250517	51.70–51.90	Haljala	A251027	102.70–102.80	Uhaku
A250523	52.30–52.50	Haljala	A251036	103.65–103.75	Uhaku
A250534	53.40–53.60	Haljala	A251046	104.65–104.75	Lasnamägi
A250544	54.40–54.60	Haljala	A251056	105.62–105.75	Lasnamägi
A250548	54.80–54.90	Haljala	A251066	106.65–106.75	Aseri
A250558	55.80–55.90	Haljala	A251068	106.80–106.90	Aseri
A250575	57.50–57.70	Haljala	A251079	107.95–108.10	Aseri
A250581	58.10–58.20	Haljala	A251088	108.85–108.95	Aseri
A250587	58.70–58.80	Haljala	A251099	109.95–110.10	Aseri
A250606	60.60–60.80	Haljala	A251109	110.95–111.10	Aseri
A250613	61.30–61.50	Haljala	A251111	111.10–111.20	Kunda
A250624	62.40–62.60	Haljala	A251113	111.35–111.45	Kunda
A250629	62.90–63.00	Haljala	A251124	112.45–112.60	Kunda
A250631	63.10–63.30	Haljala	A251134	113.40–113.55	Kunda
A250640	64.00–64.20	Haljala	A251143	114.30–114.50	Kunda
A250644	64.40–64.60	Haljala	A251152	115.22–115.32	Kunda
A250653	65.30–65.40	Haljala	A251153	115.32–115.45	Kunda
A250656	65.60–65.80	Haljala	A251159	115.90–116.00	Kunda
A250658	65.80–65.90	Haljala	A251168	116.80–116.90	Kunda
A250679	67.95–68.05	Kukruse	A251174	117.45–117.55	Kunda
A250698	69.80–69.90	Kukruse	A251177	117.70–117.85	Kunda
A250717	71.70–71.85	Kukruse	A251178	117.85–117.95	Volkhov
A250739	73.90–74.00	Kukruse	A251182	118.20–118.28	Volkhov
A250759	75.95–76.05	Kukruse	A251184	118.40–118.50	Volkhov
A250778	77.85–77.97	Kukruse	A251187	118.75–118.90	Volkhov
A250799	79.90–80.10	Kukruse	A251189	118.90–119.00	Volkhov
A250820	82.00–82.10	Kukruse	A251202	120.20–120.40	Billingen
A250848	84.80–84.90	Kukruse	A251206	120.60–120.80	Billingen
A250851	85.10–85.20	Uhaku	A251208	120.80–121.00	Billingen

APPENDIX 5

List of chitinozoan samples from the Taga-Roostoja (25A) core

Sample	Sampled level or interval (m)	Regional stage	Sample	Sampled level or interval (m)	Regional stage
A250212	21.20–21.30	Nabala	A250945	94.55–94.65	Uhaku
A250222	22.20–22.30	Nabala	A250956	95.60–95.70	Uhaku
A250235	23.50–23.70	Nabala	A250966	96.60–96.70	Uhaku
A250237	23.70–23.80	Rakvere	A250977	97.70–97.80	Uhaku
A250239	23.90	Rakvere	A250986	98.65–98.75	Uhaku
A250275	27.50	Rakvere	A250995	99.58–99.65	Uhaku
A250279	27.90	Rakvere	A250997	99.75–99.85	Uhaku
A250658	65.80–65.90	Haljala	A251007	100.75–100.85	Uhaku
A250659*	65.96–66.03	Haljala	A251018	101.82–101.92	Uhaku
A250660*	66.08–66.17	Haljala	A251027	102.70–102.80	Uhaku
A250661*	66.17–66.32	Haljala	A251036	103.65–103.75	Uhaku
A250663*	66.32–66.41	Haljala	A251046	104.65–104.75	Lasnamägi
A250664*	66.44–66.47	Haljala	A251056	105.62–105.75	Lasnamägi
A250666*	66.61–66.70	Kukruse	A251066	106.65–106.75	Aseri
A250667*	66.70–66.80	Kukruse	A251068	106.80–106.90	Aseri
A250669*	66.91–67.00	Kukruse	A251079	107.95–108.10	Aseri
A250670*	67.03–67.09	Kukruse	A251088	108.85–108.95	Aseri
A250671*	67.09–67.15	Kukruse	A251099	109.95–110.10	Aseri
A250672*	67.20–67.28	Kukruse	A251109	110.95–111.10	Aseri
A250675*	67.52–67.57	Kukruse	A251111	111.10–111.20	Kunda
A250676*	67.61–67.65	Kukruse	A251113	111.35–111.45	Kunda
A250679	67.95–68.05	Kukruse	A251124	112.45–112.60	Kunda
A250698	69.80–69.90	Kukruse	A251134	113.40–113.55	Kunda
A250717	71.70–71.85	Kukruse	A251143	114.30–114.50	Kunda
A250739	73.90–74.00	Kukruse	A251152	115.22–115.32	Kunda
A250759	75.95–76.05	Kukruse	A251153	115.32–115.45	Kunda
A250778	77.85–77.97	Kukruse	A251159	115.90–116.00	Kunda
A250799	79.90–80.10	Kukruse	A251168	116.80–116.90	Kunda
A250820	82.00–82.10	Kukruse	A251174	117.45–117.55	Kunda
A250848	84.80–84.90	Kukruse	A251177	117.70–117.85	Kunda
A250851	85.10–85.20	Uhaku	A251178	117.85–117.95	Volkhov
A250869	86.90–87.00	Uhaku	A251182	118.20–118.28	Volkhov
A250881	88.10–88.20	Uhaku	A251184	118.40–118.50	Volkhov
A250894	89.40–89.55	Uhaku	A251187	118.75–118.90	Volkhov
A250905	90.55–90.65	Uhaku	A251189	118.90–119.00	Volkhov
A250915	91.50–91.63	Uhaku	A251202	120.20–120.40	Billingen
A250927	92.70–92.85	Uhaku	A251206	120.60–120.80	Billingen
A250936	93.60–93.70	Uhaku	A251208	120.80–121.00	Billingen

* collected by Heikki Bauert

Results of semiquantitative emission spectral analyses of major and trace elements in Palaeoproterozoic rocks of the Taga-Roostoja (25A) core

Sample	Sampled interval (m)	Rock type	SiO_2	Al_2O_3	Fe_2O_3t	MgO	CaO	Na_2O	K_2O	Sc	Ti	V	Cr	Mn	Co	Ni	Cu	Pb	Zn	Sn	Ga	Zr	Nb	Y	Yb	Be	Sr	Ba	B
			%							ppm																			
253120	312.0–313.0	Gn.,w.	60	15	8	3.0	0.30	0.20	3.0	10	2500	90	100	250	13	60	15	10	130		25	100	10	20	2.0	3.0	60	400	100
253136	313.6–314.6	Gn.,w.	50	15	10	3.0	0.15	0.18	4.0	10	4000	180	150	250	15	70	30	6	180	2.0	28	150	20	6	1.0	4.0	30	300	100
253149	314.9–315.9	Gn.,w.	65	15	7	2.5	0.20	0.20	4.0	10	2500	50	60	200	9	30	13	20	80	1.0	15	150	10	20	2.0	3.0	200	600	60
253162	316.2–317.2	Gn.,w.	50	15	10	2.5	0.20	0.20	3.0	25	3500	80	90	900	15	60	18	10	150		25	180	25	50	5.0	6.0	60	400	100
253174	317.4–318.4	Gn.,w.	60	13	6	2.5	0.15	0.15	4.0	8	2500	80	130	230	18	40	8	6	130	2.0	23	100	10	10	1.0	3.0	30	250	100
253184	318.4–319.4	Am.,w.	50	13	13	5.0	0.20	0.18	4.0	20	3000	90	350	400	30	50	13	8	150	3.0	25	80		6	1.0	6.0	60	600	200
253190	319.0–320.0	Gn.,w.	60	13	10	2.5	0.10	0.15	4.0	8	2500	80	130	300	15	40	15	6	130	2.0	23	150	20	10	1.5	3.0	30	400	80
253200	320.0–321.0	Gn.,w.	65	13	4	2.0	0.30	0.15	5.0	10	2500	60	70	200	8	25	7	6	90		20	150	10	10	1.5	3.0		250	60
253210	321.0–322.0	Am.,w	40	10	10	3.0	0.50	0.18	2.0	25	4000	200	150	230	25	40	70	10	70	1.0	20	60		6	1.0	4.0	30	600	200
253214	321.4–322.4	Gn.,w.	60	15	10	2.5	2.00	2.50	5.0	25	6000	150	150	800	15	50	10	30	150	2.0	25	250	30	40	4.0	2.5	250	800	25
253218	321.8–322.8	Gn.	50	15	10	3.0	2.00	2.50	4.0	15	6000	150	150	350	20	60	9	15	200		25	200	30	10	1.5	6.0	150	400	20
253227	322.7–323.7	Gn.	60	18	13	2.5	2.00	2.50	4.0	30	6000	150	100	1000	25	90	250	30	150	1.0	30	150	25	50	9.0	2.0	200	1500	20
253236	323.6–324.6	Gran.	70	18	3	1.8	2.50	2.00	7.0	6	2500	70	60	150	7	20	5	40	80	2.0	20	100		15	0.6	2.0	250	1500	15
253245	324.5–325.5	Am.	60	15	10	5.0	3.00	2.00	4.0	25	4000	150	280	350	30	80	10	13	130		20	200	10	30	2.0	4.0	400	400	25
253256	325.6–326.6	Am.	60	15	10	13.0	8.00	0.40	1.0	40	6000	230	600	1500	40	70	4	7	150	3.0	15	150		30	2.0	3.0	250	300	30
253267	326.7–327.7	Am.	50	13	10	10.0	5.50	0.60	1.5	40	6000	250	400	1000	40	70	4	8	130	3.0	18	60	10	40	3.0	3.0	250	300	30
253278	327.8–328.8	Am.	50	13	10	8.0	6.00	0.40	1.0	30	6000	200	300	1000	40	80	9	7	80	2.5	15	80		20	2.5	2.5	300	300	20
253288	328.8–329.8	Am.	40	13	10	10.0	2.00	0.50	5.0	30	6000	230	350	600	35	80	4	7	130	3.0	20	150		20	1.5	2.0	100	400	20
253298	329.8–330.8	Gn.	60	15	13	2.5	2.00	1.50	4.0	30	4000	100	130	1500	15	40	30	40	250		20	150	20	40	6.0	1.0	200	800	10
253308	330.8–331.8	Gn.	65	13	10	2.5	2.00	1.00	1.5	25	4000	70	100	1000	15	40	15	15	200	2.0	20	300	30	40	8.0	3.0	150	400	15
253317	331.7–332.7	Gran.	70	15	4	2.5	2.00	2.50	4.0	6	3000	80	80	230	13	50	23	35	90		20	200	10	10	0.6	2.0	200	1000	15

Notes: Am., amphibolite;
Am.,w., amphibolite, weathered;
Gn., garnet-cordierite gneiss (mica gneiss);
Gn.,w., garnet-cordierite gneiss, weathered;
Gran., migmatite granite;
Fe_2O_3 t, total iron determined as Fe_2O_3 (Fe_2O_3 t=Fe_2O_3+1.111 FeO);
Empty cells – component not determined or content below the detection limit.

APPENDIX 8

Results of semiquantitative emission spectral analyses of major and trace elements in Ordovician rocks of the Taga-Roostoja (25A) core

Sample	Sampled interval (m)	Stage/ Substage	Formation/ Member	MgO	CaO	SiO_2	Al_2O_3	Fe_2O_3t	Sc	Ti	V	Cr	Mn	Co	Ni	Cu	Pb	Zn	Ag	Ga	Sr	Ba	Zr	La	Yb	Y
				%					ppm																	
250105	10.5–12.5	Nabala	Saunja	18	30	3.5	1	1	2	300	15	6	1000	2	6	3	15		0.06		30	80	40	20	0.6	10
250125	12.5–14.5	Nabala	Saunja	18	15	1.8	0.5	1	2	300	25	10	1000	3	8	4	25		0.06		30	60	40	15	0.6	6
250145	14.5–15.8	Nabala	Saunja	18	30	6	1.5	1.3	3	400	25	15	1500	4	10	6	60	100	0.2	2	60	100	60	15	0.6	10
250158	15.8–16.8	Nabala	Paekna	10	35	10	2	1	4	600	15	20	800	6	15	10	20	10	0.15	3	200	250	60	30	1	20
250168	16.8–17.8	Nabala	Paekna	1.5	40	13	2.5	1	6	2000	40	40	300	6	10	6	6		0.06	3	250	200	100	25	1	25
250178	17.8–18.8	Nabala	Paekna	1	45	8	3	0.6	6	1500	20	15	600	4	8	6	6		0.06	4	200	250	80	30	1	20
250188	18.8–19.8	Nabala	Paekna	1	40	10	3	1	6	1500	60	40	400	10	25	8				3	200	200	80	30	1	20
250198	20.8–21.8	Nabala	Paekna	2	35	2.5	0.8	1	3	800	20	20	800	6	10	6				2	200	250	60	20	0.6	15
250208	19.8–20.8	Nabala	Paekna	1.3	45	18	3	1	6	2000	40	40	600	8	15	6			0.06	4	250	400	80	30	1	20
250218	21.8–22.8	Nabala	Paekna	1	40	5	1.3	0.6	4	1000	30	10	600	2	6	4	6			2	100	300	100	30	0.6	25
250228	22.8–23.7	Nabala	Paekna	1.2	45	6	2.2	0.75	3	1000	22	6	500	6	18	5	6	35	0.06	4	180	150	60	30	0.6	12
250237	23.7–25.7	Rakvere	Tudu	1	50	2	0.8	0.35	2	600	15	10	600	2	4	4		50		2	220	100	32	20		8
250257	25.7–27.7	Rakvere	Tudu	1	50	3	1	0.5	2	400	18	10	600	2	5	5		10		2	180	180	32	20		10
250277	27.7–29.7	Rakvere	Piilse	0.7	50	3.5	1.8	0.4	4	1500	25		400		1	2				2	200	100	80	20	0.6	20
250297	29.7–31.7	Rakvere	Piilse	2		1.5	0.5	0.3	3	800	12	6	400	2	4	4			0.06	2	300	70	35	20		12
250317	31.7–33.7	Rakvere	Piilse	1		1	0.25	0.35	3	400	12	8	600	2	5	4			0.06	2	350	80	35	25		8
250337	33.7–35.1	Rakvere	Piilse	1	50	4.5	1.5	0.5	3	400	20		300	2	6	3	6	60	0.06	2	280	80	45	20	0.6	10
250351	35.1–37.0	Rakvere	Piilse	1	45	4.5	1.3	0.6	2	350	12	8	450	4	8	5	15	50	0.06	2	200	80	40	20	0.6	6
250376	37.6–37.8	Oandu	Tõrremäe	0.7	45	4	1.3	1	2	400	12	6	600	4	7	4	8		0.06	3	120	70	60	20	1	10
250380	38.0–40.0	Keila	Saue	3	25	15	3.5	1.5	4	1500	20	20	600	6	10	8	10		0.06	4	200	100	100	30	1	20
250400	40.0–41.0	Keila	Saue	2	40	10	3	1.5	4	1500	30	15	600	6	10	6	6		0.06	2	250	150	100	30	1	25
250410	41.0–42.0	Keila	Saue	1.5	35	13	3	1.3	3	1500	20	20	300	6	10	6	15			3	200	100	100	20	1	15
250420	42.0–43.0	Keila	Pääsküla/Saue	1.2	42	9	2.8	0.9	4	1000	18	10	600	5	10	9	8		0.08	4	220	120	60	20	1.2	18
250430	43.0–44.0	Keila	Pääsküla	1.5	40	8	2	1	3	1500	30	15	600	4	10	6	6			3	250	100	100	20	1	15

Appendix 8 continued

Sample	Sampled interval (m)	Stage/ Substage	Formation/ Member	MgO	CaO	SiO_2	Al_2O_3	Fe_2O_3t	Sc	Ti	V	Cr	Mn	Co	Ni	Cu	Pb	Zn	Ag	Ga	Sr	Ba	Zr	La	Yb	Y
				%					ppm																	
250440	44.0–45.0	Keila	Pääsküla	2	40	10	2	1.5	3	1500	20	15	800	6	10	8	6		0.06	3	250	150	100	25	1	20
250450	45.0–46.0	Keila	Kurtna/Pääsküla	1.8	40	13	2	1.3	3	1000	25	15	600	4	8	8	6			3	250	100	100	20	1	15
250460	46.0–47.0	Keila	Kurtna	0.5	40	18	2.5	1.3	3	1500	15	20	300	4	8	6	6			4	200	100	80	20	1	20
250470	47.0–48.0	Keila	Kurtna	1	35	15	3	1	4	1500	25	20	400	4	10	6	10		0.1	3	200	150	100	20	1	20
250480	48.0–49.0	Keila	Kurtna	18	35	25	4	1.8	6	1000	15	20	600	6	20	10	6			6	250	200	100		2.5	20
250490	49.0–50.0	Keila	Kurtna	1.3	40	20	3.5	1.8	3	1500	30	30	400	6	10	8	6		0.06	3	200	100	100	20	1.5	20
250500	50.0–51.0	Haljala/Keila	Madise/Kurtna	1	40	15	4	1	4	1500	20	6	300	4	10	4	6			3	200	100	100	20	1.5	20
250510	51.0–53.0	Haljala	Pagari/Madise	1	40	13	3	1.5	3	1500	15	15	300	4	8	6				3	200	200	100	20	1.5	20
250530	53.0–54.0	Haljala	Pagari	1.5	40	13	3	1.5	4	2000	40	20	600	8	10	10	6		0.06	6	200	150	100	20	1.5	15
250540	54.0–55.0	Haljala	Aluvere/Pagari	1	40	10	2.5	0.8	4	1500	20	15	400	4	8	6				3	250	100	100	25	1	20
250550	55.0–56.0	Haljala	Aluvere	1.5	40	13	2	0.8	4	2000	10	10	600	3	6	6			0.06	3	200	100	100	20	0.6	20
250560	56.0–57.0	Haljala	Aluvere	1.8	45	8	2	0.5	3	400	10	15	600	2	6	8	10		0.06	4	200	100	40	20	0.6	20
250570	57.0–58.0	Haljala	Aluvere	1.8	40	13	2.5	0.8	3	1500	20	15	400	3	6	6				2	200	100	100	25	1	20
250590	59.0–60.0	Haljala	Vasavere	1	35	20	2	1.5	6	1500	20	20	400	6	10	8	6		0.06	6	200	100	150	25	1.5	25
250600	60.0–61.0	Haljala	Vasavere	0.6	40	20	3	0.6	4	1500	15	15	600	3	8	4	6			3	200	100	60	20	1.5	20
250620	62.0–64.0	Haljala	Tatruse/Vasavere	1.3	40	10	3	1	6	2000	20	10	600	4	10	10	6			3	150	100	100	25	1	25
250640	64.0–65.0	Haljala	Tatruse	1.5	45	5.5	1.2	1.2	3	1000	10	6	600	5	15	7	8	13	0.06	2	180	80	50	25	1	18
250650	65.0–66.0	Haljala	Tatruse	2.5	40	13	2	2	4	1000	20	25	800	6	10	4	6		0.06	3	200	80	100	20	1.5	25

Notes: Empty cells – component not determined or content below the detection limit;
Fe_2O_3 t–total iron determined as Fe_2O_3 (Fe_2O_3 t=Fe_2O_3+1.111 FeO).

APPENDIX 9

Chemical composition of Palaeoproterozoic rocks of the Taga-Roostoja (25A) core (in per cent)

Sample	Sampled level	Rock name	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Sum	Fe_2O_3 t
253290	329.0 m	light weathered amphibolite	48.26	0.86	13.31	3.09	8.05	0.13	10.7	10.3	0.8	1.62	0.24	2.15	99.5	12.03
253300	330.0 m	light migmatized garnet-cordierite gneiss	60.74	0.5	17.08	1.47	5.03	0.06	3.14	3.63	3.32	2.96	0.17	1.56	99.7	7.06

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

APPENDIX 10

CaO, MgO, CO_2 and insoluble residue in Ordovician rocks of the Taga-Roostoja (25A) core

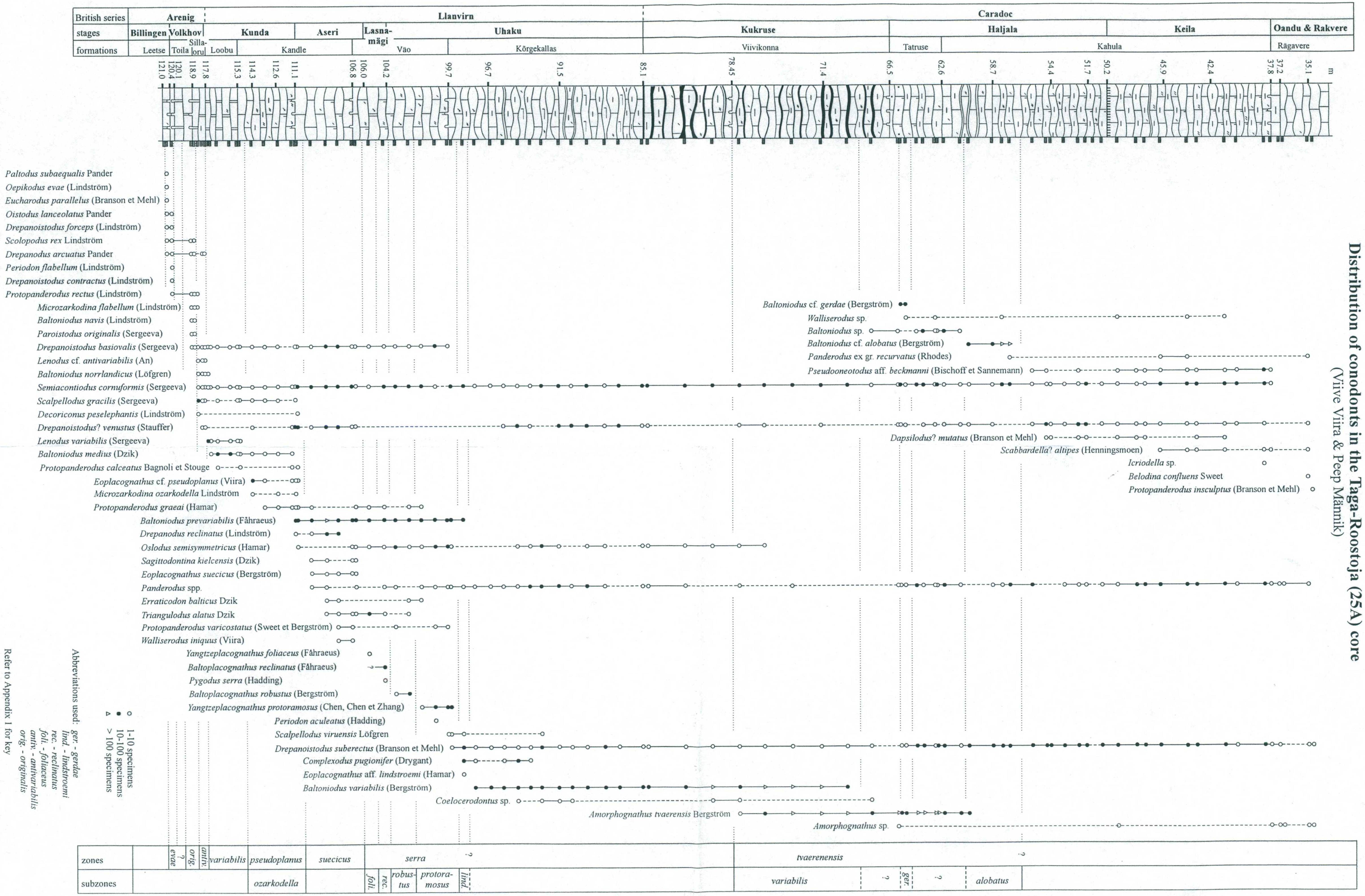
Sample	Sampled level (m)	Regional stage	CaO	MgO	CO_2	Insoluble residue (%)	Rock name
			%				
A250137	13.70	Nabala	28.85	19.66	44.55	5.10	dolostone
A250153	15.30	Nabala	28.17	18.82	43.27	7.00	dolostone
A250159	15.90	Nabala	21.76	12.26	30.90	30.04	dolomitic marl
A250183	18.30	Nabala	43.74	1.17	36.01	15.76	argillaceous dolostone
A250184	18.40	Nabala	39.89	0.79	32.56	24.34	argillaceous dolostone
A250193	19.30	Nabala	43.05	1.17	35.64	16.88	argillaceous dolostone
A250202	20.20	Nabala	48.32	1.24	39.85	8.52	limestone
A250213	21.30	Nabala	40.53	3.02	35.16	18.00	argillaceous dolomitic limestone
A250223	22.30	Nabala	51.01	0.95	41.14	6.18	limestone
A250234	23.40	Nabala	48.32	1.68	39.84	8.30	limestone
A250240	24.00	Rakvere	51.98	1.00	42.19	4.04	limestone
A250241	24.10	Rakvere	52.32	1.58	43.12	3.26	limestone
A250278	27.80	Rakvere	51.53	1.00	40.72	4.00	limestone
A250289	28.90	Rakvere	52.32	1.58	43.34	2.48	limestone
A250350	35.00	Rakvere	49.46	1.51	40.50	6.46	limestone
A250351	35.10	Rakvere	50.79	0.95	40.92	6.58	limestone
A250369	36.90	Rakvere	49.69	1.24	40.50	6.18	limestone
A250374	37.40	Oandu	46.94	0.84	37.71	9.60	limestone
A250375	37.50	Oandu	49.05	0.75	40.04	9.28	limestone
A250406	40.60	Keila	39.89	3.16	34.98	18.66	argillaceous dolomitic limestone
A250412	41.20–41.30	Keila	40.99	3.69	35.64	15.56	argillaceous dolomitic limestone
A250435	43.50–43.60	Keila	46.48	1.00	37.07	11.18	argillaceous limestone
A250444	44.40	Keila	43.82	3.16	38.28	13.72	argillaceous dolomitic limestone
A250460	46.00–46.10	Keila	29.99	2.86	26.84	32.80	calcitic marl ?
A250471	47.10–47.20	Keila	38.47	1.68	32.38	23.54	argillaceous limestone ?
A250472	47.20	Keila	43.82	1.11	36.08	17.66	argillaceous limestone
A250479	47.90	Keila	42.36	1.17	34.57	16.96	argillaceous limestone
A250493	49.30–49.40	Keila	34.81	2.35	30.25	27.70	dolomitic calcitic marl
A250509	50.90–51.00	Haljala	38.24	2.69	33.88	20.80	argillaceous dolomitic limestone
A250515	51.50	Haljala	37.78	3.36	33.88	21.92	argillaceous dolomitic limestone
A250519	51.90	Haljala	37.49	2.53	32.56	24.34	argillaceous dolomitic limestone
A250521	52.10–52.20	Haljala	30.23	2.52	27.03	33.86	calcitic marl ?
A250538	53.80–53.90	Haljala	34.58	2.52	30.45	27.34	dolomitic calcitic marl
A250555	55.50	Haljala	45.56	1.58	37.62	12.76	argillaceous limestone
A250557	55.70	Haljala	38.24	2.35	33.46	21.68	argillaceous dolomitic limestone
A250574	57.40	Haljala	42.36	1.85	34.74	17.26	argillaceous limestone
A250582	58.20–58.40	Haljala	41.68	1.51	34.52	19.12	argillaceous limestone
A250584	58.40	Haljala	28.39	2.69	25.34	38.24	argillaceous marl
A250606	60.60	Haljala	25.07	1.58	21.12	48.66	calcitic marl
A250608	60.80	Haljala	24.73	0.80	20.85	50.46	argillaceous marl
A250622	62.20–62.40	Haljala	42.59	0.80	34.74	19.76	argillaceous limestone
A250631	63.10	Haljala	46.21	1.58	37.84	11.02	argillaceous limestone
A250642	64.20	Haljala	46.94	1.85	38.57	8.64	argillaceous limestone
A250646	64.60	Haljala	45.34	1.34	38.57	12.00	argillaceous dolomitic limestone

Appendix 10 continued

Sample	Sampled level (m)	Regional stage	CaO	MgO	CO_2	Insoluble residue (%)	Rock name
				%			
A250649	64.90	Haljala	43.28	2.02	37.29	13.32	argillaceous dolomitic limestone
A250655	65.50	Haljala	45.57	1.34	37.71	12.10	argillaceous limestone
A250656	65.60	Haljala	47.09	1.58	39.38	10.28	argillaceous dolomitic limestone
A250658	65.80–65.90	Haljala	44.00	2.25	36.85	13.24	argillaceous limestone
A250759	75.95–76.05	Kukruse	47.73	1.18	38.46	9.42	limestone
A250820	82.00–82.10	Kukruse	44.79	1.50	36.30	14.32	argillaceous limestone
A250851	85.10–85.20	Uhaku	43.37	1.18	35.00	16.08	argillaceous limestone
A250915	91.50–91.63	Uhaku	37.61	1.85	31.00	24.12	argillaceous limestone
A250936	93.60–93.70	Uhaku	35.57	1.85	30.14	26.18	calcitic marl
A250986	98.65–98.75	Uhaku	47.11	1.68	38.04	10.12	argillaceous limestone
A250997	99.75–99.85	Uhaku	47.56	3.11	40.63	6.36	dolomitic limestone
A251018	101.82–101.92	Uhaku	46.65	2.02	38.35	6.82	limestone
A251036	103.65–103.75	Uhaku	48.29	3.06	41.16	4.50	dolomitic limestone
A251046	104.65–104.75	Lasnamägi	41.79	6.60	40.19	6.40	dolomitic limestone
A251068	106.80–106.90	Aseri	47.43	1.73	38.79	8.32	limestone
A251079	107.95–108.10	Aseri	46.15	2.36	38.57	9.24	dolomitic limestone

Distribution of conodonts in the Taga-Roostoja (25A) core

(Viive Viira & Peep Männik)



Abbreviations used:
- ○ 1-10 specimens
- ● 10-100 specimens
- ▷ > 100 specimens

ger. - gerdae
lind. - lindstroemi
rec. - reclinatus
foli. - foliaceus
antiv. - antivariabilis
orig. - originalis

Refer to Appendix 1 for key

APPENDIX 6

Distribution of chitinozoans in the Taga-Roostoja (25A) core

(Jaak Nõlvak)