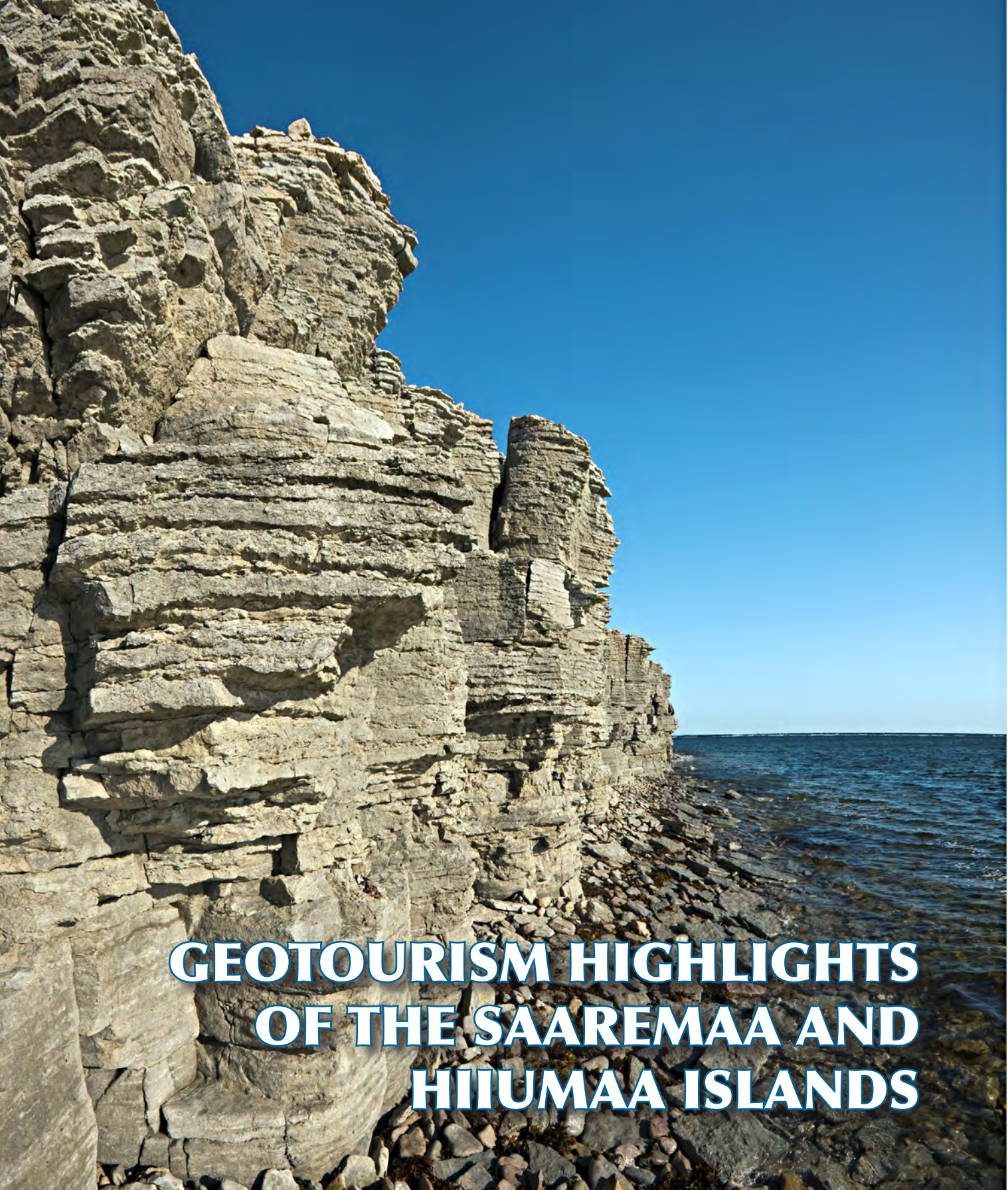

GEOTOURISM HIGHLIGHTS OF THE SAAREMAA AND HIIUMAA ISLANDS

NGO GEOGUIDE BALTOSCANDIA
UPPSALA UNIVERSITY

GEOTOURISM HIGHLIGHTS OF THE SAAREMAA AND HIIUMAA ISLANDS

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Back cover: Map of major islands in the Baltic Sea

Inner back cover: Map of Hiiumaa with places of geotourism interest

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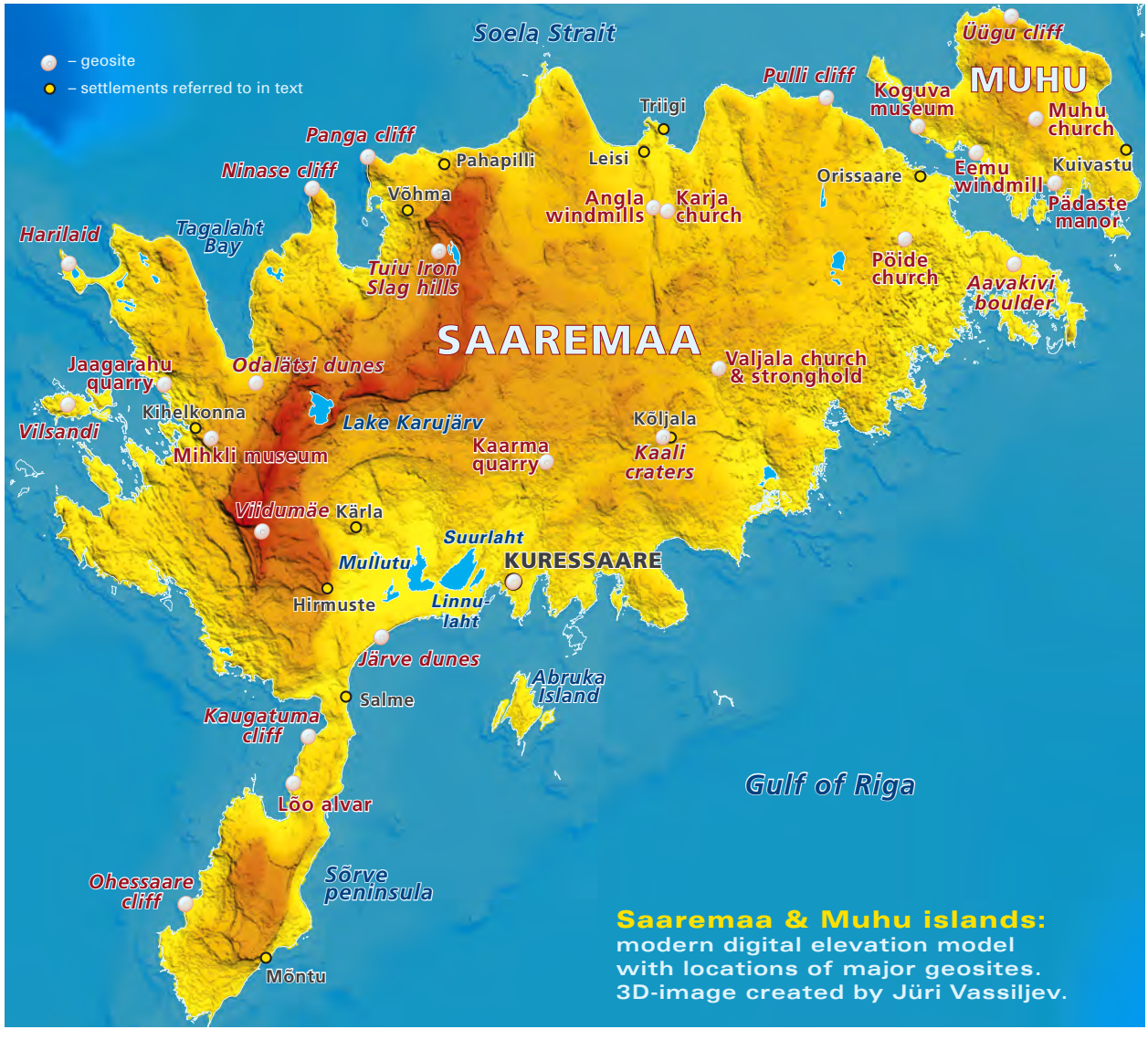
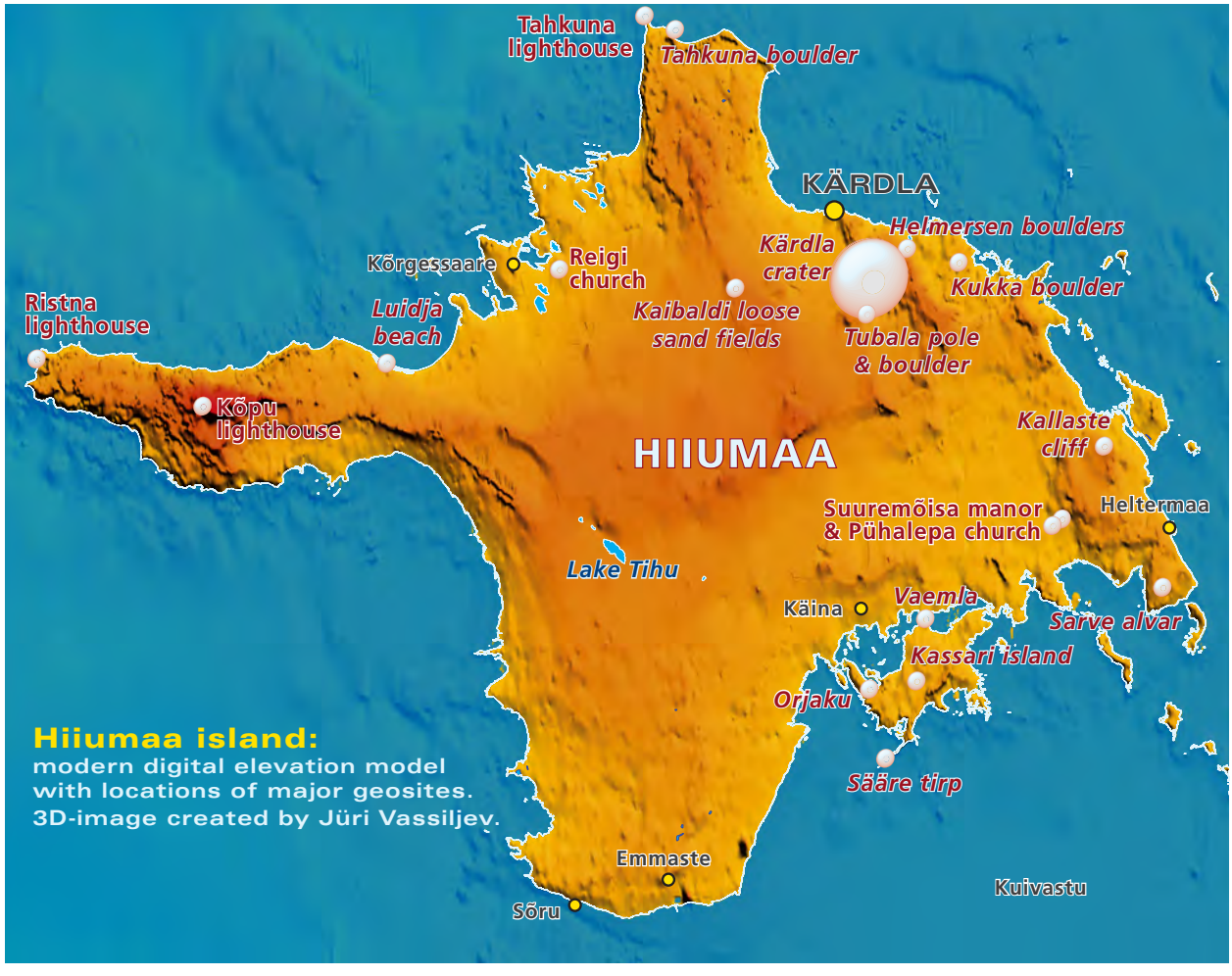
INTRODUCTION

Islanders of Saaremaa and Hiiumaa are descendants of ancient seafarers who still make jokes that there are only three genuine maritime powers in the world – England, Hiiumaa and Saaremaa. A favourable location on trade routes and active participation in the Baltic Sea trade provided ancient islanders with valuable seafaring skills and brought them great wealth as they did not hesitate to commit piracy when the opportunity arose.

Hiiumaa and Saaremaa boast a rich and complicated history as witnessed by numerous historical and cultural monuments. But these islands are also strikingly rich in natural monuments including the meteorite craters at Kärdla and Kaali, attractive coastal cliffs, large erratic boulders, alvars (limestone areas covered





with very thin soil and specific vegetation cover) as well as by numerous rare plant species little known elsewhere in the world. Saaremaa limestone cliffs and shingle beaches abound with Silurian fossils and offer lots of excitement to fossil collectors. The islands are situated along the flyway for hundreds of thousands of migratory birds, and serve as nesting grounds for a great number of species. Naturally, there are many more things that make the islands attractive to people with different interests.

Saaremaa (2673 km^2) and Hiiumaa (989 km^2) are among the largest islands in the Baltic Sea. In addition, the reader will also be introduced to Muhu (199 km^2) – an island that is historically closely connected with Saaremaa and has similar nature. Muhu Island is linked to Saaremaa by a 3.5 kilometre long causeway – the Väinatamm. Kassari Island (19.3 km^2), just off the southeastern coast of Hiiumaa will be treated as part of Hiiumaa. Kassari and Hiiumaa are connected by much shorter Laisma and Orjaku causeways.

The inhabitants of Saaremaa and Hiiumaa are very proud of their home islands and they are great jokers. It is often argued where the geographical cen-

ter for Europe or even for the whole world is to be found. Someone from Hiiumaa solved this problem quickly in his own way. He took a pole, drove it into the ground and declared: "*The center is here! If you don't believe that, measure it up – it is all the same distance in every direction!*"

The book you are holding in your hands is the first of a six volume series called *Fostering geotourism on the Central Baltic Islands*. The following books will deal with the island of Gotland, the Estonian small islands, the development and characteristics of the Baltic Sea, meteorite craters in the Baltic Sea region and Palaeozoic fossil-rich sedimentary rocks.

A SHORT COURSE ON GEOLOGIC HISTORY

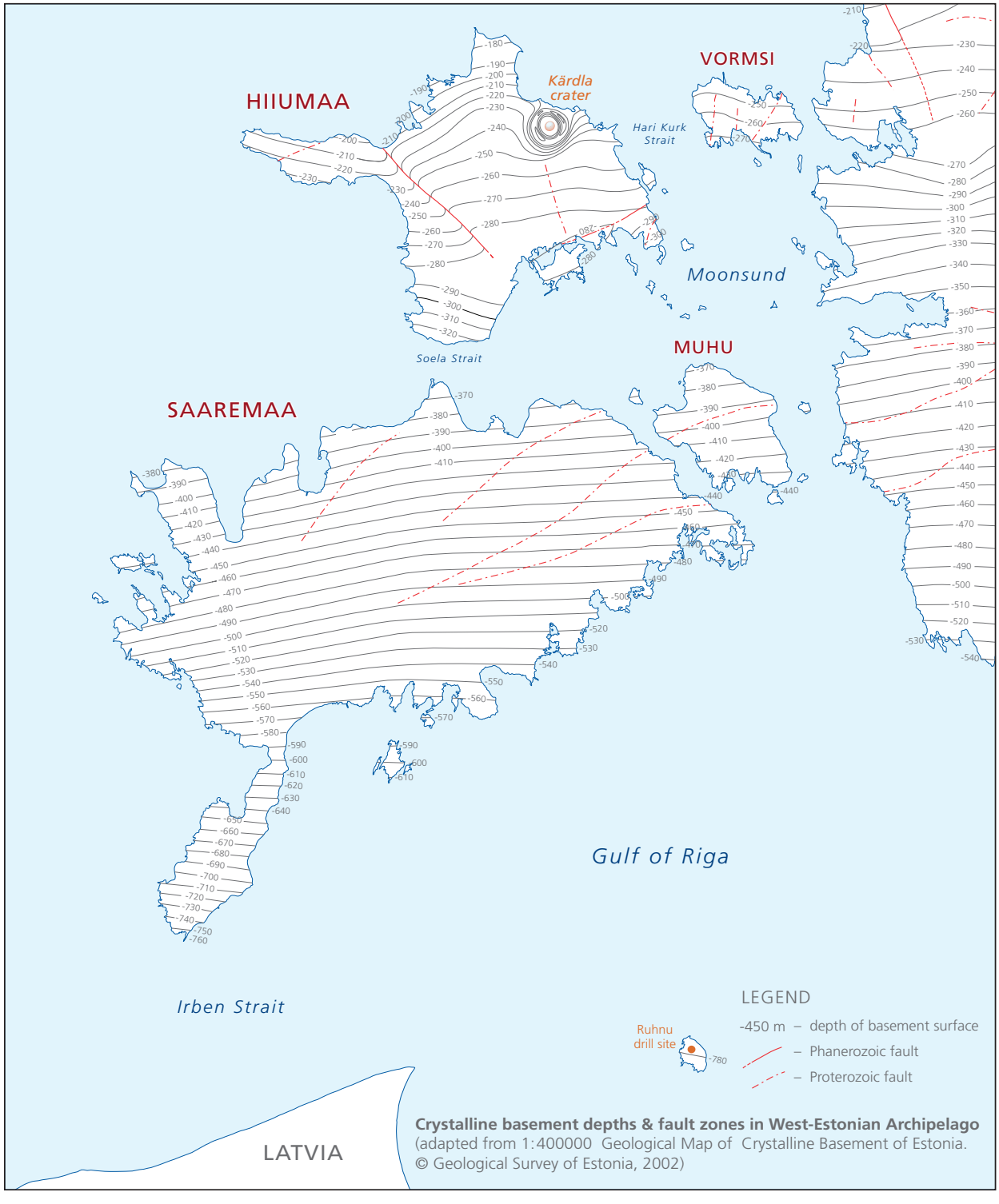
It is often said that the Earth is like a grain of sand in the universe. But this 'grain' has a very long and exciting history going back some 4.5 billion years. The time in Earth's history preceding the Palaeozoic Era (when sedimentary rocks cropping out on Saaremaa and Hiiumaa islands were formed) is largely known as Precambrian – comprising the Archaean and Proterozoic eons. At the very beginning of Archaean, the Earth was in a molten state. Gradually it cooled down to form a thin but still unstable crust, which constantly ripped here and there, permitting lava to flow out onto the surface. Over time, continuous cooling of the Earth allowed the crust to grow bigger and stronger. The cooling also condensed the water vapor in the atmosphere to water that gradually formed oceans. The earliest findings of stromatolitic limestone of presumed cyanobacterial origin deposited in ancient water bodies date back to Archaean. Archaean rocks are not known in Estonia nor in neighbouring areas, however crystalline rocks of Proterozoic age form a crystalline basement beneath exposed Palaeozoic sedimentary cover.

Precambrian crystalline basement

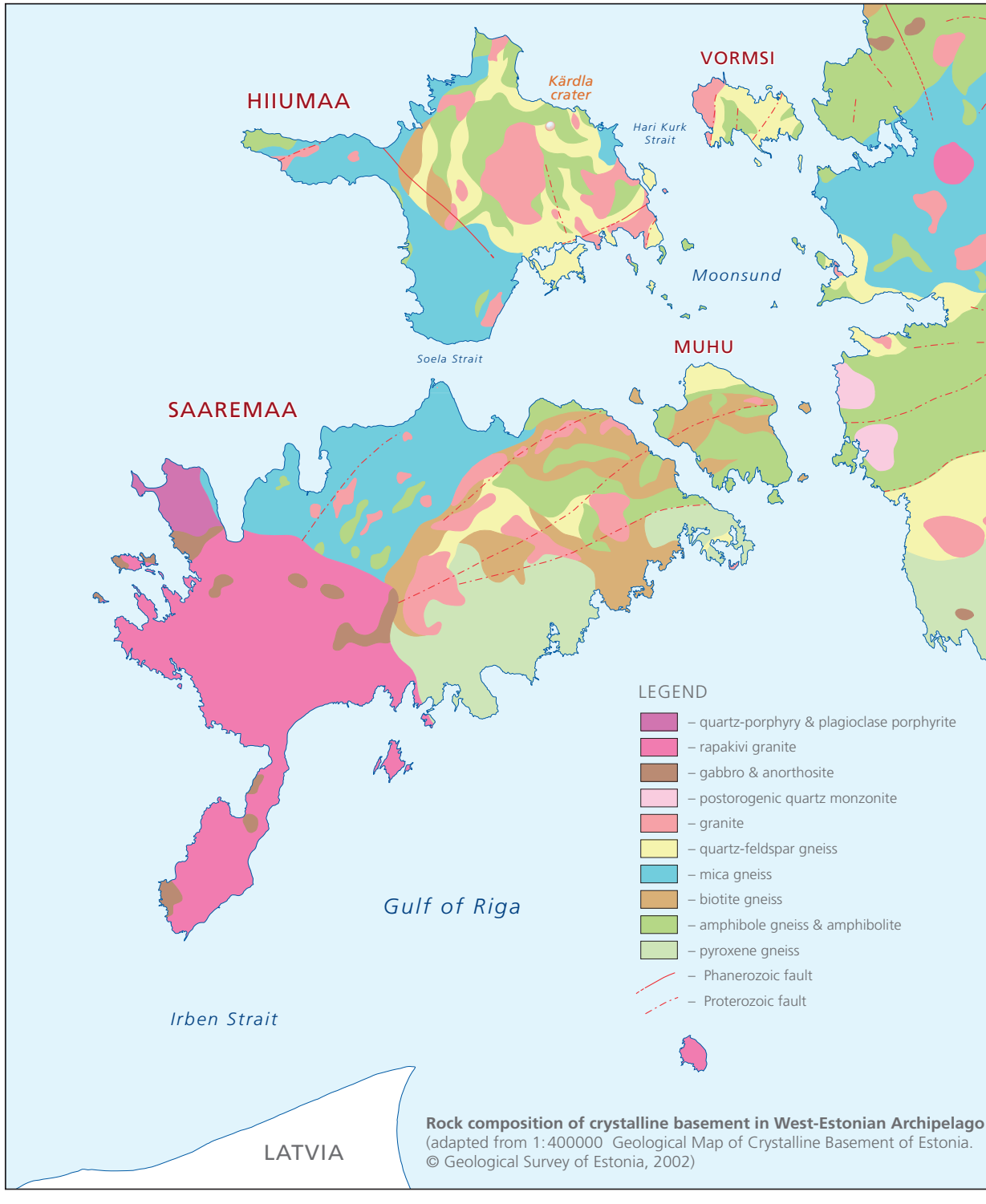
Like the whole Estonian territory, Hiiumaa and Saaremaa are located on the southern slope of the Fennoscandian Shield. This shield is composed of crystalline rocks which actually form a southward extension of crystalline rock complexes cropping out in southern Finland. The surface of the Fennoscandian Shield is dipping slightly southwards – about 3.2 metres per kilometre. Based on borehole data and geophysical evidence, the Proterozoic crystalline rocks occur at a depth of 180–760 metres in Hiiumaa and Saaremaa, while the 500 metre isobath runs through the central part of Saaremaa in roughly west-east direction. The borehole data from Ruhnu Island in the Gulf of Riga show that here the top of the crystalline basement lies at a depth of 778.2 metres. These Proterozoic crystalline rocks are represented by different magmatic and metamorphic rocks some 1.9–1.6 billion years old.

The basement of Hiiumaa is mainly composed of metamorphic rocks, however, in southeastern Hiiumaa and in Kassari it comprises also granites. The basement rocks are intensively folded and penetrated by numerous faults and intrusions. The relatively flat upper surface of crystalline rocks in this area is dissected by steep local uplift areas – the best-known is the Paluküla hill in northeastern Hiiumaa. The Paluküla hill is part of the Kärdla meteorite crater rim wall which is made up of crystalline rocks, some reaching up to 5 metres above sea level.

Most of Saaremaa area is located within the Latvian-Estonian folded basement complex, 1.9–1.8 billion years old. The northern edge of this complex is marked by a bit younger (1.6–1.55 billion years) Riga rapakivi pluton which extends to the southwestern corner of Saaremaa. Metamorphic rocks prevail in eastern Saaremaa, while acid igneous rocks (mostly



Crystalline basement depths & fault zones in West-Estonian Archipelago
(adapted from 1:400000 Geological Map of Crystalline Basement of Estonia.



Rock composition of crystalline basement in West-Estonian Archipelago
(adapted from 1:400000 Geological Map of Crystalline Basement of Estonia.

various types of granite) dominate in the western part of the island.

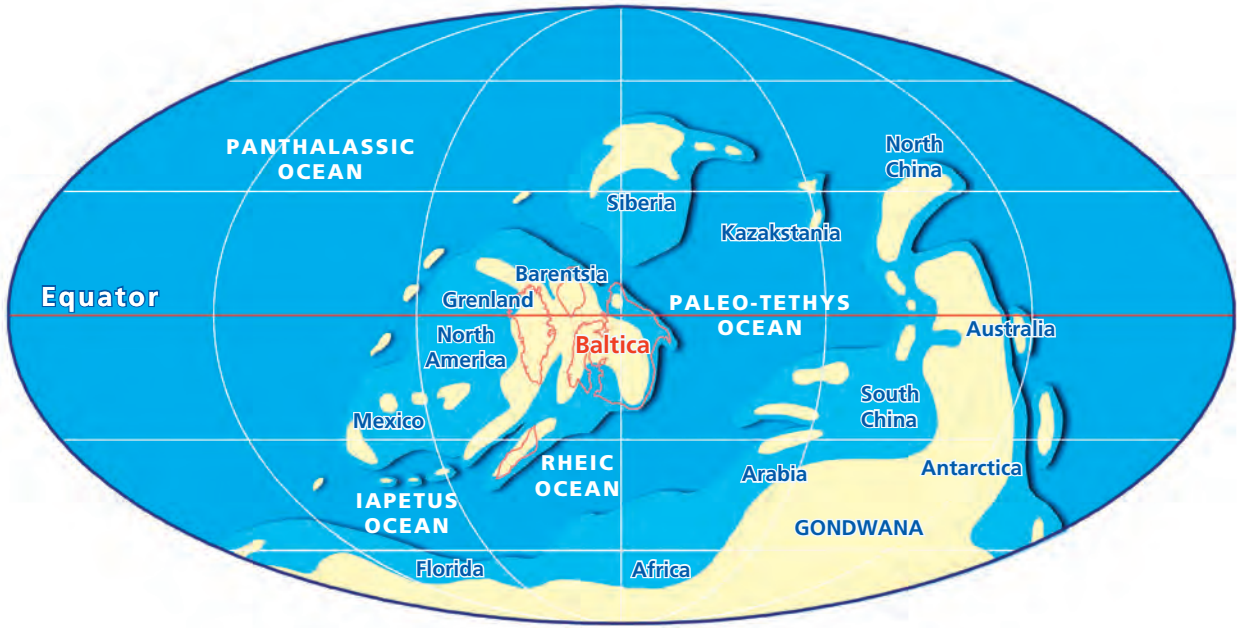
Ordovician and Silurian bedrock

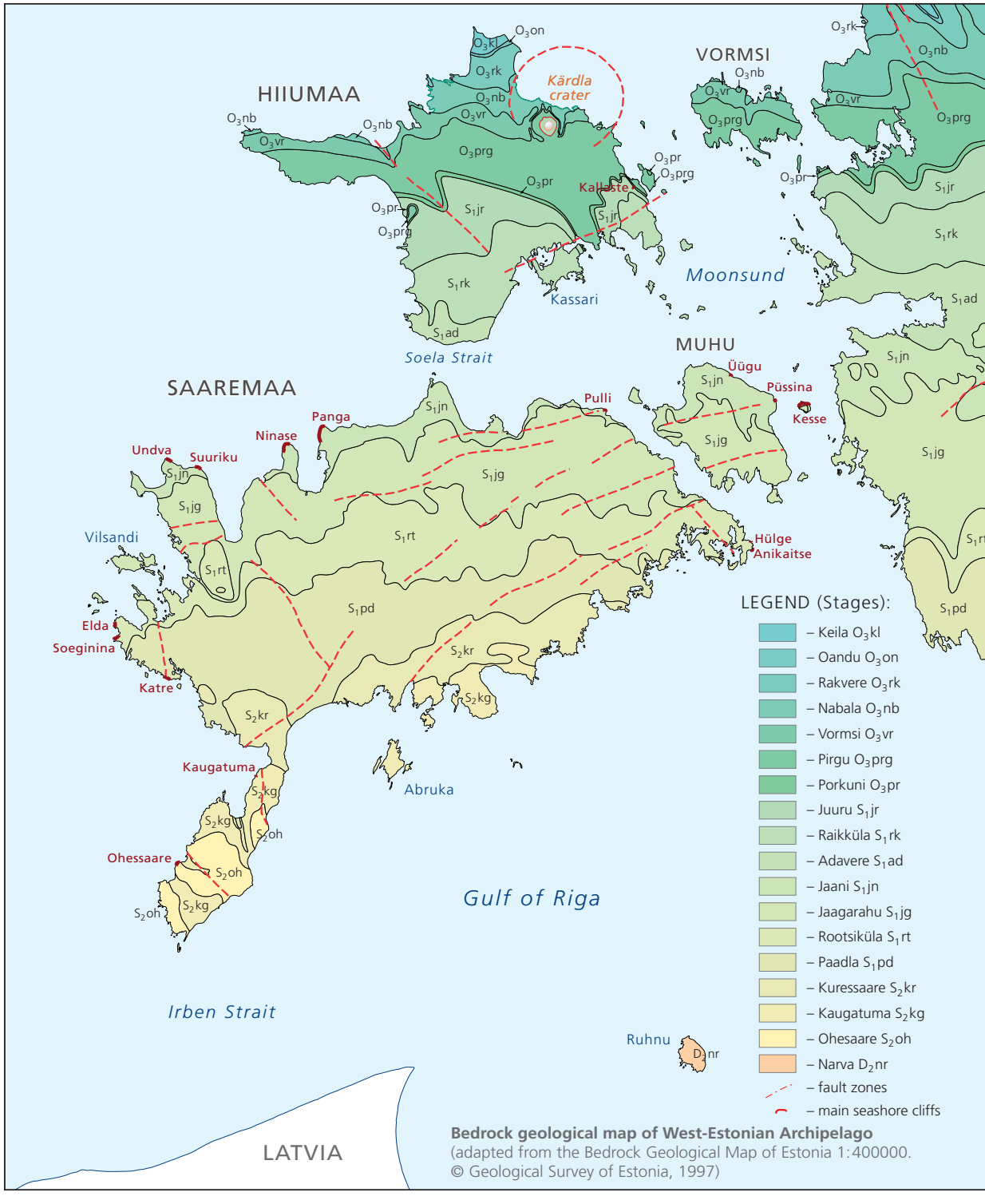
At the end of the Proterozoic (in the Ediacaran Period, also known as the Vendian), the present-day Estonia was drifting on a small Baltica continental plate, which formed some 600 Ma (million years ago) during the Rodinia supercontinent break-up. Based on palaeomagnetic records, the Baltica terrane was located at very low latitudes in the Southern Hemisphere at this time, but it drifted towards the Equator, reaching the temperate zone in Cambrian and the subtropics in Ordovician age. In Late Ordovician (some 450 Ma) Estonia was located about 25 degrees south of Equator. But in mid-Silurian time, when carbonate rocks were formed in an area of present-day Saaremaa, the Baltica terrane was already positioned close to the Equator – being only about 15 degrees southwards.

Because Baltica's palaeolatitudes steadily decreased with time, the abundance and diversity of the successive benthic faunas increased proportionately as the average water temperatures increased. The once thriving fauna of Ordovician and Silurian seas is well recorded in the seashore limestone cliffs and attract the attention of both scientists and tourists.

Let's take another look back at the end of the Proterozoic when present-day Hiiumaa and Saaremaa islands were located in an area of a large land mass which was subjected to a long-lasting erosion of ancient folded mountains. At the beginning of the Palaeozoic, in the Cambrian about 540 Ma, the land area covered by weathered sediments was inundated by sea and a variety of fine-grained terrigenous sediments accumulated here. Cambrian sandstones, siltsones and clays are not exposed anywhere on these islands but are

Position of continents in the mid-Silurian, about 425 Ma (modified after C.R. Scotese, "Plate tectonic maps and continental drift animations", The PALEOMAP Project, www.scotese.com)





Bedrock geological map of West-Estonian Archipelago
(adapted from the Bedrock Geological Map of Estonia 1:400000.
© Geological Survey of Estonia, 1997)

known from drilling cores. What catches the eyes of visitors on the ground are limestones and dolostones of Ordovician and Silurian age, which, due to the southward inclination of the sedimentary cover, crop out in east-westward oriented belts. Therefore, Upper Ordovician carbonate rocks are exposed on northern Hiiumaa and Lower Silurian limestones on southern part of the island.

The sedimentary bedrock of Saaremaa is entirely formed by Silurian carbonate rocks. The boundary between Lower and Upper Silurian carbonate rocks (between the Rootsiküla and Paadla Stages) runs through central Saaremaa, approximately along the Kihelkonna – Valjala line. The youngest Silurian rocks – limestones of the Ohesaare Stage, which formed ca 417 Ma – crop out on the southwestern cliffs of the Sõrve peninsula, southernmost Saaremaa.

The Ordovician Period spans the time between 488 to 443 Ma. This era in Earth's history is known for prevailing seas over land areas. The present-day area of Saaremaa and Hiiumaa islands was then covered by a shallow, flat-bottomed Paleobaltic Sea. In Early Ordovician age (488 – 472 Ma) only sands, silts and clays, all very poor in fossils, accumulated here. But in Middle Ordovician (472 – 460 Ma), the sea deepened and as the Baltica terrane continued a drift towards the Equator, calcareous muds started to accumulate. These carbonate sediments which during early diagenesis were lithified into hard limestones and dolostones, can now be observed in the upper parts of the North-Estonian Klint escarpments. As on Hiiumaa, the Middle Ordovician limestones are known to crop out on the sea floor some twenty kilometres north of the island.

Vahtrepa (Kallaste) cliff in SE Hiiumaa

It should be mentioned that the Ordovician or Silurian carbonate bedrock sequence is in most areas overlain by a loose Quaternary sedimentary cover on Hiiumaa. However, small outcrops of cryptocrystalline limestones of the Upper Silurian Nabala Stage are known at Hausma, Kõrgessaare and Paluküla surroundings in NE Hiiumaa. The whitish-grey to bluish-grey, clayey limestones of the Vormsi Stage and the greyish and brownish-grey nodular limestones of the Pirgu Stage are encountered at Kõrgessaare and Paluküla as well. Both the Pirgu Stage argillaceous limestones and sandy, biohermal limestones of the Porkuni Stage can be spotted also on Vohilaid Island. The limestones of Upper Ordovician Keila, Oandu and Rakvere Stages form the core of the Tahkuna peninsula, but they never crop out here.

The Lower Silurian carbonate rocks are exposed on Hiiumaa to the same extent as Ordovician rocks. The biohermal limestones of the Juuru Stage crop out in the southeastern corner of Hiiumaa – in the Vahtrepa – Aruküla – Sarve area. The highest limestone hillocks may rise as high as 10 metres above sea level. The limestone crops out in the form of several low terraces – the highest of terraces is known as the Vahtrepa (Kallaste) cliff. Here the thickness of the exposed clayey limestones may reach up to 3.5 metres. In the southern part of this cliff, a small coral bioherm can be observed.

The Silurian lasted approximately 27 million years (443 – 416 Ma). All Palaeozoic carbonate rocks cropping out in Saaremaa are of Silurian age. The total thickness of Silurian sequence is impressive – reaching 445.7 m according to data from the Ohesaare drillcore. The Silurian sequence in Estonia consists of 10 chronostratigraphical units (referred to as stages). The Juuru, Raikküla, Adavere, Jaani, Jaagarahu and Rootsiküla Stages belong to the Lower Silurian sequence, while Paadla, Kuressaare, Kaugatuma and Ohesaare Stages form the Upper Silurian sequence. Two oldest Lower Silurian units, Juuru and Raikküla Stages, are not exposed in Saaremaa, but crop out on the bottom of the northern part of the Soela Strait and in southern Hiiumaa.

The Silurian carbonate rocks in Saaremaa are rich in fossils. The Viita Beds of the Rootsiküla Stage are best known for well-preserved occurrences of sea scorpions (eurypterids), which most nature museums in the world would be proud to exhibit in their collections.

Eurypterid *Eurypterus* sp. from the Viita quarry (Rootsiküla Stage). Specimen length – 6 cm. From collections of the Institute of Geology at Tallinn University of Technology (IGTUT). Photo: G. Bauert

Mortars and pestles from Selgase mottled dolostone

Several Silurian limestone and dolostone varieties are highly valued as an excellent source material for making natural-finish stone products. For instance, the Upper Silurian Selgase mottled, easily handled limestone is widely used not only for limestone carvings (cups, plates, candlesticks) but also to make fireplace parts, wall blocks and wall veneers.

In as early as the 13th century, Kaarma dolostone was used to build Kuressaare and Pöide fortifications, as well as Valjala and Karja churches. This massive, easily cut dolostone is sometimes called 'Saaremaa marble' by local folks. Another rather pure Jaani Stage limestone which resembles the 'Vasalemma marble' – limestone (mined on the NW Estonian main-

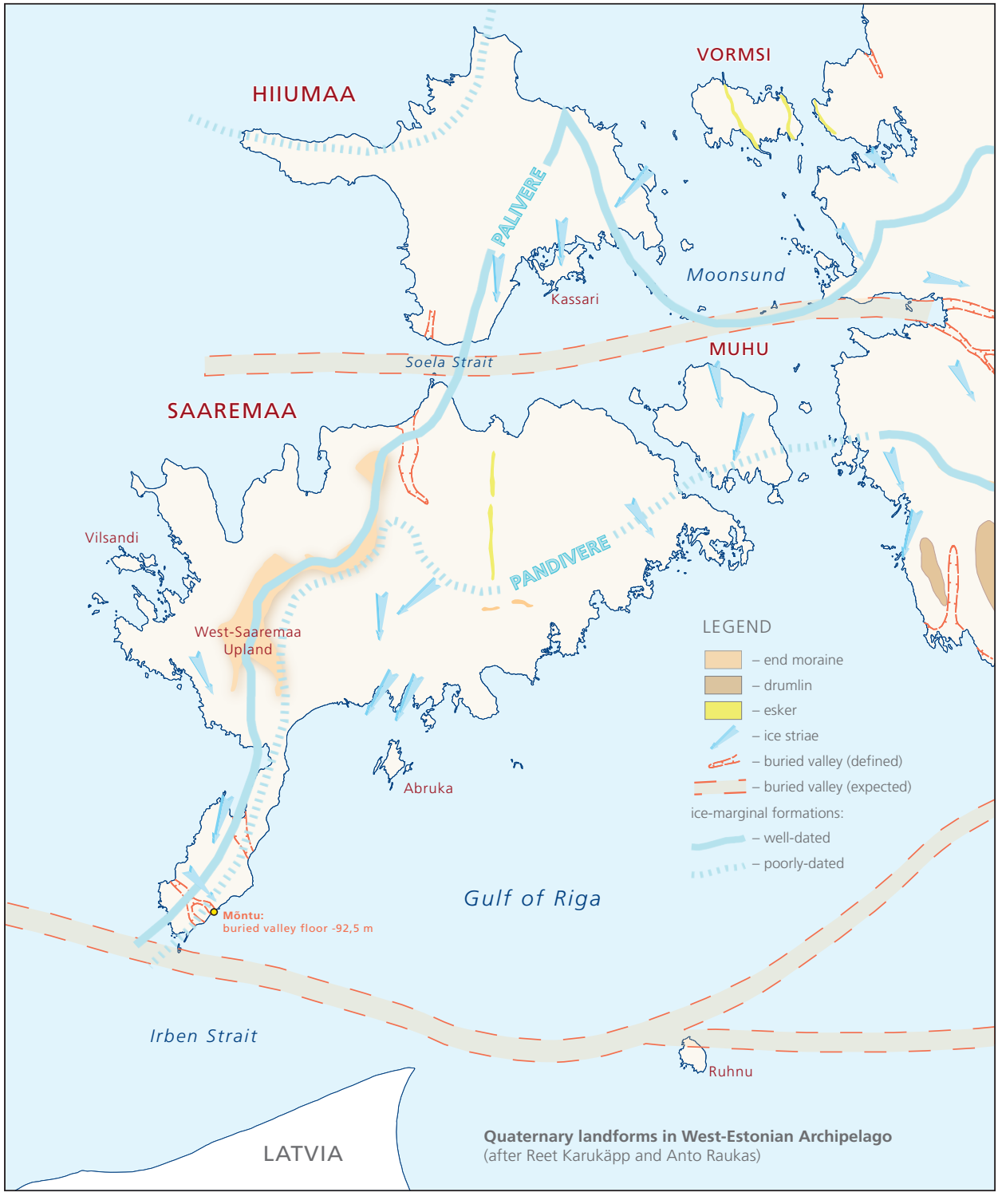
Quarrying of dolostone at Jaagarahu in 1930s. Courtesy of the Saaremaa Museum

Püssina cliff in NE Muhu

land), is found at Undva cliff in NW Saaremaa. But several other limestone varieties are used in Saaremaa to produce natural building and finished stones. For centuries, impurity-free, chemically pure limestone has been used for burning high-quality lime. This kind of limestone was mined at Jaagarahu limestone quarry north of Kihelkonna village in NW Saaremaa in the beginning of the 20th century. In the late 1920s, about 200–300 tons of pure limestone suitable for use in the metallurgical, sugar, pulp and glass industries was mined there daily during summer. As much as 98% of the mined limestone was exported – mainly to Sweden, Finland, Poland and Germany.

Spectacular landscape features in Saaremaa are numerous seashore cliffs, which are actually coastal escarpments eroded by waves into carbonate bedrock. The Saaremaa cliffs display a variety of shapes – some of them stand as almost vertical walls (Panga cliff) but others may look like scarps with wave-cut notches in the lower part (Üügu cliff). There are also cliffs rising towards the land in the form of terraces. Cliffs can be categorized as active – descending straight into the sea and subjected to direct wave action, and inactive, which exist further inland. These inactive cliffs are coastal scarps formed during earlier Baltic Sea developmental stages. Cliff height varies considerably – ranging from a few metres up to 21.3 metres at the Panga (Mustjala) cliff. Steep vertical walls have developed in carbonate rocks with uniform resistance to erosion and weathering. Wave-cut notches are characteristic to the lower parts of cliffs which consist of more argillaceous carbonate rocks. The latter are less resistant to sea erosion than pure limestones.

The Silurian sea retreated from the Saaremaa area in the Late Silurian, about 417 Ma. There are no geological records available on either islands since the end of Silurian, spanning throughout the whole Mesozoic and most of Cenozoic time. However in the adjacent areas younger clastic rocks of Devonian age are recorded on Ruhnu Island in the Gulf of Riga with a total thickness of 138.3 metres. Therefore, geologists cannot be certain what may have happened in this region since the Devonian age.



Quaternary landforms in West-Estonian Archipelago
(after Reet Karukäpp and Anto Raukas)

One thing is clear: neither the Baltic Sea nor Lake Peipsi existed in this region during these eras. The whole Baltic area was dry land with great absolute heights, dissected by giant rivers cutting deep into the ground. It is assumed that at this time the ancient Neva River was flowing along a riverbed that was to become the present-day Gulf of Finland. It may have carried its waters to the hypothetical Eridanos River running from Gulf of Bothnia southward along the present-day Baltic Sea basin. The Eridanos River apparently also collected waters from its tributaries flowing through the present-day Soela and Irben Straits. Geological mapping points out that erosion caused the formation of deep valleys in the Sõrve peninsula (e.g. the limestone bedrock lies 92.5 metres below sea level at Mõntu). In NW Saaremaa, between the Tagalaht Bay and Kihelkonna village as well as in the western part of the Pammana peninsula, the ancient valley floors are known to extend about 20 metres below sea level.

ICE AGES ON HIIUMAA AND SAAREMAA

The periods when the seas dominate on the Earth are characterized by warm climate and vice versa. For instance, at the Paleogene–Neogene boundary approximately 26 Ma, the uplift of continents was particularly fast and was accompanied by an abrupt climate cooling. A distinct cooling event took place at the end of Neogene (ca 3–4 Ma). The northern boundary of the tropical zone shifted southward by 20 degrees and warmth-loving plant species survived only in the present-day Mediterranean countries. This triggered an extensive continental glaciation, which culminated in the Quaternary – the period extending up to the present. Mighty massive continental glaciers descended from the northern Scandinavian mountains and moved across our area with enormous power. These bulldozed the bedrock surface, picked up all loose material underneath, and carried it along over long distances further to the south. At the same time, the glaciers transported erratic boulders in huge quantities from Finland as well as from the bottom of the present-day Baltic Sea. While finally retreating, these continental ice sheets left behind a picturesque glacial topography.

We have no clue how many times the continental ice sheets have moved over Hiiumaa and Saaremaa during the last million years. Interglacial deposits have not been found on Hiiumaa and Saaremaa so far. However, geological research in Lithuania and Belarus suggest the occurrence of at least six glaciations. There are speculations by some geologists that older tills preceding the last Ice Age might be found in the core of the Kõpu peninsula, Hiiumaa and in the southern part of the Sõrve peninsula, Saaremaa. But the glacial landscape topography of the islands originates mainly from the last Ice Age, although the waters of the Baltic Sea have strongly eroded emerging land and, in some places, have changed the original ice-sculptured landscapes beyond recognition.

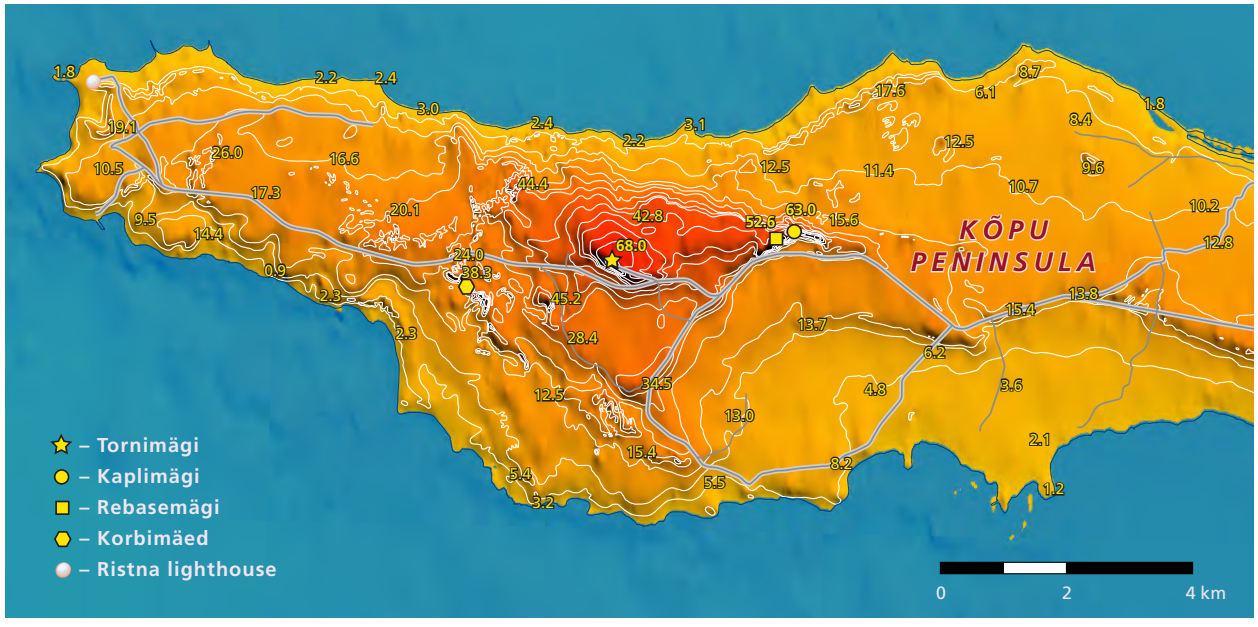
The most magnificent glacial landform is without any doubt the West-Saaremaa Upland – a huge end moraine height, composed mainly of till and rising 20–35 metres above its surroundings. The West-Saaremaa Upland formed between two ice flows, which moved in different directions and were not simultaneous. The most recent glacier moved from northwest to southeast and this one brought to western Saaremaa erratic boulders which differ in composition

Esker – glacially formed long, winding, stratified ridges

Till – unsorted glacial sediments

Drumlin – glacially formed smoothed mounds, elongated in the direction of ice flow

Moraine – sediment deposited directly from glaciers



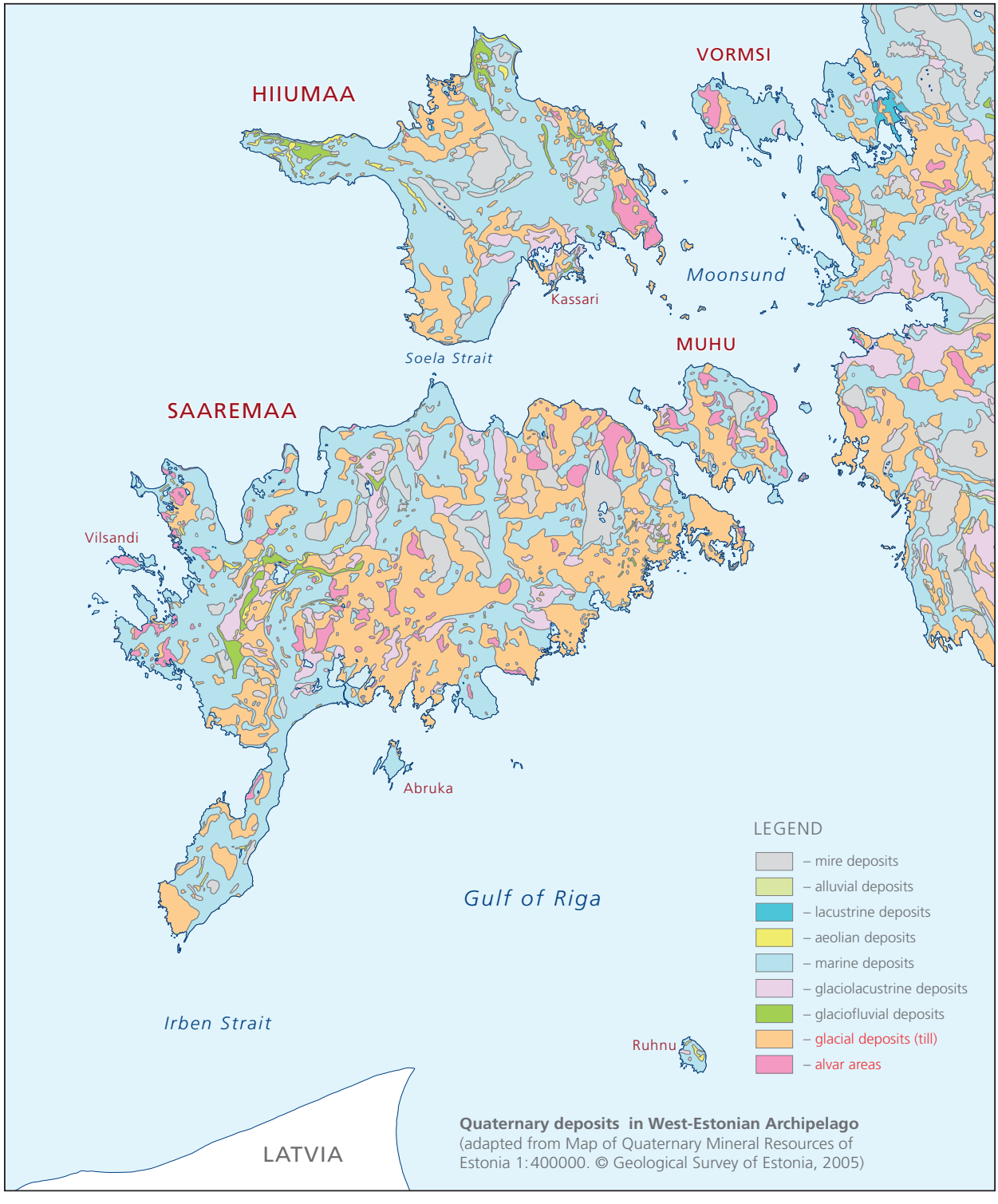
Topography of the Kõpu peninsula. Digital elevation model for background created by Jüri Vassiljev

from those found in eastern Saaremaa. The southern extension of the West-Saaremaa Upland is the Sõrve Upland, but this upland also continues northward marked by the buried Emmaste end moraine on southern Hiiumaa.

The most outstanding glacial landform on Hiiumaa is the Kõpu Upland, more than 50 metres in height. It has been interpreted either as an end moraine, radial esker or a drumlin. Based on drilling data, the upland consists mostly of tills, which are separated by the varved clay layer. The tills are overlain by glaciofluvial gravel and marine sediments, but occasionally also by aeolian sediments. The initial morphology has been strongly altered by sea waves and many scarps have eroded into its slopes. The upland is at its highest at Tornimägi – 68 metres above sea level. There are several dune fields on the southern area of the Kõpu Upland. Of those, the most remarkable are Rebasemäed (up to 52.6 m a.s.l.) and the St. Andreas dune field (with its highest point at Kaplimägi – 63.0 m a.s.l.) in the east.

All other glacial landforms of Hiiumaa and Saaremaa are much smaller in scale. The ice marginal formations on Hiiumaa are marked by end moraines running along the Väinameri (also known as Moonsund) islets to Salinõmme in southeastern Hiiumaa as well as by scattered eskers and small ice-marginal deltas. The most wide-spread glacial accumulations in Saaremaa are reflected by hilly landscape in the Pöide – Laimjala – Tõnija – Valjala – Kangruselja area. The largest glaciofluvial landforms are represented by Leisi and Haeska eskers and deltas on the West-Saaremaa Upland (e.g. at Kodaramägi) and on the Sõrve peninsula (e.g. Viieristi). Glaciofluvial deltas are also known in the central part of the Tahkuna peninsula on Hiiumaa Island. In the southern part of Kassari Island, a northeast-southwest trending esker is clearly traceable. It continues in the sea as the Sääre Tirp spit.

During the last Ice Age Hiiumaa and Saaremaa were under the influence of a glacier moving along the Bal-



Quaternary deposits in West-Estonian Archipelago
(adapted from Map of Quaternary Mineral Resources of Estonia 1:400000. © Geological Survey of Estonia, 2005)

tic Sea depression and imposing both denudational and accumulative impact. Denudational effect mostly prevailed and, as a result, the Quaternary cover is rather thin in most areas on the islands. In its final advancement stage, the glacier tongue passing east of the West-Saaremaa Upland moved mostly from north to south or even from northeast to southwest. But west of this upland area, another glacier tongue advanced prevailingly from northwest to southeast.

When the Estonian territory was freed from the ice load, the Earth's surface started to rise rapidly as a result of glacioisostatic adjustment of the Earth's crust. Reconstructing past landscapes, one has to keep in mind that during the past 12,000 years, this adjustment has caused the land to rise in a range of 40–50 metres. After the retreat of the ice sheet, the ice-free areas were almost completely inundated by waters of coldwater ice-dammed lakes. The lowering of the water level in glacial lakes was determined by the speed and extent of the ice sheet retreat. But this retreat was not uniform in time, but occasionally alternated with short-term advances of glacier tongue and accompanying water-level rises. The extent of ancient ice-dammed lakes on Hiiumaa and Saaremaa can be studied more precisely by considering the evidence stored in geological records:

- of denudational plains with outwash till and erratics,
- in scarps eroded into the slopes of hills, as well as
- in glaciolacustrine accumulative plains covered with varved clays, sand and silt.

Varved clays occur in vast areas of Hiiumaa (an area extending from Tahkuna peninsula in the north to Emmaste in the south) and they are missing only in the easternmost part of the island. These varved clays seldom crop out on the land surface (but can be spotted in the surroundings of Käina–Vaemla area and in Metsalauka and Lelu villages), as they are usually covered by younger marine sediments. In Saaremaa, the sediments of ice-dammed lakes, particularly varved clays, are known on both sides of the Leisi–Haeska esker, on the northeasten coast of the Sõrve peninsula, in surroundings of Kuressaare Town and in some other areas. Continental glaciers originating from the Scandinavian mountains transported a great number of erratic boulders to Hiiumaa and Saaremaa; some of them are rather huge.

The continental glaciers were retreating during what is called the Late Glacial period, which spanned the time from 13,000–10,000 ^{14}C* years ago. The beginning of the Late Glacial had a harsh arctic climate, which gradually warmed up to a milder subarctic climate. This geologically brief Late Glacial period, called the Dryas, was characterised by alternating warmer and colder climates. In the Dryas, three cold climate phases are distinguished – the Younger, Middle and Older Dryas. These phases were separated by the Bølling (12,700–12,200) and Allerød (11,800–10,800 ^{14}C years ago), warmer periods. During the Late Glacial the whole of Hiiumaa and most of present Saaremaa were still under water. The emerged, woodless patches of dry land were probably covered by permafrost, like the present-day Siberia.

** Different methods have been used for the age determinations of sediments. Most popular is the radiocarbon method, often calibrated by tree rings. Pleistocene/Holocene boundary is agreed as of 10,000 conventional radiocarbon years (equals to about 11,500 calibrated years) ago. In this book we use the noncalibrated, conventional radiocarbon years for age references.*

LAST 10,000 YEARS: LAND SLOWLY EMERGING FROM SEA

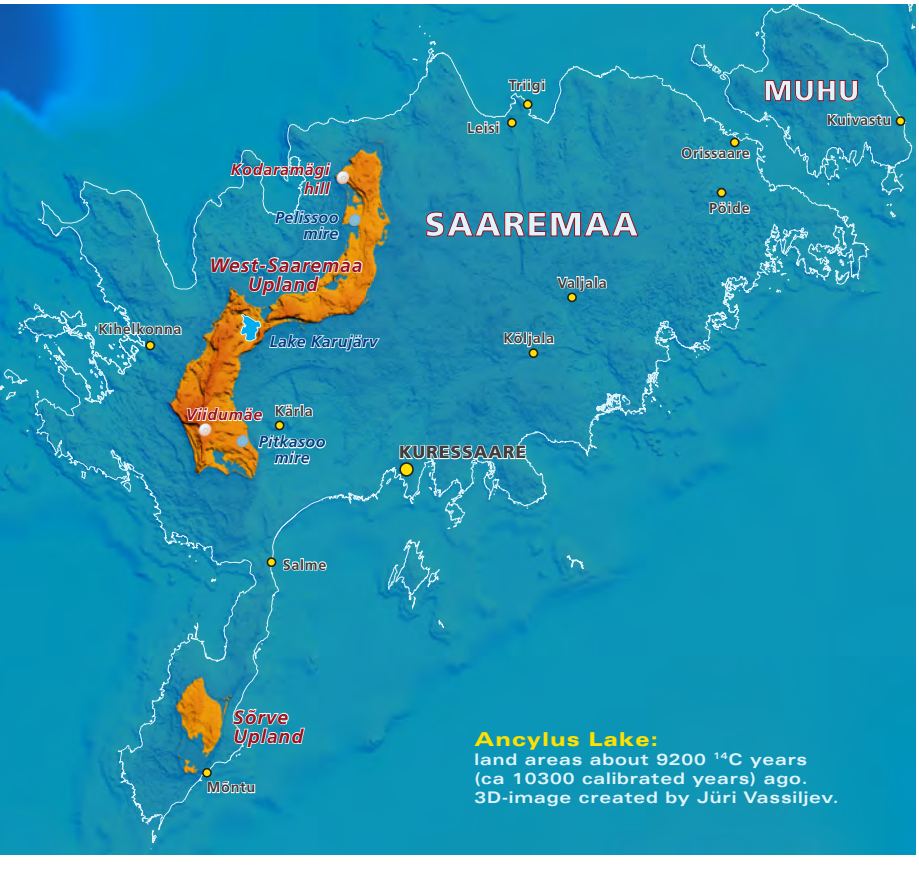
After the retreat of the continental ice sheet, Hiiumaa and Saaremaa were flooded by waters of the vast **Baltic Ice Lake**. The Kõpu peninsula on Hiiumaa and four islets on Saaremaa – two in the area which is now the West-Saaremaa Upland and two at present-day Sõrve peninsula – emerged from the sea approximately 10,300–10,200 ^{14}C years ago when the waters of the Baltic Ice Lake broke their way to the ocean through central Sweden, slightly north of the Billingen mountain. As a result of the breakthrough, the level of the Baltic Ice Lake lowered 20–30 metres to the ocean level. Water exchange with the Atlantic Ocean was established and this led to the existence of a new stage of the Baltic Sea – a brackish **Yoldia Sea** (named after the bivalve *Portlandia (Yoldia) arctica* who lived in that sea) which lasted about 900 years. During that period large areas of Hiiumaa and Saaremaa emerged from the sea. By the end of Yoldia stage (ca 9600–9500 ^{14}C years ago) the West-Saaremaa Upland, the central part of the Sõrve and Kõpu peninsulas were already free of sea waters. Bog and lake sediments dating the Yoldia Sea stage, have been found in Pitkasoo mire on the southeastern slope of the West-Saaremaa Upland, where the first peat layers formed ca 9800 years ago. At that time species-poor, sparse birch and pine forests dominated on both islands.

As a result of the continuing Earth's crust uplift, an area of Saaremaa and Hiiumaa expanded and this process is still ongoing. During the Ancylus Lake and Litorina Sea transgressions, some land areas which had emerged from the sea were again temporarily inundated. The rise of land due to post-glacial rebound was very rapid at first – as much as several centimetres per year. It has been slowing down with time and it is only 2.8 millimetres on the Kõpu peninsula at the present. Elsewhere in Estonia, it is even less than that.

Crustal uplift restricted the inflow of saline water from the North Sea which led to the short-term transitional phase between the Yoldia Sea and Ancylus Lake (9300–8000 ^{14}C years ago). This transitional phase was a brackish-water **Echeneis Sea**.

The melting of glaciers in the Scandinavian mountains was still in a full swing, and for that reason the first **Ancylus Lake** phase was transgressive. The water-level rise culminated ca 9200–9000 years ago. On Kõpu peninsula it reached 45 metres and on the slopes of the West-Saaremaa Upland up to 35 metres above the present-day sea level. In Saaremaa Island, the coastal formations of that period are known to occur at Kodaramäe (at a height of 35 metres) and 31 metres from sea level at Viidumäe area. There was an island – about 6 kilometres long and 4 kilometres wide – in an area of present-day Sõrve peninsula where the coastal formations of the Ancylus Lake are known to occur at a height of 25 m. The highest areas of central Muhu Island also emerged from the waters at that time.

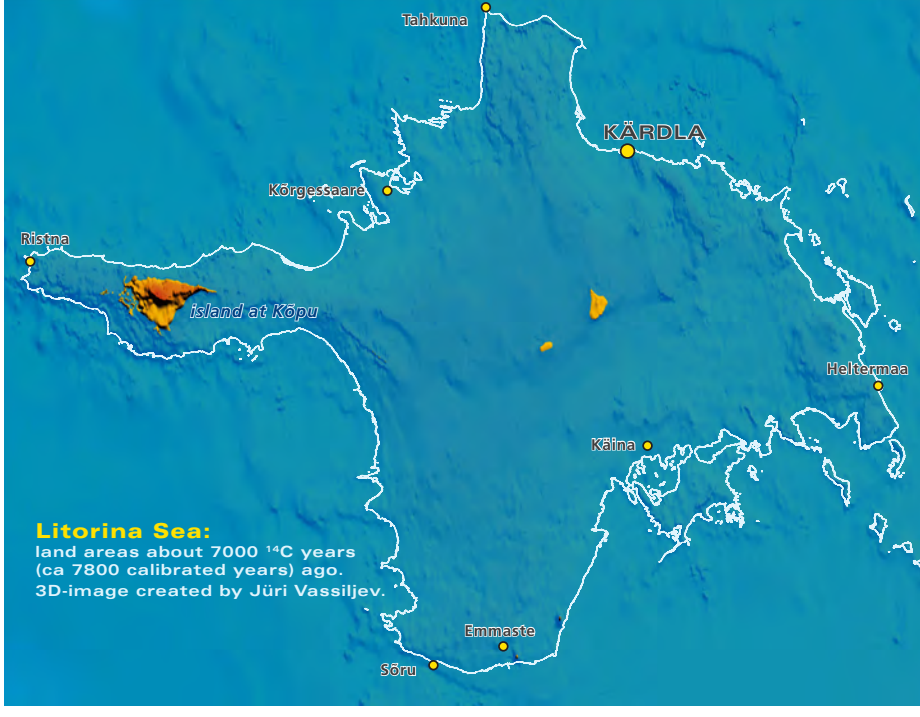
The rising Ancylus Lake waters covered older bog and lake sediments in many places. Dating of those sediments enables the more precise determination of the individual phases of the Ancylus Lake development. In Hiiumaa and Saaremaa, the coastal formations of the Ancylus Lake have been recorded at six levels. The sediments studied in Lake Karujärv, Pitkasoo and Pelisoo mires and elsewhere in Saaremaa suggest that the birch and pine forests prevailed at the beginning of the Ancylus Lake, but soon elm and hazel appeared. At the end of this stage, the broad-leaved species were prevailing on better soils and the forests became denser and richer in species. The

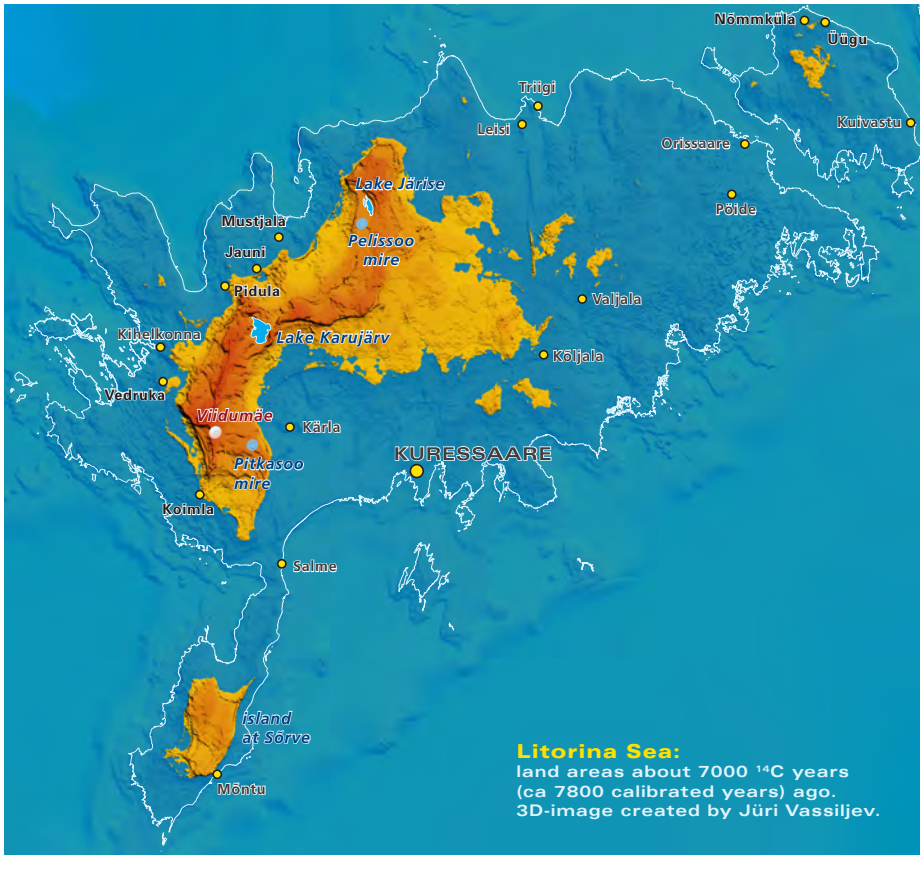


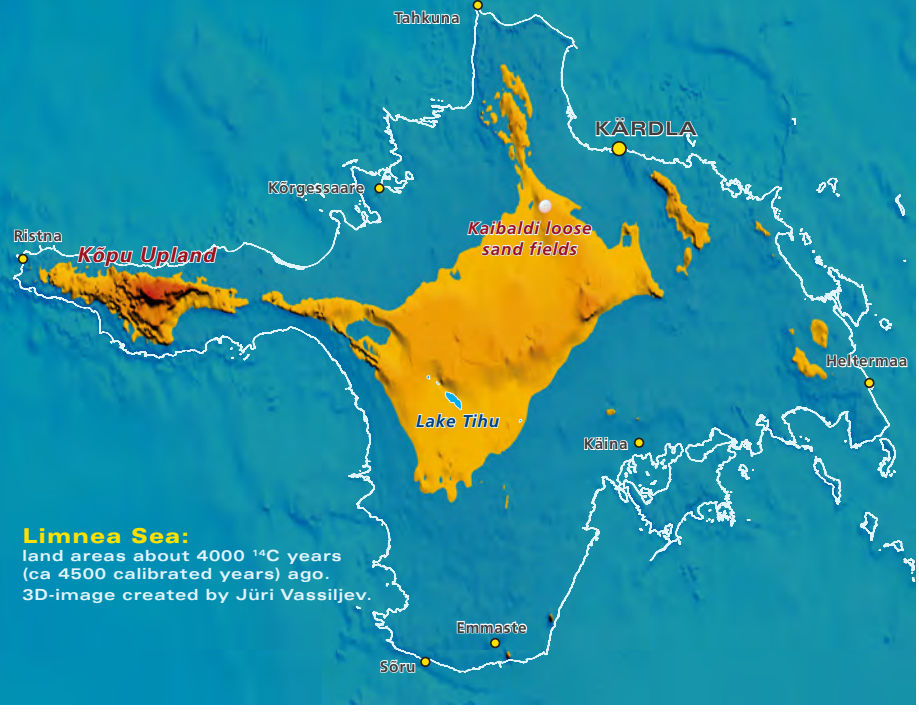
Ancylus Lake owes its name to the fresh-water snail *Ancylus fluviatilis*. As this species does not tolerate salinities higher than 2–3‰ and the remaining mollusc fauna was represented also by fresh-water species (*Physa fontinalis*, *Radix ovata var. baltica*, *Bithynia tentaculata*, *Pisidium amnicum*, *Anodonta cygnea*, *Unio tumidus*), the Ancylus Lake is considered to be an entirely fresh-water basin. The lake water temperature was evidently close to that currently in the Baltic Sea. The striped seal were among the mammals living in this lake, while the fish probably were perch, pike and roach. Primitive crustaceans were also abundant and lake plants were represented by fresh-water diatoms. The coastal formations that developed at the end of the stage occur at a height of 16 metres in the northern part of Saaremaa, which shows that both islands were already rather large at that time.

Approximately 8500 ^{14}C years ago, as a result of land subsidence in the area of the Danish Straits, the waters of the Ancylus Lake started to flow across the threshold known as the Darss Sill. The Ancylus Lake drained down to the ocean level and the Litorina Sea (8000–4000 ^{14}C years ago) was initiated. The **Litorina Sea** is the first real marine stage in the history of the Baltic Sea. However, there was a transitional phase – the **Mastogloia Sea** (named after the diatom *Masto-*

gloia schmidti) between the Ancylus Lake and Litorina Sea stages. At first, the salinity of water increased slowly and the coastal waters of Hiiumaa and Saaremaa were inhabited by the freshwater species, as earlier. Malacofauna typical of brackish-water basin developed some 7000 ^{14}C years ago, marking the beginning of the Litorina Sea (after the gastropod genus *Littorina*). Compared to the present-day Baltic Sea, the water salinity in the Litorina Sea was much higher – reaching up to 15–16‰. The Litorina Sea water level was variable and at least one remarkable sea level rise occurred at this time. The coastal formations of the Litorina Sea have been recorded at five levels to the height of 25 metres above sea level on Kõpu peninsula. In Saaremaa, the coastline of this time covered Koimla, Vedruka, Pidula and Jauni from southwest to northeast. There was an approximately 5-kilometre long and 3-kilometre wide island in the location of the present-day Muhu with some small islets at the area of Nõmmküla and Üügu in northern Muhu. The transgressive coastal formations of that time occur at a height of 21 metres above sea level at Mustjala, 19–17.5 metres on Muhu and 15 metres on the Sõrve peninsula. Large areas of dry land emerged from the sea in the final stage of the Litorina Sea. The West-Saaremaa Upland considerably increased in size, and Reo







called the **Limnea Sea** after the freshwater mollusc *Lymnaea ovata*. Since the beginning of the stage the water salinity dropped 5–8‰ and the invasion of freshwater species characteristic to the Limnea stage began. On Hiiumaa, most remarkable Limnea Sea coastal formations can be traced at five different levels up to a height of 13 metres above sea level on Kõpu peninsula. The oldest Limnea Sea coastal formations on Saaremaa are known to occur at a height of 5–11 metres above sea level. Other facts known from this period:

and Kõnnu islands merged with it. The islands off the coast of Hiiumaa, Sõrve and Muhu island expanded, and the highest points of Kessulaid islet rose above sea level.

The postglacial warm period reached its maximum during the Litorina Sea stage and the temperature was at least a couple of degrees higher than nowadays during the summer months. This favored the formation of extensive oak and other broad-leaved forests. At first, the broad-leaved forests were dominated by elm, followed by linden; at the end of the stage oak was also widespread. Among other tree species, alder was abundant, while birch and pine grew in less fertile areas. The rich Baltic Sea biota was dominated by warm-loving, brackish water species such as *Littorina littorea*, *L. saxatilis*, *Mytilus edulis* and others.

About 4000 ^{14}C years ago the ocean level started to drop slowly. This was caused by climate cooling and growth of the ice sheet in the polar regions. As a result, the Danish Straits became more shallow and the saline water inflow into the Baltic Sea decreased. This still ongoing freshwater stage of the Baltic Sea is

- the inland bays – Mullutu, Suurlaht and Linnulaht around Kuressaare Town became isolated from the sea
- the wave-cut notches in the lower part of the Üügu cliff on northern Muhu were eroded by the sea waves only a few thousand years ago
- the highest parts of Vilsandi emerged from the sea some 3000 years ago
- the island in an area of present-day Sõrve peninsula merged with the rest of Saaremaa about 1000 years ago.

If the land uplift continues at the same rate, then after 3000 years at the latest, Muhu, Hiiumaa and Saaremaa will merge together and join the mainland of western Estonia, while some inner lakes may remain only in the deepest parts of the Moonsund (Väinameri). With this process continuing, the Gulf of Riga will be transformed into a lake at some time in the more distant future.

Some researchers have distinguished one additional stage, the most recent in the evolution of the Baltic Sea. It was named the **Mya Sea** after the soft-shell

clam *Mya arenaria*, which is thought to have been brought in from the American coast on the exterior of Viking ships. At that time the ships were few. Currently, however, more 60,000 vessels either enter or leave the Baltic Sea annually, possibly carrying large numbers of alien species, and posing a threat to local ecosystems. Considering this, it would not be reasonable to distinguish separate Baltic Sea stages on the basis of alien species invasions.

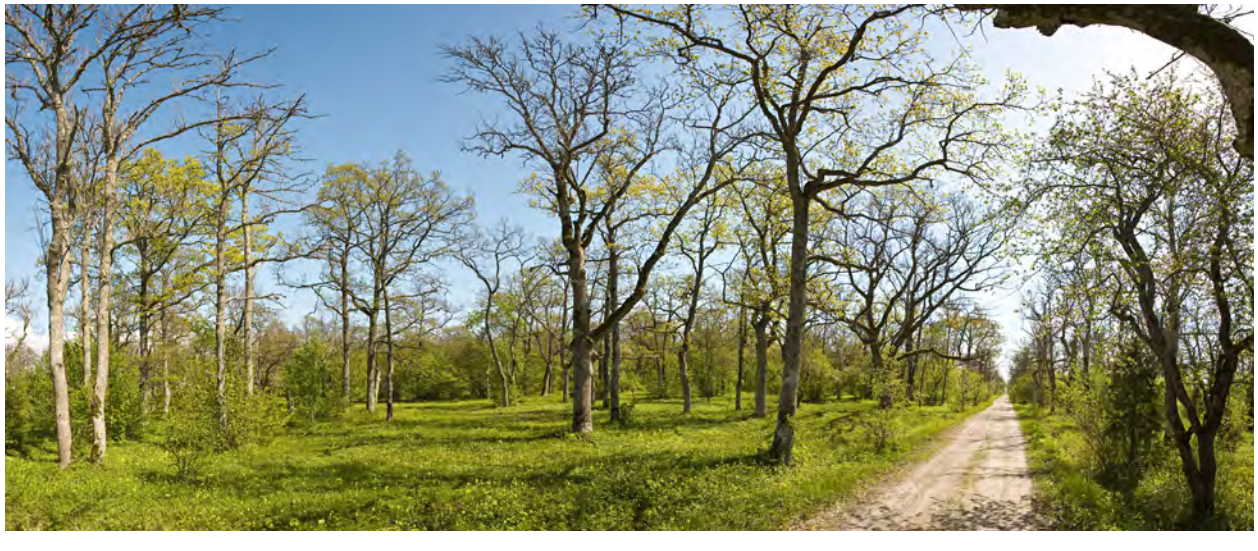
ISLAND LANDSCAPES

Contemporary landscapes owe their development to the long-term interaction between the nature and man. The types of landscapes developed on islands are primarily determined by the presence of Palaeozoic carbonate rocks as well as by the composition and thickness of the Quaternary cover. The retreating continental glaciers at end of the last Ice Age left behind a barren land inundated by meltwaters. The West-Estonian archipelago emerged from these waters due to the glacioisostatical uplift of Earth's crust. During the past ten thousand years the land has expanded its area on account of the sea and therefore, the islands landscapes are of different age and in continuous change.

The landforms shaped, by the sea and covered by various marine sediments, are typical of the islands. These landscapes are characterized by slowly overgrowing shallow coastal lakes, dunes, coastal ridges interspersed with mires. The island's scenery is enriched by alvars and limestone cliffs rising here and there along the shoreline.

Throughout its history, Hiiumaa has always been known as a forest-rich island. To date, various forests cover 71.5% of Hiiumaa and 59.5% of Saaremaa. These are deciduous forests, but some areas also host pine forests and mixed conifer-deciduous forests. Oak groves are rather common in Saaremaa. Shrubs, natural meadows and pastures cover about 15.0% of Saaremaa and about 8.6% of Hiiumaa. Wide areas covered by juniper shrubs are characteristic to the Saaremaa coasts and to eastern Hiiumaa. Man and nature in cooperation have here created valuable nature heritage landscapes – seashore and wooded meadows.

The Loode oak grove some kilometers southwest of Kuressaare town, Saaremaa



The landscapes of both islands have been considerably influenced by human activity. Many alvars have formed as a result of destruction of the forest vegetation and grazing of animals. When the bush scythe was taken into use by islanders, preconditions were created for the development of wooded meadows. In all likelihood, cultivated fields first appeared along the margins of coastal meadows. It should be noted that Saaremaa was one of the leading areas in land cultivation in Estonia during the Early Iron Age.

Mild maritime climate and a variety of soils have supported the development of rich vegetation on these islands. For instance, about 80 per cent of all plant species recorded in Estonia are also found growing on species-rich alvars, coastal and wooded meadows or in deciduous forests of Saaremaa. Several subatlantic species, such as yew (*Taxus baccata*) and ivy (*Hedera helix*), which are otherwise encountered only in the northwesternmost part of mainland Estonia, have made their home in Saaremaa. A rare vascular plant – the yellow rattle of Saaremaa (*Rhinanthus rumelicus subsp. osiliensis*) – is known only in Saaremaa and nowhere else in the world.

The sea halts the spread of many faunal species to the islands. Nevertheless, representatives of most mainland animal species have reached the islands from mainland Estonia. Among large mammals are common elk, roe deer and wild boar. Man has also contributed to the spread of some species, including red deer (*Cervus elaphus*), American mink (*Mustela vison*) and racoon dog (*Nyctereutes procyonoides*). Additionally, Saaremaa and Hiiumaa lie within the East-Atlantic flyway, which is the major migration route for waterfowl from Africa to Arctic breeding grounds. Hundreds of thousands of migratory birds pass Saaremaa each spring and autumn.

Yew (*Taxus baccata*). Photo: G. Bauert

Ivy (*Hedera helix*). Photo: G. Bauert

SPECIFICS OF SAAREMAA AND HIIUMAA LANDSCAPES

Saaremaa has 854 km of rugged coastline. There are some 710 islands and islets in its coastal waters – the largest are Muhu (199 km^2), Abruka (8.78 km^2) and Vilsandi (8.75 km^2). Most of the islets are less than 1 ha in area and have emerged from the sea within the past thousand years. The southern and western coasts of Saaremaa are particularly rich in peninsulas and capes extending far out into the sea, with numerous inlets in bays in between. As a result of land uplift, many former bays have turned into shallow coastal lakes. Saaremaa and Hiiumaa are separated from mainland Estonia by a relatively shallow Moonsund or Väinameri Sea (max. depth 23 metres). The narrow Soela Strait (minimum width, 5.4 kilometres) between Saaremaa and Hiiumaa islands most probably marks a pre-glacial buried river valley. Saaremaa and Muhu islands are connected by a 3.6 kilometre long causeway, built in 1894–1896.

Hiiumaa, Estonia's second-biggest island (see also the map on the inner back cover), has a 310 km long coastline and is surrounded by about 230 small islets and shallows. The only large island is Kassari (19.3 km^2) in southeastern Hiiumaa, separated from Hiiumaa by a shallow (less than 1 metre deep), rapidly overgrowing Käina Bay. Several small islets are located off the east coast; Vohilaid (3.9 km^2) and Heinlaid (1.6 km^2) are the largest. The Salinõmme cape jutting out into the sea in the southeastern part of Hiiumaa is actually a northwestward extension of a series of islets emerging from Väinameri. These islets represent the tops of ice-marginal formations rising above sea level. Hiiumaa owes its diversity of landscapes to glacial sediments, reshaped by waves and winds under the continuing land uplift. The island is covered by thick forests mostly because of its dominant sandy soils.

View over forest-rich Kõpu Upland from the Kõpu lighthouse

SEACOASTS

A great number of landforms characteristic to islands (terraces, cliffs, dunes, etc.) are related to coastal areas. Both the bedrock topography and the distribution patterns of late glacial sediments have played an important role in the development of coastal cliffs and alvars. The processes taking place on modern sea coasts reflect those happening on the coasts during the last ten thousand years. The formation of different shore types is predetermined both by ancient land relief as well as by subaquaeous environment of the surrounding seas.

Cliffed shores occur mostly on the West-Estonian Klint and are related to the extent of Jaagarahu Stage bioherms (for example Püssina cliff on Muhu Island and Pulli cliff on northeastern Saaremaa). Due to land uplift, several ancient cliffs (e.g. Tupenurme and Üügu on northern Muhu island) have already retreated far from the waterfront. Many cliffs, still subject to sea erosion (e. g. Anikaitse and Kübassaare cliffs in southeastern Saaremaa), will share the same fate in the near future. Even the Panga cliff, the highest of all cliffs in Saaremaa, can be eroded by seawaves only during heavy storms.

Rocky shores occur on gently sloping bedrock outcrops. The best places to get acquainted with rocky shores are at the westernmost tip of Vilsandi or nearby Vaika islets.

Scarp shores, eroded either into till or gravelly-sandy deposits, can be seen in several places on Saaremaa and Hiiumaa. The most extensive and impressive is the scarp shore at Järve, on the eastern shore of Sõrve peninsula where a sand bluff is up to 8 metres high and several kilometres long.

Typical **shingle shores** occur south of the Panga cliff at the NE coast of the Küdema Bay, in the northern

A widespread shingle shore, SW of Ninase cliff

Places of geotourism interest in eastern Saaremaa and island of Muhu

Places of geotourism interest in NW Saaremaa

parts of the Ninase and Tagamõisa peninsulas, on the western coast of the Harilaid cape and on the western coast of the Sõrve Säär spit.

Till shores with abundant erratics are found on the small islets adjacent to Hiiumaa and on both sides of Tahkuna peninsula. On Saaremaa, till shores are spread along the southwestern coast, on Sõrve peninsula and elsewhere.

Picturesque **sandy shores** can be found on the Tahkuna and Kõpu peninsulas in northern and northwestern Hiiumaa. On Saaremaa, these can seen at Järve (on the east coast of the Sõrve peninsula), but also at the Harilaid cape and bordering Tagalaht Bay in NW Saaremaa.

Silty shores are common on very flat coasts, sheltered from winds. These are particularly widespread along the coasts of muddy-bottomed Väike Väin Strait between Saaremaa and Muhu. Silty shores are often overgrown to coastal meadows with species-rich, halophilous vegetation. At present, large areas of coastal meadows have become covered with reed because grazing of cattle is no longer common here.

COASTAL CLIFFS

Coastal cliffs are steep escarpments along the coastline, which were eroded into the bedrock by sea waves. In places, cliffs have retreated landward from the sea due to land uplift. In the West-Estonian Archipelago, coastal cliffs occur mainly along the northern coast of Muhu as well as along the northern and western coasts of Saaremaa and Hiiumaa islands. The cliff shapes vary from steep, vertical walls to rather low formations. The main factors influencing the shape of the cliffs are: the presence of fissures and fractures, the rock composition itself and the dip of rock strata. For those interested in learning about the Earth's history, such cliffs can provide lots of information on ancient marine life and on sedimentation conditions in the Paleobaltic Sea more than 400 million years ago.

The majority of individual cliffs on Saaremaa form part of the Gotland – West-Estonian klint belt. This klint belt is sometimes also called the Silurian klint because it is composed of Silurian carbonate rocks formed some 430–416 Ma. In the following, we will

be introducing the most representative cliffs on Muhu and Saaremaa islands.

There are several impressive cliffs on northern Muhu, but the scenically most attractive is **Üügu or Andruvälja cliff**, which is situated ca 1.5 kilometres east of Nõmmküla village in northern Muhu Island. This 450-metre long cliff, up to 7 metres high, originates from the Limnea Sea stage and is now located ca 200 metres landward of the present coastline. The cliff exposes dolostones of the Kesselaiu Member, Jaagarahu Stage. Softer sediments – marls of the Jaani Stage – are covered by rock debris at the cliff foot. Quite spectacular are the wave-cut notches – human traffic has widened the largest over the years. In the lower part of the cliff, two small springs seep out. Üügu cliff is situated in the Üügu Landscape Reserve founded in 1996 to protect the cliff, the spring bog at the cliff foot and several rare plant species: wall rue (*Asplenium ruta-muralia*), orchids – fen orchid (*Liparis loeselii*), marsh helleborine (*Epipactis palustris*), and early marsh orchid (*Dactylorhiza incarnata*).

Panga (Mustjala) cliff is 2.7 kilometres in length and is located on the northern coast of Saaremaa ca 1.5 kilometres northwest of Panga village. It is the highest (21.3 m) coastal escarpment in the West-Estonian Archipelago. In ancient times, the highest portion of the cliff served as a cult gathering site where sacrifices were made to the sea. The north-southward directed longshore drift of abraded, loose sediments have formed a long limestone gravel spit on southern end of the cliff. The cliff has three benches – two above the sea level, and one (10–12 metres in height) under water. Most of the cliff wall is composed of argillaceous dolostones and domerites of the Jaani Stage. Almost all beds contain remains of fossils. Occasionally rather large voids with calcite crystals occur. The carbonate sequence exposed on the cliff wall is pene-

Wave-cut notches at the Üügu cliff foot. Photo: T. Bauert

The majestic silhouette of Panga cliff at sunset

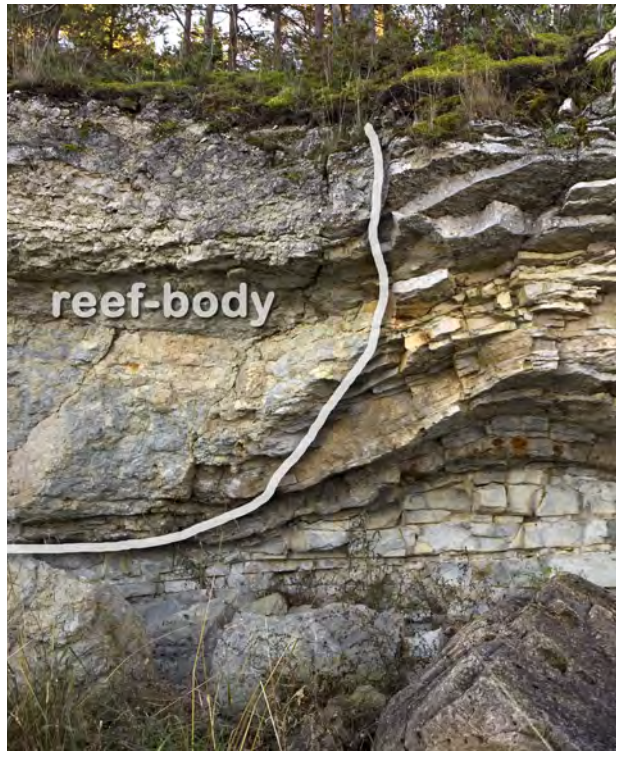
View from the Üügu cliff, northern Muhu.
Photo: T. Bauert

View from Panga cliff

Sundial at Panga cliff

trated by numerous fractures; large blocks commonly fall during heavy storms. The Panga Nature Reserve was founded in 1959 to protect the cliff and its surroundings.

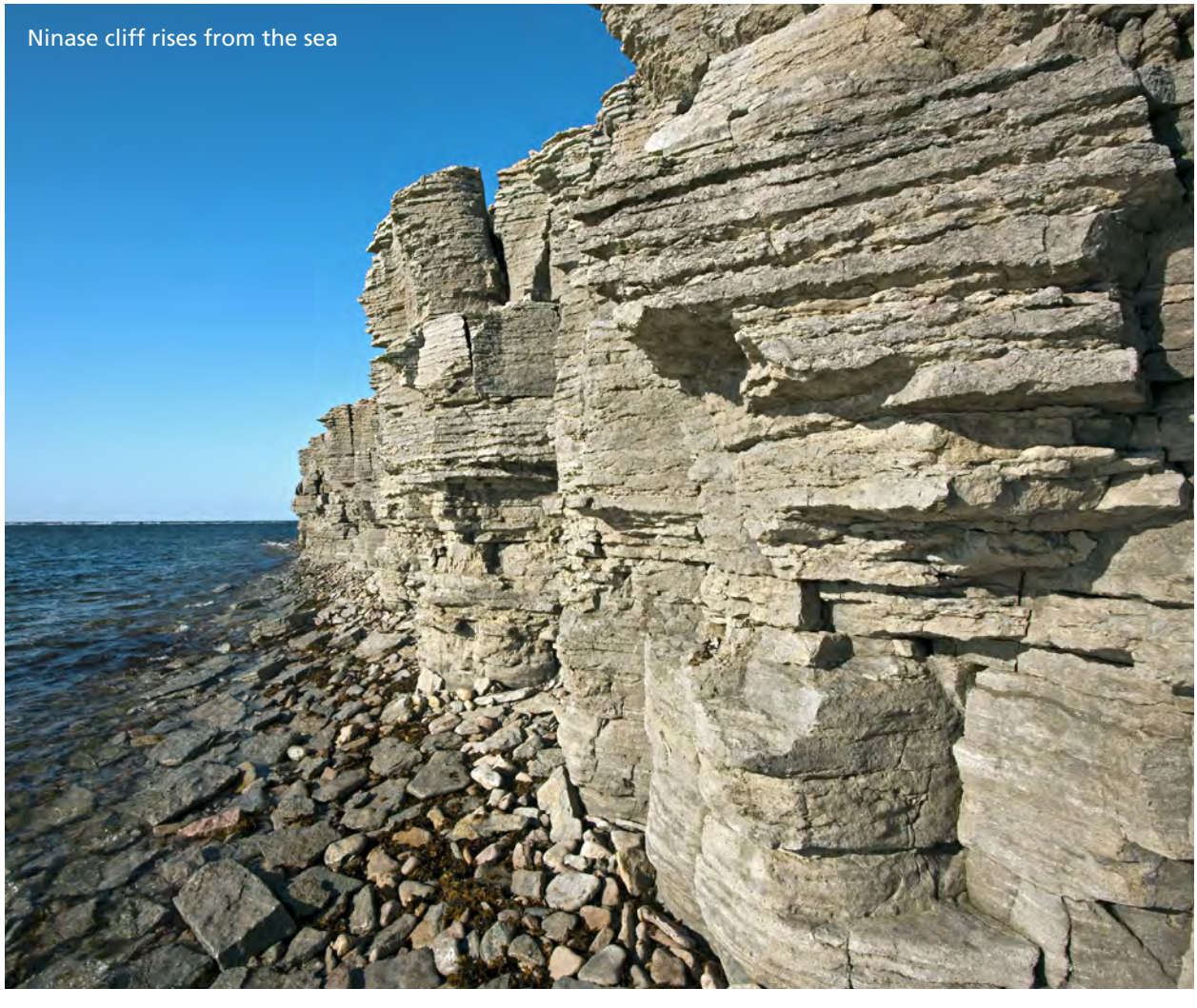
Pulli (Oiu) cliff is is situated on the northeastern tip of Saaremaa, at the sea coast, less than a kilometre northeast from the Orissaare–Leisi road. The cliff is 3.5 metres high and more than 400 metres long. It is composed of platy, hard dolostones of the Jaagarahu Stage, which expose various sized bioherms. These biohermal dolostones rest on soft dolomitized marls of the Jaani Stage. A strongly pyritized discontinuous surface marks the boundary between the stages. A striking geological feature in this outcrop are the downbent beds in the vicinity of the bioherm bodies. These spectacular curved beds were formed by the load of large bioherms which sunk into the semi-lithified carbonate sediments.



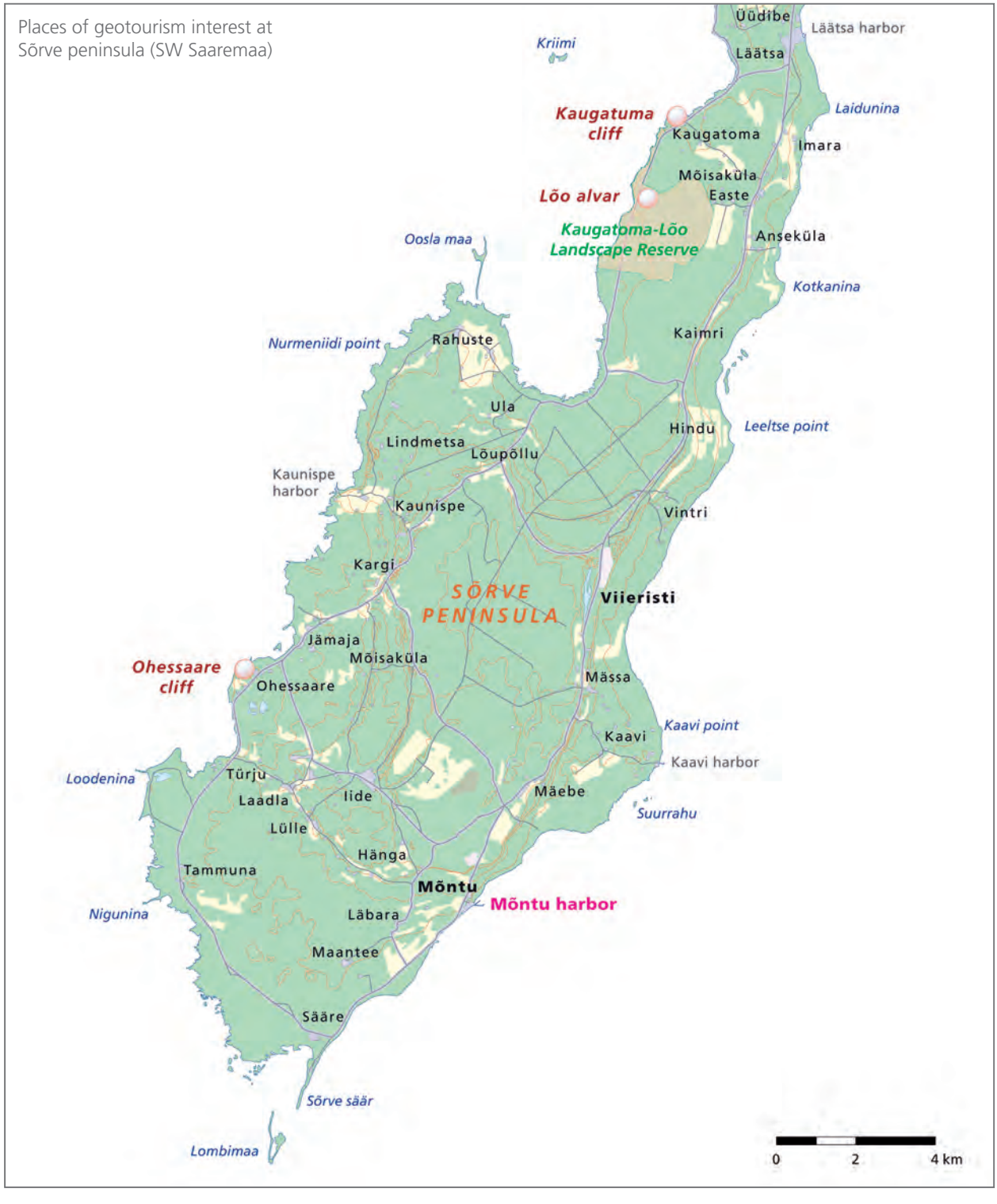
Pulli cliff in NE Saaremaa

Ninase (Tagaranna) cliff is situated along the northern and northwestern coast of the Ninase cape in northwestern Saaremaa. It is about 1.5 kilometres long and in some places more than 5 metres high. The lower part of the Ninase cliff exposes marls of the Mustjala Member overlain by dolomitized limestones of the Ninase Member (both belonging to the Jaani Stage). Small, rounded bioherms (up to 1 m in diameter) which are mostly composed of bryozoans abound in the cliff wall. These limestones also contain an abundance of brachiopod shells and remains of sea lilies.

A grass snake sunbathing in limestone crevasse. Photo: T. Bauert



Ninase cliff rises from the sea


Places of geotourism interest at
Sõrve peninsula (SW Saaremaa)
Üüdibe
Läätsa harbor
Kriimi
Läätsa
Laidunina
Kaugatuma
cliff
Kaugatoma
Imara
Mõisaküla
Lõo alvar
Easte
Kaugatoma-Lõo
Landscape Reserve
Oosla maa
Anseküla
Kotkanina
Nurmeniidi point
Rahuste
Kaimri
Ula
Hindu
Leeltse point
Lindmetsa
Lõupõllu
Kaunispe
harbor
Kaunispe
Vintri
Kargi
SÕRVE
PENINSULA
Viieristi
Jämaja
Mõisaküla
Ohessaare
cliff
Ohessaare
Mässa
Kaavi point
Kaavi
Kaavi harbor
Loodenina
Türju
Laadla
Iide
Mäebe
Suurrahu
Lülle
Hänga
Tammuna
Mõntu
Mõntu harbor
Nigunina
Läbara
Maantee
Sääre
Sõrve säär
Lombimaa
0
2
4 km

A series of separated limestone exposures up to 2 m in height occur in a 2-kilometre long stretch along the coast, south of Kaugatoma village in the western part of the Sõrve peninsula. This is the vanishing **Kaugatuma cliff**, which has been out of the reach of stormy waves for quite a long time. Small wave-cut notches can be seen in the lower part of the cliff wall which is composed of clayey limestones with marl interbeds. The upper part of the cliff is made up by hard, coarse, crinoidal limestones with abundant holdfasts of sea lilies. Due to the presence of numerous crinoid fragments, resembling wedding rings, this rock is often called 'ring limestone' by local folks. Coral colonies and other fossils including brachiopods, ostracods, trilobite fragments, and bryozoans also occur on the rock surface. A stretch of the coast here, ca 200 metres long and 10 metres wide, exhibits nearshore ripple marks preserved in coarse carbonate sands deposited more than 400 Ma.

Crinoidal limestone (aka 'ring limestone') at Kaugatuma shore. Photo: G. Bauert


Ohesaare cliff

The **Ohesaare cliff** is located on the western coast of Sõrve peninsula. The cliff is about 700 metres long and up to 3.5 metres high, composed of variably argillaceous limestones and marls. The cliff is the only outcrop in the Baltic region that exposes the youngest Silurian carbonate rocks. Here can be found fossil remains of almost all marine organisms (brachiopods, rugose corals, crinoids, molluscs, bryozoans, trilobites, nautiloids, etc) that thrived in the Silurian seas, as well as fish scales and fragments of agnathans*. Trace fossils are also common on bedding planes.

ALVARS

Meadows densely overgrown with juniper thickets immediately draw the attention of people arriving on Hiiumaa and Saaremaa by ferry. These areas are called alvars (an alvar is an area on a limestone plain with very thin or no soil cover) which, due to their specific plant communities certainly belong to the more interesting landscapes. Here, the carbonate rocks formed hundreds of millions of years ago provide ground for unique habitats and species communities that simply cannot exist elsewhere.

Alvars can either be completely barren with limestone pavement exposed, covered by limestone shingles or with a thin soil cover. During dry seasons, these soils may dry down to the bedrock, while rainfalls may lead these areas to appear as temporary ponds (since the limestone base prevents the water from running

** Agnathan – primitive jawless fish*

off). Winter winds may frequently blow off the snow cover from open alvars leaving the ground barren. All these extreme conditions have led to the formation of unique alvar ecosystems and specialized plant communities which have become accustomed to calcareous and dry habitats.

Alvars are actually a meeting place of plants from various climate and vegetation zones. On Saaremaa's alvars plants which are common in southern Siberia or which are widely spread in steppes of southeastern Europe can be found. These species include sagebrush (*Artemisia rupestris*), purple milk-wetch (*Astragalus danicus*) and dyer's woodruff (A*sperula tinctoria*), which grow here side by side with the species originating from the subarctic zone of North Europe – alpine meadow-grass (*Poa alpina*), alpine cinquefoil (*Potentilla crantzii*) or preferring the maritime climate of southwestern Europe – rue-leaved saxifrage

Lady's slipper (*Cypripedium calceolus*).
Photo: G. Bauert

Sarve alvar, SE Hiiumaa

(*Saxifraga tridactylites*) and white stonecrop (*Sedum album*). One of the most fascinating aspects of alvars is that, although small in scale, they are among the most species-rich communities in the world. Up to 49 species of vascular plants have been found growing on a patch of land (on 1m^2 area); on larger patches this number may even exceed one hundred. In more fertile areas, which are not intensively used for grazing, alvar shrublands or alvar woodlands may occur. It should be noted that alvar meadows on Saaremaa have been used as pastures for centuries.

The picturesque **Sarve alvar** is located on the Sarve cape in the southeastern corner of Hiiumaa. The carbonate bedrock exposed on Sarve alvar is fossil-rich Silurian limestone of the Juuru age which rise gently up to ten metres above sea level. Sea waves have eroded this carbonate bedrock and deposited limestone shingle ridges on the top. The landscape reserve

White stonecrop (*Sedum album*) at Lõo alvar.
Photo: G. Bauert

Lõo alvar on the western coast of the Sõrve peninsula, Saaremaa

was founded on the Sarve cape in 1973 to protect rare and scientifically valuable geological landscapes (beach ridges of the Limnea Sea) and the related natural and semi-natural plant species communities. At present the landscape is covered by juniper thickets as well as pine and birch groves, but about 60 years ago, the southern and eastern parts of the Sarve cape were prevailingly open areas and the highest points offered superb sea views.

The Sarve alvar provides good habitats for species-rich and variegated vegetation of which several endemic species are under protection. These include small scabious (*Scabiosa columbaria*), wall rue (*Asplenium ruta-muraria*) and also several orchids, such as lady's slipper (*Cypripedium calceolus*). The lady's slipper orchid has the largest blossom of the many orchid varieties in Estonia. In springs, the depressions between coastal ridges are covered with blooming chives (*Allium schoenoprasum*). Scanty or non-existant grass cover favours the growth of mosses and lichens on alvar. Rare birch groves growing on shingle soil are attractive landscape features in the Sarve Landscape Reserve.

The largest alvar in Saaremaa and one of the most representative alvars in Estonia is located at Lõo, on the western coast of the Sõrve peninsula. **Lõo alvar** in Kaugatoma–Lõo Landscape Reserve is the habitat for many protected plant species, the most significant being pyramidal orchid (*Anacamptis pyramidalis*). Here, lichens from different climate zones grow side by side on barren limestone pavements.

SAND DUNES

Coastal dunes are associated with sandy beaches, which occur mostly on bay sides and in the bayhead areas. Strong wind is the main agent responsible for the formation of dunes – it triggers the movement of sand and formation of larger aeolian accumulations. To understand the development of dunes one should observe snowdrift processes: the wind gusts lift loose snow flakes into the air; once in air, the snow flakes will continue to drift until the wind slows down, usually when encountering obstacles. The same is true for dune formation – the windward slope of dunes is flat,

Luidja sandy beach, a former drifting sands area

and the leeward side is steep. Based on this feature, it is easy to figure out the direction from which prevailing winds blew in the past. Land uplift exerts an adverse impact on the development of dunes since it causes the coastline to retreat rapidly towards the sea. As a result, the dunes which have just started to develop lose contact with the source area and vanish.

The dunes occur both along the modern coastline as well as in central areas of islands. In the past, drifting sands caused much trouble to islanders, threatening to bury arable lands and settlements. In the 17th century, the drifting sand dunes threatened the Kärla church, manor and neighbouring farm houses. At the end of the 19th century, drifting sand became a real nuisance in the surroundings of the Ristna lighthouse on Hiiumaa. When strong southwesterly winds blew steadily for a long time, the volume of drifting sand was so great that people had to work days to cart away heaps of sand in front of their doors. In the early 20th century, pine and mountain pine (*Pinus mugo*) groves were planted to stabilize sand on the Tahkuna peninsula. In an area where groundwater was close to the surface, common alder (*Alnus glutinosa*) was also used for that purpose. A key example is the alder grove at Luidja in northwestern Hiiumaa. This grove, which covers an area about 1.7 kilometres in length and 80–110 metres in width, was planted between the road and sea in the beginning of the 20th century under the guidance of head forester K. Ahrens. Almost at the same time, lyme grass (*Leymus arenarius*) was sown to fix sandy fields. Currently, we have only a few loose sand areas left in Hiiumaa. Of those, most noteworthy is the Kaibaldi sand field in the central part of the island, where the sandy ground has suffered heavily from the Soviet military activities which allowed the sand to begin drifting again.

Kõpu dune field

In Hiiumaa, dunes are widespread on the Kõpu and Tahkuna peninsulas; ridge-like dunes predominate. On the Kõpu peninsula, there are 22 larger and smaller dune fields; parabolic dunes also can be seen. Usually, the dunes are 2–8 metres, occasionally up to 25 metres high (Korbimäed, Rebasemäed). The dune sands have accumulated here over the last 5000 years. However, some dunes in the central part of the peninsula formed during the Ancylus and Litorina stages of the Baltic Sea, when the island was exposed to winds from all directions. Dunes with very steep (inclination up to 40°) seaside slopes meet they eye at the St. Andreas dune field in Kõpu.

Ristna lighthouse

Kaibaldi loose sand field

Kaibaldi loose sand field

In our climate zone, most of the dunes rapidly become overgrown with vegetation and, therefore, loose sand areas are quite rare. Still, there is a loose sand field in the central part of Hiiumaa. This is Kaibaldi – the largest loose sand field in Estonia. It forms part of the Pihla–Kaibaldi Nature Reserve, covering an area of more than 3000 ha, and is host to scenic heath forests.

Mires and forests in Kaibaldi are home for protected bird species such as the Common Crane (*Grus grus*), Montagu's Harrier (*Circus pygargus*), Golden Eagle (*Aquila chrysaetos*). The protected plants found here are marsh helleborine (*Epipactis palustris*), early marsh orchid (*Dactylorhiza incarnata*), common spotted orchid (*Dactylorhiza fuchsii*), fly orchid (*Ophrys insectifera*), fen orchid (*Liparis loeselii*) and bog myrtle (*Myrica gale*). The Pihla mire, the largest one in Hiiumaa, is also an important water reserve for the island.

Järve dune field

Järve dunes are located about 8 kilometres southwest of Kuressaare town on a narrow strip of land between the sea and Kuressaare–Sääre road. These rather low dunes (2–5 metres in height) are covered by pine forests. The sandy soils are habitats for several endangered species such as deptford pink (*Dianthus arenaria*), small pasqueflower (*Pulsatilla pratensis*), etc. Rare plants are represented by *Alyssum gmelinii*. The sandy beaches at Järve are highly valued as an excellent swimsite for island residents and visitors.

Odalätsi dune field

Odalätsi dune field with two parallel Litorina Sea dune ridges (a relative height of up to 10 metres) is situated northeast of Kihelkonna village in northwestern Saaremaa. Here you can see parabolic dunes which are rare elsewhere in Estonia. A stronghold in the eastern part of the southern dune ridge is pro-

A sharp bluff is eroded into Järve dunes

tected nowadays as the site of a historical monument. The dunes are covered by a sparse dry pine forest. The Pidula stream gets its start from high yield Odalätsi springs in the vicinity of the dune field. The Odalätsi Landscape Reserve was founded to protect the springs and the most representative part of the dune field with its distinctive plant communities.

Right: deptford pink (*Dianthus arenaria*), below: small pasqueflower (*Pulsatilla pratensis*). Photos: G. Bauert

Odalätsi dune field

LARGE ERRATIC BOULDERS

The ground on the islands is littered with rocks of various sizes – they are just everywhere. Aside from angular-shaped limestone blocks and shingles derived from the local Palaeozoic sedimentary bedrock, the islands are full of scattered, rounded, variegated crystalline erratic boulders transported here either from Finland or from the bottom of the Baltic Sea by continental ice sheets. These erratics are highly variable in size. The perimeter of the largest boulders may exceed 25 metres. How did the ice sheet manage to tear up and transport such giant boulders over a distance of hundreds of kilometres to Hiiumaa and Saaremaa islands?

Usually, huge continental ice sheets are described as acting like tremendous bulldozers, powerfully pushing objects along the ground. Actually, a glacier does not so much use its brute strength, but rather its wits, softness and plastic properties. At first the moving ice fills up and freezes all cracks and grooves on a boulder's surface and then, like an octapus, takes a long slow swallow of its prey and passes it slowly into its ravenous glacial stomach.

There are considerably more large erratic boulders known in Hiiumaa (particularly on the island's eastern part) than in Saaremaa, as Hiiumaa is located much closer to the areas where the advancing continental glaciers picked up crystalline rocks. Therefore, the transport route to Hiiumaa was shorter than to Saaremaa. The same is true for mainland Estonia, where the largest erratics are found only in the north.

KUKKA BOULDER

The Kukka boulder is the largest erratic boulder in the West-Estonian Archipelago. Its perimeter is 42 metres, length 16 metres, width 11.3 metres and height 3.9 metres. The actual volume of the boulder is not

Kukka boulder

known, but its visible volume is impressive – 324 m^3. The boulder is located on a wooded meadow about 700 metres northwest of the Kukka village farmhouses in northeastern Hiiumaa. This large boulder can be easily found as local road signs give directions to the boulder site. There is also another large rectangular boulder about 200 metres eastward lying on the open field, called Kukka Põllukivi.

Tubala boulder

The Tubala boulder is located on the 5th kilometre of the Kärdla–Käina road, in the northern part of Tubala village, ca 20 metres west, off the road, on the forest edge. It is known also as the Tõllu or Leigri boulder, and is easily visible from the road. Tubala boulder (6.8x4.7x3.6 metres, perimeter – 20 metres)

Tubala boulder and pole.
Photos: T. Bauert

is approximately half the size of the Kukka boulder, but lots of folk stories are related to this rock. One of those tells us about Leiger, a local hero on Hiiumaa, who was worried that heavy storms could push the island into the open sea. So he decided to fix the island firmly onto the sea floor. He grabbed a big stone and rammed a pole through Hiiumaa, which now firmly holds the island in place. You can still see this Tubala pole next to the Tubala boulder. In fact, a celebration of Leiger's initiative began in 2003: for a donation of 1000 kroons to advance the cultural life of Hiiumaa, and on July 28th at 3 PM, you may join the people of Hiiumaa for a folk party – to dance, to have fun and, of course, to hammer new nails to be sure that the island will never float out to sea!

Helmersen boulders

A group of about 20 large rapakivi boulders can be seen in the forest of Hausma village close to the Hiiesaare–Paluküla road. The perimeter of the largest boulder is 22 metres. This boulder field has derived its name from the famous Russian geologist Gregor von Helmersen (1803–1885), who was born in Estonia. As a member of the Imperial Academy of Sciences in St. Peterburg, he founded and became the first head of the Russian Geological Committee (established in 1882). G. von Helmersen's research encompassed various fields in geology, but his passion was large erratic boulders, which he described and sketched in great detail.

Helmersen boulders

Tahkuna boulder

Tahkuna giant boulder

The boulder is situated on the Tahkuna peninsula (northernmost tip of Hiiumaa), about one kilometre eastward of Tahkuna lighthouse. The giant boulder (10.9x9.1x4.6 metres, perimeter is 30.3 metres) has a volume 280 m^3 and juts out from shallow coastal waters.

Aavakivi boulder at Kõrkvere

This is the only giant boulder (perimeter 25.2 m) on Saaremaa. It is located on the northwestern margin of Kõrkvere village in eastern Saaremaa, in the middle of a large field to the north of the road. The Aavakivi is migmatite granite and measures 9.8x6.9x4.5 metres with a perimeter of 26.5 metres.

Aavakivi at Kõrkvere

MAJOR GEOTOURISM DESTINATIONS

Kaali meteorite craters

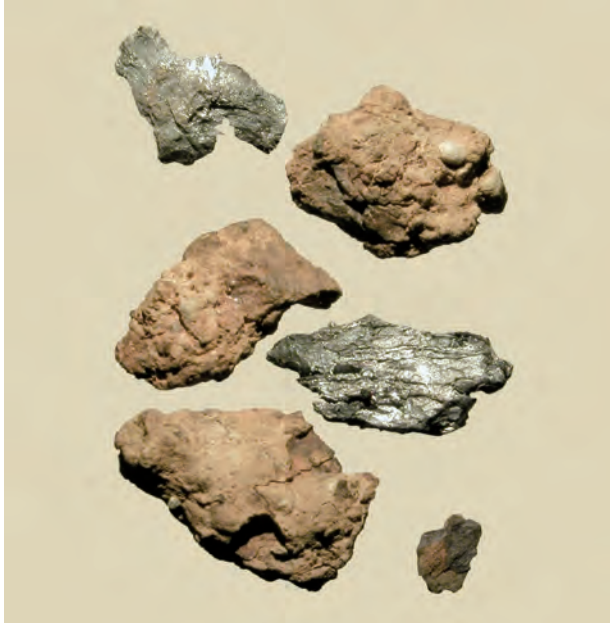
Throughout Earth's long history, the area of Estonia has been hit by numerous meteorites of various sizes. With such a large number of meteorite craters and findings of small meteorites relative to the country's size, Estonia certainly ranks among the first in the world for scientists and geotourists. But it is hard to believe that Estonia is an intentional target. Presumably the great number of meteorites and meteorite craters found here can be explained both by the islands' dense population and high public awareness of local residents. Whatever the explanation, both Saaremaa and Hiiumaa islands can proudly exhibit their meteorite craters.

The group of Kaali meteorite craters on Saaremaa has deserved high attention throughout the world, because these were the first craters in Europe which were scientifically proven to be of meteoritic origin. Of the nine craters in the Kaali area, the largest one, the Kaali main crater, has a rim-to-rim diameter of 110 metres; the maximum depth from the top of the crater rim to the bottom is 22 metres.

A small observation terrace in the middle of crater's inner slope offers a great overview of the crater lake. Large dolostone blocks jutting out from the slope wall next to this terrace are witnesses of a huge impact. The lake area depends greatly on the water level and may extend from 30 to 60 metres. The depth of the lake also varies between 1 – 6 metres. During dry

seasons, the crater lake may dry up almost entirely, exposing a pile of stones in the centre of the lake. On that spot, a former Kaali manor owner established a small islet with its own pergola.

The total mass of meteorites responsible for the Kaali impact craters is roughly estimated at a range of about 1000 tons and the velocity of meteorites at the time of impact may have been up to 20 km/sec. The Kaali craters were first described by J. W. Luce in 1827, a well-known writer and Saaremaa explorer. The first hypotheses desribed the crater's formation as a result of volcanic eruption or underground blasts of either water, steam or gases. There were also speculations referring



Iron meteorite chips from Kaali satellite craters. The diameter of chips is 1- 5 mm. Collections of Institute of Geology at Tallinn University of Technology. Photo: G. Baranov

Kaali main crater

Places of geotourism interest in central Saaremaa

to karst processes or to salt tectonics. Julius Kalkun-Kaljuwee, a teacher in Tallinn, was the first to suggest an impact by outer space objects. His theory was not proved until 1937, when Ivan Reinwald, a mining engineer, found the first small chips of meteoritic iron. To date, about 3 kilograms of meteoritic matter have been collected from the Kaali crater field. The largest chip of meteoritic iron found weighed 28.2 grams.

By now, the researchers have agreed on the origin of the craters. However, opinions still differ about the age of the impact and the direction from which the meteorite approached the target. In all likelihood, it fell from the east or southeast. The timing of the impact that formed the craters has also been narrowed down with time. It is clear that the Kaali meteorite craters cannot be younger than 4000 years. However, the study of extraterrestrial spherules in the surrounding areas suggests a meteorite shower to have occurred some 7600 years ago.

This older impact age unfortunately makes obsolete Estonian folkloric explanations of the crater's origin: the flight of Tarapita (the god of ancient Estonians) over Ebavere hill on the Pandivere Upland in north Estonia, as desribed in the Chronicle of Henry the Livonian, or the tale of Phaeton (a son of the Sun god Helios), who drove a flaming chariot over Europe's sky only a few thousand years ago. Also giving way to scientific discoveries are all those delightful legends described by writer Lennart Meri (also former President of Estonia) in his famous books Hõbevalge (1976) and Hõbevalgem (1984).

The Kaali meteorite craters were taken under protection in 1938. Those interested can learn more in the Kaali Visitors' Center with its small museum exhibiting meteoritics and local geology. It also has a restaurant and souvenir shop.

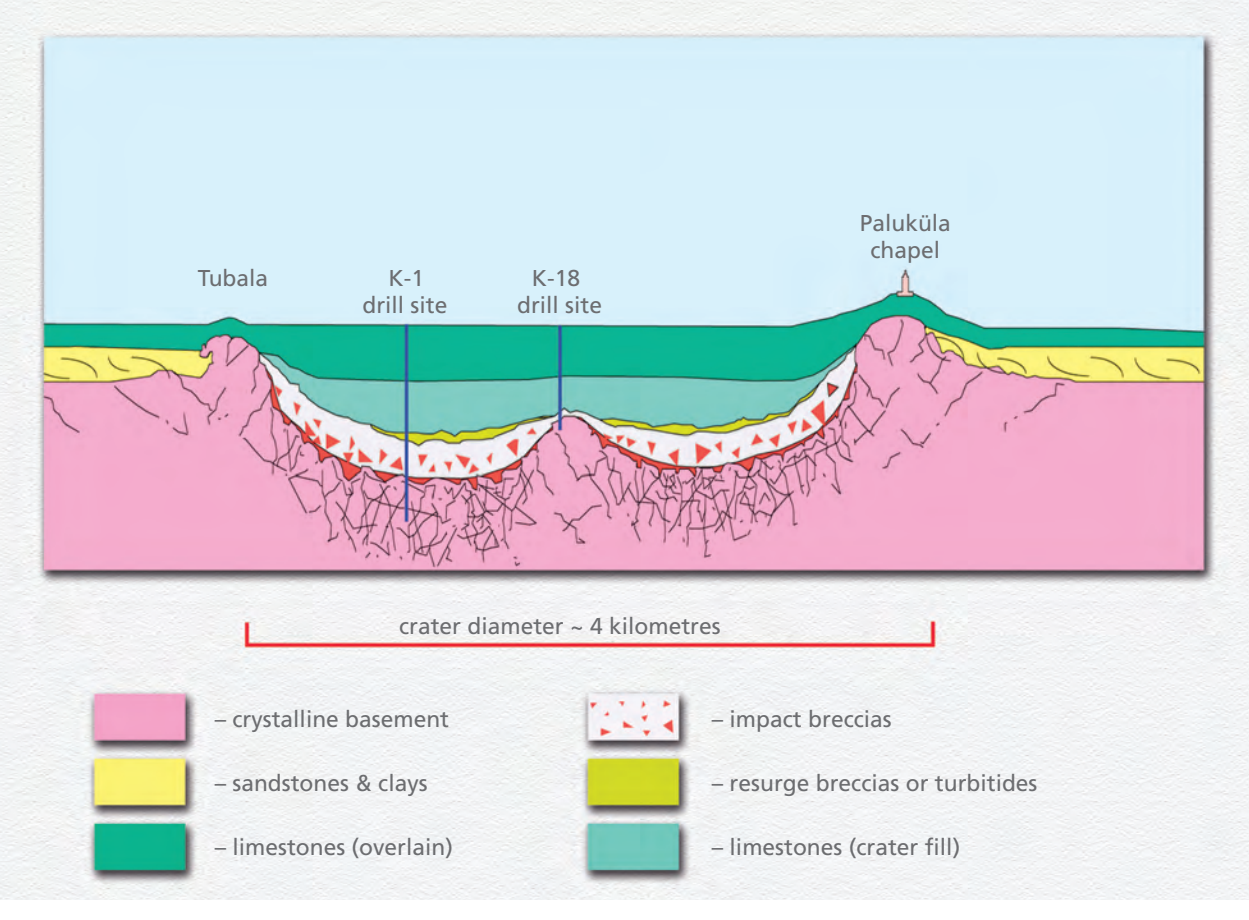
Kärdla Crater

While the Kaali main meteorite crater on Saaremaa has a diameter of 110 metres, Hiiumaa owes the Kärdla meteorite crater, approximately 4 kilometres in diameter in the northeastern part of the island. This crater was formed as result of a huge meteorite impact into a shallow Late Ordovician sea some 455 million years ago. The crater depression was almost

instantly covered by sea waters and with time was buried under Upper Ordovician and Silurian carbonate sediments. Therefore, the crater is almost invisible in present-day topography, but its structure has been studied in great detail on the basis of numerous drillcores and geophysical measurements. To obtain thorough information about the rock sequence in the meteorite crater, the 815.2 metre deep Soovälja K-1 borehole was drilled through a central crater depression. This is the deepest core drilling ever made in Estonia. Unfortunately, not much is visible on the surface; only the tilted limestone beds at Paluküla quarry hint at the presence of crater rim wall at this location. An observation deck next to the Heltermaa–Kärdla road at Paluküla offers an impressive view over flat arable land fields marking the crater's central depression.

So far only vague speculations about the size of the Kärdla meteorite exist. Based on comparison with a well known crater in Arizona, the United States (diameter – 1207 metres, depth – 180 metres and an estimated meteorite weight – 63,000 tons), the Kärdla area was hit by a meteorite weighing at least 150,000 tons.

The geological cross-section of the Kärdla meteorite crater (adapted from figures of Kalle and Sten Suuroja, Geological Survey of Estonia)



Places of geotourism interest in northwestern and western Saaremaa

Vilsandi National Park

The Vilsandi National Park was established in 1993 to preserve the coastal landscapes and adjacent marine areas of western Saaremaa as well as local cultural heritage. Particular care is taken to protect the nesting grounds of numerous seabirds and lounging sites of seals. The national park covers an area of 238 km^2, including 163 km^2 of sea and 75 km^2 of land areas.

The predecessor of Vilsandi National Park was the Vaika Bird Sanctuary created on August 14th, 1910 to protect the abundant seabird population on Vaika islands. These are six rocky islets off the southwestern coast of Vilsandi Island. The Vaika Bird Sanctuary was the first nature reserve ever established in the Baltic countries. From 1924 to 1941, the bird sanctuary was administrated by Tartu University. It was reorganized as the Vaika State Nature Reserve in 1957 and enlarged in 1971 with a new name – Vilsandi Nature Reserve. It was re-structured and re-named Vilsandi National Park in 1993. The national park belongs to the Natura 2000 network of protected areas throughout Europe, both as a bird sanctuary and nature reserve. The headquarters are located at the Loona manor on Saaremaa, about 4 kilometres south of Kihelkonna village.

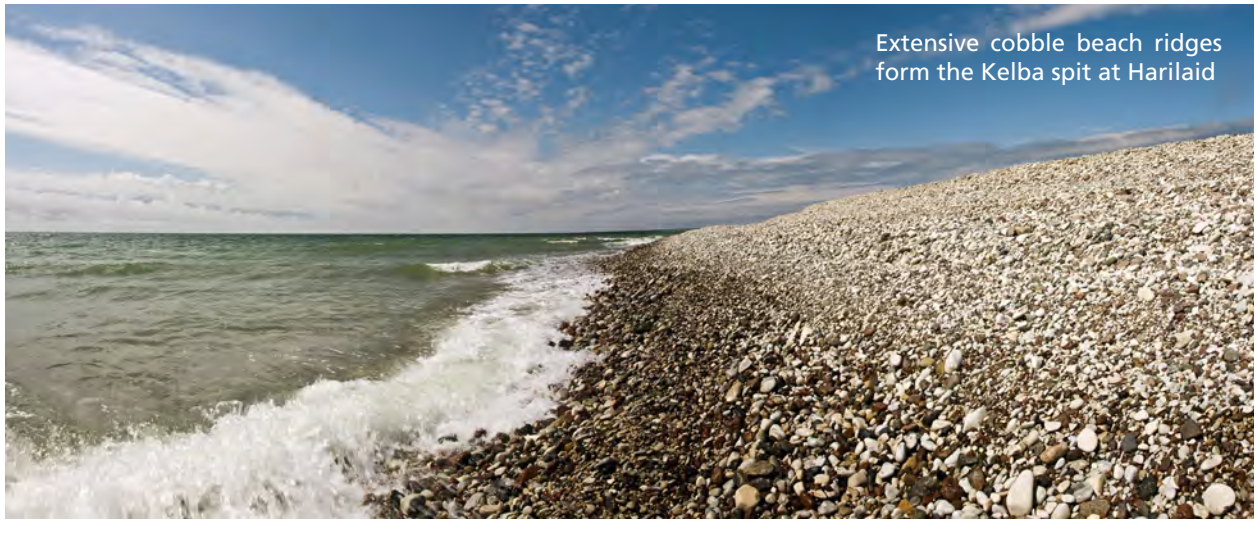
The coastal limestone pavement landscapes with karst topography exposing void-rich, biohermal dolostones of the Jaagarahu Stage can be seen on the western coast of Vilsandi and on neighbouring Vaika islets. From a geological viewpoint, they deserve the most attention. The most striking karst features here are karren fields, recognized by very closely spaced and rounded, 2 – 5 cm deep hollows which are dissolution surfaces on carbonate rocks. Other karst features encountered are large furrows dissecting limestone blocks. These furrows apparently represent dissolution-expanded fractures in massive dolostones.

Waves splashing against rocky shores on westernmost tip of Vilsandi

Some of the national park's coastal landscape on Saaremaa amazes visitors with an impressive array of narrow capes stretching far out to the sea with bays wedged between them. There are dozens and dozens of islets in those shallow bays. The coastal area is characterized by numerous juniper shrubberies interspersed with groves, grasslands and occasional field strips. Particularly beautiful juniper meadows can be seen at the Eeriksaare cape.

Harilaid cape (4.6 km^2), with its unique and widely differing landscapes is one the most attractive sites to visit within Vilsandi National Park. The cape, extending from the Tagamõisa peninsula in northwestern Saaremaa, stretches several kilometres into the sea. It is connected with the rest of the peninsula by a narrow, sandy plain which has emerged from the sea quite recently (historical maps point out that Harilaid was an island even at the end of the 17th century). Harilaid cape is most probably a former esker, which

Sandy plain connecting Harilaid with the Tagamõisa peninsula



Extensive cobble beach ridges form the Kelba spit at Harilaid

has been considerably reshaped by storm surges. The northern part is a sandy flat, covered by beach grasses and mosses, while on the southernmost tip known as Kelba spit, intensive formation and reshaping of cobbly beach ridges, several metres high, are currently underway. There are several coastal lakes on the cape; the largest, in the central part of the cape, is known as Laialepa Bay.

One of the wonders of the Harilaid cape is a 25-metre high inactive lighthouse on the northwestern end. It was built in 1933, dozens of metres landward from the cape's west coast, but as these sandy shores have been actively eroded and reshaped by storms, the lighthouse now rises straight up from the sea.

Kiipsaare lighthouse in 2003

Kiipsaare lighthouse in 2009

This lighthouse has behaved in a puzzling way, resembling Italy's famous leaning landmark – the Pisa tower – for over 10 years. Standing straight up until the beginning of the 1990s, it then started to deviate, developing a serious tilt of seven to nine degrees towards the sea. In February 2008, it suddenly straightened up – popular folklore attributing its move to the 90th anniversary of the Republic of Estonia. The explanation of this enigma lies in coastal erosion processes: the lighthouse started to lean when the wave erosion reached its basement. In 2008, completely surrounded by water, the lighthouse foundation adjusted to the ground underneath and regained its upright position.

Vilsandi National Park is a particularly attractive destination for bird-watchers: thousands of migratory birds stop and nest here each year. During the nesting season, the open areas of the islands are full of densely packed bird colonies – breeding sea gulls, terns, geese, eiders and mergansers. The coasts of western Estonia are in the East-Atlantic flyway of migratory birds; many remain here for the entire winter to enjoy the ice-free sea water. Steller's eiders (*Polysticta stelleri*) are the most numerous winter visitors. The waters of the national park are also a home to numerous seals, who come to breed on small islets in the surrounding seas, making these islets the main breeding and lounging sites for the grey seal in the Baltic Sea.

The maritime climate, abundance of habitats and favorable spreading conditions have promoted the development of a species-rich vegetation. More than twenty species of orchids including Danish scurvygrass (*Cochlearia danica*), sea wormwood (*Artemisia maritima*), bog-rush (*Schoenus nigricans*), rock whitebeam (*Sorbus rupicola*) and shoreweed (*Littorella uniflora*) grow here.

Pebbly sandflat at the northernmost tip of Harilaid. Kiipsaare lighthouse on background

Viidumäe Nature Reserve

Viidumäe is the oldest and highest part of the West-Saaremaa Upland, reaching 59 metres above sea level. The West-Saaremaa Upland is an arch-shaped ice-marginal formation, about 50 kilometres in length and less than half of that in width. The slopes of this upland abound in coastal formations – coastal ridges, dunes and erosional plains originating from the earlier Baltic Sea stages.

The diverse topography of the region has allowed the development of various ecosystems.

In order to preserve rare plant species and communities, the Viidumäe Nature Reserve was established in the southwestern part of the upland in 1957.

The high, steep coastal bluff (up to 18 metres in height, with occasional slope inclination of 25–30°) which formed during the Ancylus stage of the Baltic Sea, splits the present-day Viidumäe nature reserve into two different areas: 1) a dry area of forests and wooded meadows dissected by low coastal ridges on top of the bluff, and 2) a spring fen in between sandy coastal ridges at the foot of the bluff.

Early marsh-orchid (*Dactylorhiza incarnata*).
Photo: G. Bauert

White helleborine (*Cephalanthera damasonium*). Photo: G. Bauert

Viidumäe Nature Reserve stands out for its species-rich plant communities which thrive in the diverse habitats here. The Viidumäe spring fen is famous for its rare plant species, such as yellow rattle (*Rhinanthus osiliensis*) endemic to only Saaremaa, alpine butterwort (*Pinguicula alpina*), short-spurred fragrant orchid (*Gymnadenia odoratissima*), blunt-flowered rush (*Juncus subnodulosus*), etc. Noteworthy plants growing on forest edges are woolly milk-vetch (*Oxytropis pilosa*), imperforate St. John's-wort (*Hypericum maculatum*); whitebeam (*Sorbus rupicola*). The whitebeam is the most rare local tree species. Wooded meadows are the home of blooming orchids – lady's-slipper (*Cypripedium calceolus*), white helleborine (*Cephalanthera damasonium*), pyramidal orchid (*Anacamptis pyramidalis*), fly orchid (*Ophrys insectifera*), etc.

Viidumäe nature trails take the visitors through the landscapes characteristic to the West-Saaremaa Upland – through different types of forests, a species-rich fen area and a restored wooded meadow. The high observation tower at Rauna hill offers magnificent views of the West-Saaremaa Upland forests.

View over West-Saaremaa Upland forests at Viidumäe

Kõpu peninsula

The Kõpu peninsula (about 20 kilometres in length, up to 7 kilometres from north to south) in the western part of Hiiumaa is the oldest and highest area of the West-Estonian Archipelago.

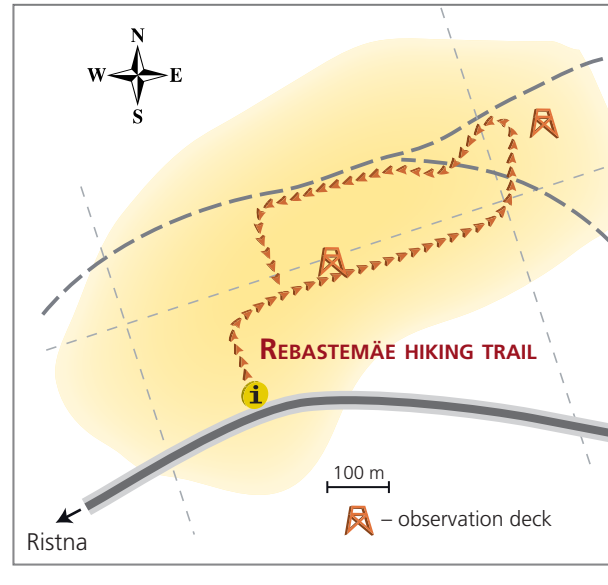
The first areas of dry land emerged from the sea here when the water level of the Baltic Ice Lake dropped considerably, some 10,200 ^{14}C years ago. An island, washed by waves of the surrounding Litorina Sea, existed in an area of present Kõpu peninsula about 7000 years ago.

At that time, the most complete and unique set of coastal formations in the eastern part of the Litorina Sea was formed here. These coastal formations were represented by various coastal ridges, coastal plains, terraces and dunes. A total of 40 bluffs at different heights have been counted on Kõpu peninsula; the relative height of the biggest is 17.5 metres. The most representative dune fields in Hiiumaa can also be seen here – the highest form the Korbi hills, reaching 43 metres above sea level. The dunes in the central part of the peninsula are now overgrown with dense natural forests, primarily dry boreal pine forests growing on nutrient-poor sandy soils. Small mires at various developmental stages can be seen in depressions between coastal formations. There is a 1.5 kilometre long hiking trail with two observation decks running across the Rebastemäe dune field where the relative height varies within a range of 20 metres, and several types of forest can be seen within a relatively small area.

Sea-holly (*Eryngium maritimum*). Photo: G. Bauert

More than 80 plant species, rare in the Baltic States, have been found on the Kõpu peninsula. Here, plants common to the warmer climate periods, such as ivy (*Hedera helix*) and yew (*Taxus baccata*) can be found. A sea-holly (*Eryngium maritimum*) grows on sandy beaches, while wet depressions between coastal ridges are a favorable habitat for marsh pennywort (*Hydrocotyle vulgaris*) and rare orchids – fen orchid (*Liparis loeselii*), burnt orchid (*Orchis ustulata*) and marsh orchid (*Dactylorhiza russowii*). The Kõpu Landscape Reserve, an area of 1155 ha, was founded to preserve and protect this unique natural environment.

Sketch of 1.5 km long Rebastemäe hiking trail in central Kõpu Upland (adapted from "Õppe- ja matkarajad Hiiumaal", Hiiumaa Keskkonnateenistus 2005)



Käina – Kassari Landscape Reserve

A folk story tells how Kassari was formed: "*Leiger, a famous local hero of Hiiumaa, used to visit his older brother Suur Tõll on Saaremaa. He also invited his brother to come to visit him on Hiiumaa, but Suur Tõll was afraid of deep waters between the islands. So, Leiger decided to build a bridge between Saaremaa and Hiiumaa. He carried a pile of stones and levelled it with gravel. But, as the stormy waves carried away the stones and dirt farther into the sea, this bridge was never completed*".

The landscape of Kassari (19 km^2) is characterized by alvars, species-rich wooded meadows and grasslands, coastal meadows and juniper thickets growing on gravel ridges. Käina Bay, now actually a coastal lake, with its numerous small islets, extensive reed beds and surrounding coastal meadows forms an important breeding site and stopping place for migratory birds. Migrants, such as avocet (*Recurvirostra avosetta*) and bittern (*Botaurus stellaris*), find it a perfect nesting site, but cormorants (*Phalacrocorax carbo*) and reed warblers are also plentiful. From time to time, you may glimpse a white-tailed eagle (*Haliaeetus albicilla*) flying above the open waters. Cranes (*Grus grus*) and geese gather here in flocks during the migration period.

Käina Bay, with an abundance of birds and Kassari island, with its juniper fields, form the Käina–Kassari Landscape Reserve that was founded in 1998. Käina Bay (915 ha) was also included in the Ramsar list of Wetlands of International Importance in 1997.

The best way to get acquainted with the local landscape reserve is to take a trip along Orjaku nature trail, which starts from Orjaku bird observation tower in the northwestern part of Kassari and runs along the Käina Bay coast.

There is another observation deck just next to Kassari–Vaemla road where one can learn how cattle grazing helps to maintain coastal meadows. This coastal meadow is a nesting ground for woodcocks and a stopping place for various species of migrating swans and geese.

Most people coming to Kassari will certainly visit the Sääre tirp – a narrow esker extending far south to the waters of the Soela Strait. Driving to the Sääre tirp parking lot is an experience hard to forget – juniper meadows along the road offer a picturesque view with the sea glimmering behind. An almost 2 kilometre long curvy hiking path takes you to the very end of this gravelly spit.

View over Käina Bay from bird observation deck.
Photo: T. Bauert

View over coastal meadows from Vaemla observation deck

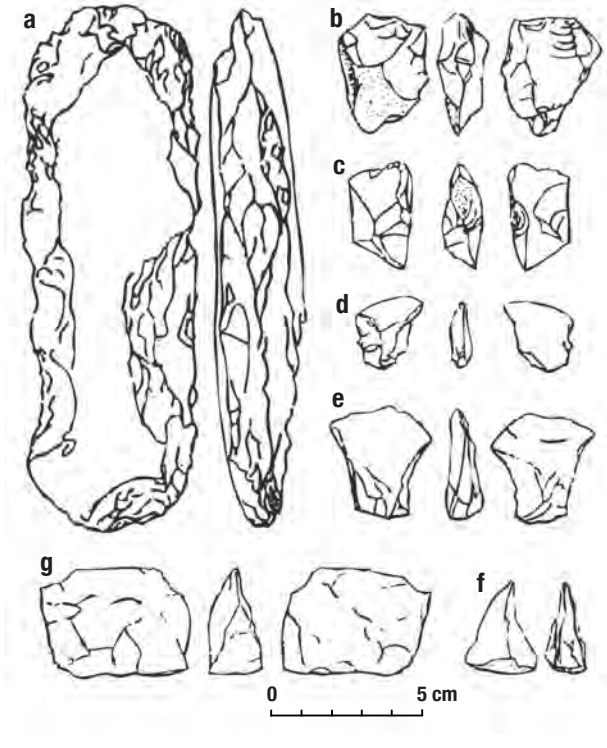
WHO WERE THE FIRST SETTLERS ON THESE ISLANDS?

Very little is still known about the early human settlements on Hiiumaa and Saaremaa. It is clear that people settled here later than in mainland Estonia. However, there could have been some seal-hunting mavericks who got lost and reached as far as the islands during the retreat of the Yoldia Sea some 10,000 ^{14}C years ago. The early hunters used both bows and arrows and snares to catch wild animals. Fishing and gathering of edible plants were important food sources as well.

Most discoveries on the Kõpu peninsula relate to the Mesolithic pre-pottery Stone Age period, but the Neolithic Narva and Combed Ware cultures are also represented. The peninsula is the oldest part of West-Estonian islands, the land having emerged there at the end of the Baltic Ice Lake stage, forming a separate small island until the beginning of the Limnea Sea stage, when it joined with the central part of Hiiumaa. A major number of the Mesolithic finds are quartz flakes, with some flint and quartz blades as well. The small artefacts represent scrapers and knives.

Eight Mesolithic settlements are known in the surroundings of Võhma and Pahapilli villages in northern Saaremaa, but these have not been thoroughly studied yet. At the Võhma I settlement site, researchers have found fireplaces built deep in the ground and filled with stones but also primitive flint and quartz tools – scrapers, graving tools and blades, similar to those from the Kõpu site at Hiiumaa. The similarity of artefacts from both islands suggests that the inhabitants of these settlements were in touch with each other.

The oldest human remains found date back to 3000 years BC (the Early Iron Age, also known as Neolithic age). The human bones were found at Kõljala in southern Saaremaa and at Naakamäe in Hirmuste village, ca 20 kilometres west of Kuressaare. A woman's skull found at Kõljala belonged to what anthropologists call a short-headed individual and looked similar to that found at Hvellinge in Skåne, Sweden. This woman's face was low-vaulted with flat features. The preserved parts of a man's skull allow researchers to presume that this belonged to a medium- or short-headed person. Similar anthropological types have been recognized in many settlements of the East-Europen forest zone. Therefore, it is complicated to identify the origin of the first tribes which arrived



Axe blank (a), scrapers (b, c, e, g) and burins (d, g) from Kõpu VIII settlement site of Late Mesolithic age (adapted from Fig. 3 in Kriiska, A. & Lõugas, L. 1999. "Late Mesolithic and Early Neolithic seasonal settlement at Kõpu, Hiiumaa Island, Estonia". In: Environmental and Cultural History of the Eastern Baltic Region. PACT 57, Rixensart, 157-172

on Estonian islands. But by body length and general appearance, the ancient islanders apparently resembled the present-day people.

Animal bones collected from Late Mesolithic settlement sites at Kõpu peninsula on Hiiumaa and at Võhma on Saaremaa belong mainly to remains of ringed seals (*Pusa hispida*). The severely burned bones suggest that these fat-rich bones most probably were used for lighting fires. All this refers to extensive seal hunting at this time. Therefore, the first inhabitants of Hiiumaa and Saaremaa apparently were seal hunters and fishermen.

The ancient islanders were also known as brave warriors. But to produce tools and weapons, they needed their own iron industry. The largest iron melting center of Estonia was situated in Mustjala Parish, northern Saaremaa. The dunes area with more than a hundred slag heaps in surroundings of the Tuiu village on the western margin of Järisesoo mire is known as the Tuiu Iron Slag hills. The slag cones occur on top of a dune ridge, but ancient masters used to dig bog iron from the paludified areas at the foot of the ridge. The production of iron started here in the 8th–9th centuries and culminated, most likely, in the 12th–14th centuries. Judging by the amount of slag in the remaining heaps, probably 1500–2000 tons of iron were produced here. As, in all likelihood, the number of inhabitants on Saaremaa did not exceed 20,000 at that time, the local iron need was rather low and at least 1000 tons were apparently sold elsewhere – most likely to the gotlanders. There were strong trade relations between Saaremaa and Gotland at this time.

The inhabitants of Saaremaa and Gotland have been in close touch over the centuries. According to Gutasaga (written in the 13th century and dealing with the history of Gotland), about a third of gotlanders who were forced to leave their overcrowded home island and search for a new place to live, arrived on Hiiumaa in the 6th century. The Swedish influence is still felt here in family names (Quarnström, Espenberg, Piilberg, etc.) and in pronounciation where, for instance the Estonian vowel "e" sounds like "æ". Swedish-type villages existed both on Saaremaa and Hiiumaa.

The ancient inhabitants of Hiiumaa were the tallest people in Estonia due to the influence of the Swedes. There are speculations that the word "hiidlased" (native people of Hiiumaa in the Estonian language) derives from a word "*hiiglased*" (meaning "*giants*" in English) and that the name "*hiiglased*" was mostly attributed to tall, savage pirates and smugglers from Sarve village in southeastern Hiiumaa.

The name of Hiiumaa is *Dagö* in Swedish and German (*Päivansalo* in Finnish) meaning the "Island of Day", while Saaremaa is known as *Ösel* (*Yösalo* in Finnish) – the "Island of Night".

Saaremaa and Hiiumaa islands as depicted on the map "*Nova Totius Livoniae accurata Descripto*", 1638. From Tartu University Library collections (hdl: 10062/2888)

BRIEF OVERVIEW OF MAJOR HISTORICAL EVENTS

The most important milestones in the history of Saaremaa and Hiiumaa (written records of the events prior to the 12th century are rare) are as follows:

Saaremaa:

• 1008: Olav Haraldsson, the king of Norway landed on Saaremaa Island, won a battle and forced local inhabitants to pay a tribute.

• 1187: Sigtuna – the most important trading town and unofficial capital of Sweden in the central part of the country was burnt down. Based on scanty historical data, this was attributed to warriors from Saaremaa, but the warriors of Novgorod and Karjala have also been implicate.

• In the 12th century: the Vatican became increasingly interested in conquering the Baltic countries as the last stronghold of Paganism. Pope Alexander III (Pope between 1159–1181) summoned the Christian rulers of the northern countries to fight against heathen Estonians and other pagans. The pope's appeal coincided with the interests of Denmark to end the occasional so-called Eastern Vikings attacks from Ösel (Saaremaa) and Curonia on Danish merchant fleets.

• 1206: the Danish king Valdemar II and the Danish archbishop of Lund, Andreas Sunesen, launched an offensive on Ösel (Saaremaa). The islanders were forced to submit and the Danes built a fortress there, but they could not find any volunteers to man it. Relinquishing their brief occupation of the island, they burnt the fortress and left the island. However, they laid claim to Estonia as their possession, a claim the Pope recognized.

• *The Chronicle of Henry the Livonian* (embracing events from 1184–1227) is the most detailed, comprehensive and quoted source on prehistoric Estonia, including Saaremaa. It is a typical missionary chronicle, in which the monk Henricus describes the events of the Crusade that was carried out by the Order of the Brethren of the Sword (known also as the Livonian Brothers of the Sword) in present-day Latvia and Estonia. Saaremaa is directly mentioned in this Chronicle in chapters dealing with Osilian piracy among other military events.

• 1222: the Danish king Valdemar II organized the second conquest raid to Saaremaa, this time erecting a stone fortress and manning it with a strong garrison. The Osilians also destroyed this fort in a few months.

• 1227: the Order of the Livonian Brothers of the Sword organized a new attack against Saaremaa in the course of which the Muhu stronghold was completely destroyed and the armies started to besiege Valjala, which has been described by Henry as the center of Saaremaa. The stronghold surrendered quite rapidly and the Osilians accepted Christianity. With this event monk Henricus ends his chronicle.

• 1228: the crusaders founded the Bishopric of Ösel-Wiek. After the defeat of the Order of the Brethren of the Sword in the Battle of Saule in 1236, military struggle on Saaremaa broke out anew. In the course of the campaign all the clerics on the island were killed and the bishop Heinrich himself had a narrow escape. The result was a treaty that was signed by the Osilians and the Master of the Order, Andreas Velven, in 1241.

• 1343, July 24th: the following written sources about Saaremaa are connected with the uprising of St. George's Night in the mid-14th century. By the 24th of July in 1343 the Osilians had again killed all the Germans on the island, drowned all the clerics and started to besiege the castle at Pöide. After the

surrender of the castle, the Osilians, despite their former promises, killed all the defenders and levelled the castle.

• 1381: the Ösel-Wiek bishopric castle first mentioned

• 1560: the Bishopric of Ösel-Wiek was sold by the last bishop Johannes V von Münchausen to King Frederick II of Denmark; it became part of Danish Estonia. From 1573–1645 the entire island was under Danish possession.

• 1563, May 8th: Kuressaare was granted town status (Riga's bylaws)

• 1645: Saaremaa was ceded from Denmark to Sweden by the Treaty of Brömsebro.

• 1710: Saaremaa along with the rest of Livonia was ceded to the Russian Empire, becoming part of the Governorate of Livonia.

• 1721: Estonia was formally ceded by Sweden to Russia by the Treaty of Nystad.

• 1710–1917: Estonia was part of the Russian Empire

• 1914–1917 World War I: the Estonian islands were conquered by the Imperial German Army in October 1917 and occupied until the end of hostilities.

• 1918 February 24th: Estonia declared independence.

• 1940: as a result of the Molotov–Ribbentrop Pact, Estonia was occupied and incorporated into the Soviet Union in June 1940 as the Estonian Soviet Socialist Republic.

• 1941: Saaremaa was occupied by Nazi Germany. German troops remained there until expelled by the Red Army in the Moonsund Landing Operation in October–November 1944

• 1944–1991: Estonia was again occupied by the Soviet Union

• 1946: Saaremaa was declared a restricted zone, closed to foreigners and to most mainland Estonians and remained so until 1989.

• 1991: Estonian independence was regained on August 20th, 1991 with the collapse of the Soviet Union.

Hiiumaa:

1228: Hiiumaa is first mentioned in written documents by the name Dageida ("*insula deserta, quae dicidur Dageida*", a barren island called Dageida).

• 1254: Hiiumaa was divided between the Bishopric of Ösel-Wiek and the Livonian branch of the Teutonic Order, who were also partly acting on behalf of the Hanseatic League.

1559–1563: Bishopric of Ösel-Wiek, including part of Hiiumaa, belonged to Magnus, Duke of Denmark

1563: beginning of the Swedish reign in Hiiumaa

1564: Kärdla, the present-day county capital, was mentioned for the first time as the Swedish village Kärtil.

1710: Hiiumaa becomes essentially part of the Russian Empire (officially by the Treaty of Nystad in 1721).

For the following historical dates, see Saaremaa above.

MAJOR CULTURAL HERITAGE SITES

Different local building materials have been used in various areas of Estonia. Buildings made by local carbonate rocks are common to Saaremaa and Hiiumaa, although erratic boulders brought by the continental ice sheet here were also used in erecting churches and manor houses.

While both the Ordovician and Silurian carbonate rocks were used as a building stone in Hiiumaa, the oldest churches on Saaremaa, dating back to the 13th century, were entirely constructed of local Silurian carbonate rocks. At such times, carbonate rock slabs were broken at the nearby quarries, but later on carbonate rocks with better building properties were transported to the building sites from greater distances. Based on the bedrock exposures and carbonate rock usages in buildings, Helle Perens from the Geological Survey of Estonia has separated five distinctive limestone usage regions in Saaremaa.

Although there are lots of carbonate rock varieties with different building stone properties available in Saaremaa, the usage of mainly Kaarma dolostone for building purposes was widely expanded beginning in the 14th century. The key role was played by both the massive nature of this dolostone, allowing it to be trimmed into large wall building blocks, as well as by the quarry location in the heart of Saaremaa. Aside from being mainly used as a wall stone, tombstones and monuments carved out of Kaarma dolostone are widely encountered in graveyards. Spectacular sights are also chimneys built from the Kaarma dolostone that can be spotted all over Saaremaa. The polished slabs of Saaremaa dolostones are also used as a finishing stone in a number of buildings on the Estonian mainland and in several foreign countries.

Visiting the manor houses, churches and fortifications on Saaremaa and Hiiumaa, one can see how densely the local geology and cultural heritage are intertwined, reflecting the uniqueness of these islands.

Suuremõisa manor

HIIUMAA:

Suuremõisa manor

The historical Suuremõisa manor complex is one of the most attractive manor houses on Hiiumaa. The luxurious and spacious two-storey main building, one of few late-baroque buildings well preserved in Estonia, was built by the countess Ebba Margaretha Stenbock (1704–1775). This manor complex exhibits the skills of simple islanders, who did everything on the spot – quarried the limestone, burnt the lime, baked the bricks, did all forging and woodwork.

The Suuremõisa manor was bought in 1796 by Baron Otto Reinhold Ludwig von Ungern-Sternberg (1744–1811), a nobleman of Baltic German origin who established a construction works at Suuremõisa to build sailing ships. Historical records tell that he killed one of his ship's captains in 1802. After a long trial in which he was also accused of plundering wrecked ships on the coast of Hiiumaa, von Ungern-Sternberg was deported to Siberia in 1803. Although accusations of piracy were never proved in court, he is still remembered among the local folks as a famous pirate and murderer.

In the 1920s, the manor was expropriated from its owner and thereafter was used as a schoolhouse. During Soviet time, the building accommodated several establishments, but at present it houses both a Suuremõisa primary school and a vocational school.

Pühalepa church

The Pühalepa church (dedicated to St. Lawrence) stands close to the Suuremõisa manor and is the old-

Pühalepa church

Reigi church

est church in Hiiumaa. Although it looks like a common 18th–19th century church, the Teutonic Order started the building of this church here in the place of a former wooden church about 1255. The vaulted stone church, at first with no tower, was completed in the 14th century. The church was plundered during the Russian–Livonian war in 1575, but was soon restored. The impressive pulpit made of dolostone was donated to the church by local landlords in 1636. This donation allowed them the right to be buried in the church choir-room (tombstones can be seen by the southern window). Construction of the church tower started in 1770 (this year is also marked above the church entrance), but reached its final height in the second half of the 19th century. At that time, the church tower served also as a seamark for sailors. In the 19th century, the church was reconstructed once again. The circled crosses of the Maltese Order (which included some of the Ungern-Sternbergs) were probably painted on the nave's wall during that reconstruction.

During the 1950s in the Soviet period, the church interior was dismantled – the benches were cut out, the organ was smashed and the church was turned into a warehouse. The church was recovered in the beginning of the 1990s and was blessed again in 1993.

Reigi church

The name "Reigi" originates from the local Swedes (derives from the Swedish word "*rök*" meaning smoke) and was once the biggest Swedish settlement in Hiiumaa.

The stone church (inaugurated in 1802) was built by Baron Otto Reinhold Ludwig von Ungern-Sternberg in memory of his son Otto Dietrich Gustav. It is common to have a rooster attached to the weather vane on top of the church tower in Estonia. But the Reigi church is an exception: a lily blossom decorating the weather vane originates from the coat of arms of the Ungern-Sternbergs, whose heraldry can also be seen above the main entrance.

The greatest treasure of the Reigi church is its art collection. The most interesting pieces in the Reigi church include "The Holy Feast", "Kolgata" and "The Christ on the Cross", painted on wood in the 17th century and brought here from an old wooden church. The church may also be proud of its organ, presumed to be of Hiiumaa origin.

Kõpu lighthouse

The Kõpu lighthouse is one the best known symbols and tourist sights in Hiiumaa. The IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) has included the Kõpu lighthouse in its listing of 100 historically most important lighthouses of the World. It has been in continuous use since its completion in 1531 and is regarded as one of the oldest operating lighthouses in the world. The lighthouse is built on the top of Tornimägi (68 metres above sea level) – the highest hillock in Hiiumaa. As the building itself is 36 metres high, the light beam warns ships from 104 metres above sea level, making this the highest lighthouse light on the Baltic Sea. The light can be used for navigation as far as 26 nautical miles, equal to 48 kilometres, away. If you dare to climb the narrow stairs to the top of the lighthouse, you will be rewarded with a spectacular view over the forest-rich Kõpu peninsula.

The story of this lighthouse began more than 500 years ago, when the Hanseatic Merchants League needed an effective seamark, as the merchants com-

Kõpu lighthouse

plained that ships were getting lost in the Baltic Sea. The construction works for the original seamark, using mainly local limestone and glacial erratic boulders for building, started around 1504. By 1531, the initial look of this solid lighthouse was more or less complete.

Historical documents give reason to presume that Kõpu seamark became a functional lighthouse only in 1649, when a wooden staircase was built onto the outside wall of the construction, and a grate for burning wood was set up on the top. About 800–1000 cords (1 cord = 3,62 cubic metres) of firewood were consumed there per year. Larger-scale reconstruction work started in 1810, when the building was transferred to the Russian Crown. At that time a staircase was cut inside the lighthouse and has been used ever since. In 1845, a crack in the upper part of the lighthouse demanded more extensive reconstruction, during which the lighthouse reached its final height.

But some islanders who earned their everyday living as shipwreckers were not as interested in the seamark as they were worried about the bounty from the sea diminishing. In olden times, fake seamarks were set out to lead the ships straight on to shallows and rocks. The greatest number of victims claimed is in the notorious Suurrahu Shallow (Neckmannsgrund), about 10 kilometres long, between the Ristna cape and Tahkuna peninsula where hundreds of ships were wrecked on shallows. Almost as dangerous to the ships was the westernmost tip of the Ristna cape where, in foggy weather, warning sound signals as well as light beams from the lighthouse were used. However, during heavy autumn storms and fogs all this did not help much. The unfortunate captains noticed that the local currents always carried ships astray from the right course. When storms created especially high waves, saving ships and people often proved impossible.

Muhu church

MUHU:

Muhu church

The St. Catharine's church is the only medieval church on Muhu and is considered to be one of the most beautiful rural churches in Estonia.

The Muhu church was mentioned in historical records as early as 1267, although it was most probably a wooden church at that time. The building of a stone church started at the end of the 13th century. The southern part of the church is primarily built of the oncolitic limestone of the Jaagarahu Stage. The oldest and most beautiful decorative stoneworks (corner stones, lintels, window frames and interior sculptures, including the altar) are also made of this stone. Presumably, the closest quarry for excavating the oncolitic dolostone was near Päelda village. Along with local carbonate rocks, Kaarma dolostone was used here. The medieval baptismal font and the grave slab are made of grey detrital limestone brought to the church from Gotland bearing a circularly-arranged Latin text: "*Here rests Johannes from Gotland – pray for his sole*."

A remarkable trapezoid tombstone has been walled into the lintel of the western wall of the stairwell. This decorative element might be interpreted as a tree of life or a tree of the world, a symbol of the axis of the world, representing the passing from one world to the other. One can also notice the figure of a primitive warrior with a spear and a ritualistic horn. This grave slab apparently dates back to Viking times.

The whole church was decorated with mural paintings of the Last Judgment. Only fragments of these have remained, most of them in the choir.

Pädaste manor complex: main building (below), grain storage (right page). Photos: T. Bauert

Pädaste manor

The earliest written history of Pädaste manor dates back to 1566. Remnants of original walls dating back to the 14th century are partially preserved, although the representative heart of the manor was built in the 1870–90s by Baron Axel von Buxhoeveden. During the Soviet period, the manor served consecutively as the army headquarters, a fish distribution center and home for elderly people until its abandonment in the early 80s. In 1996, the endeavour to restore Pädaste manor to a new splendor was undertaken, with the goal to create one of the finest hotels in the Baltic countryside. The measures succeeded and it was designated as a 5-star hotel in 2009.

Mõega dolostone of the Jaagarahu Stage stands out in the buildings of Pädaste manor. But even here one couldn't manage without Kaarma dolostone, used to build the supporting elements of storage buildings.

Koguva village

Koguva, a charming former fishing village, represents the complete architectural landmarks from the 19th century village architecture of West-Estonian islands. It is located on the western coast of Muhu. A typical Saaremaa farm at that time consisted of a threshing barn/dwelling house, storehouses, a sauna, stables for animals, and a summer kitchen. Very often the farm also had a smithy. There were separate storehouses for grain, meat, fish and clothing. The number of storehouses depended on the wealth and size of the farm family.

In the days when it was the custom for unmarried girls in Estonia to sleep in the clothing storehouses during summer months, special 'sleeping barns' were built on the island of Muhu. These buildings had plank flooring and larger windows. The most common type of sauna on Muhu was the 'manure sauna',

which was also used as a sheep barn. When the family wanted to have a sauna, the sheep were chased out, straw was spread over the manure, and the sauna stove was fired up.

The Muhu Museum is situated in the heart of Koguva village, giving an overview of the life in a prosperous coastal farm in the 19th century. Old dry-stone fences, covered with a thick moss carpet and winding village lanes create a unique atmosphere around the museum. Although Koguva is a museum village, it is worth remembering that except for the museum farm, the rest of the village is living a normal daily life.

Eemu windmill

Eemu windmill is located on western Muhu Island, just next to the main Kuivastu – Kuressaare road and less than a kilometre from the beginning of the causeway connecting Muhu and Saaremaa islands. This windmill was built at the traditional windmill site and was opened to visitors in 1980. The Eemu windmill is in fully operating condition and can be used for grinding grains. Traditionally baked round bread loaves can be purchased from a nearby kiosk. Although wooden windmills are no longer used for their primary purpose, they still remain as symbols of Saaremaa, enriching the local landscape.

Farm houses in Koguva village.
Photo: T. Bauert

Eemu windmill

SAAREMAA:

Pöide church

The Pöide St. Mary's church is easy to recognize from a distance – its size and massiveness make it look more like a castle. In fact, the church at Pöide is closely linked with the fortification of Saaremaa during medieval times. The eastern part of the island was under the control of the Livonian Order, which in the second half of the 13th century erected the Pöide castle as their main foothold in the area. On the southern side of the stronghold, there was a chapel. The fortress was destroyed during the St. George's Night uprisings in 1343 and the current church was built on the remains of the chapel. St. Mary's church at Pöide was burnt during World War II and also struck by a lightning bolt, which caused the crack in the facade of the tower.

The walls of the church were laid from dolostone slabs of Jaagarahu and Rootsiküla age, broken in nearby quarries. The tombstones in the church dating from different centuries are carved from various carbonate rock varieties. Most of the sculptural works in the church interior, including cantilevers and arched vaults, are from Kaarma dolostone. Detrital limestone from Gotland is also used.

Kuressaare castle

The town of Kuressaare draws attention with its ancient stone buildings. In the beginning of the 19th century, almost half of all buildings were laid here from stone. The quarry, with its high quality Kaarma building stone, was about 10 kilometres outside the town.

Kuressaare castle (right page). Photos: T. Bauert

Pöide church

Cannon Kotkas. Courtesy of the Saaremaa Museum

The most magnificent historical object in Kuressaare is the Kuressaare castle dating back to the 14th century, and built from large trimmed blocks of Kaarma dolostone. The convent building of Kuressaare castle is the only medieval fortification in the Baltic States that has not undergone considerable reconstruction. Consequently, it is considered as an architectural monument of international importance. The architecture of the convent building is unique in Estonia from the aspect of the room's layout and interior's stone-carved decorations. The side length of the convent building is 43 metres and the mighty seven-storey defence tower is 37 metres high. The building looks quite simple outside but its interior reveals elaborate stonework, including pillars, cantilevers and coats of arms. The floors, staircases and window decorations are also from Kaarma dolostone as this was almost the only stone used for sculpture and engravings over the centuries in Saaremaa.

Visitors to Kuressaare castle can see the oldest working cannon in Estonia at the entrance to the castle. The cannon was made in Eskilstuna, Sweden, in 1803. Friedrich Wilhelm von Buxhoeveden (1750–1811), the owner of Võlla manor, brought it from Finland in 1809 as a trophy of the Russian–Swedish War. In the old Livonia, Kuressaare included, cannons were taken into use at the end of the 14th century. There were altogether 162 different cannons in Kuressaare castle during the Danish era.

The permanent exhibition about the history of Saaremaa is in the cloister of the upper floor and in two large halls. The access is from the entrance hall of the Watchtower.

Karja church

The St. Catherine's church of Karja is the smallest medieval church in Saaremaa, but is one of the most beautiful. The building's architectural design is very simple, but it's interior sculptural decoration make this church an outstanding place to visit. Its portals, bosses and vaulting supports show a superb High Gothic stone decor. The exact time of church construction still remains obscure in historical records, but most probably it was erected in the beginning of the 14th century.

The vault above the church choir is covered with enigmatic signs the meaning of which remains unclear. It has been assumed that they were intended for keeping demonic powers out of the church, following the principle that "*evil should be warded off with evil*". The pentagram sign, for example, was already in use for the same purpose in pagan times. There is also a sign consisting of three legs (the triscelion) on the vault. For the Vikings, this was the sign of their god Odin, but in the Middle Ages it was used to symbolize of the Trinity.

Karja's interior elaboration is extraordinary, with abundant dolostone decoration. The best example is the Calvary relief located on the southern exterior

Karja church

church wall, sculpted from Kaarma dolostone, depicting the crucifixion at Calvary with Mary and John mourning for Christ. The two crucified robbers also appear on the relief: one of them listened to Jesus and repented of his sins. The other, however, only laughed at Christ's words. The relief depicts the moment when the souls, in the form of little children, depart from the robber's bodies. The sculptor defines repentance for us: an angel carries away one of the souls, while the other will take a journey with the Devil.

Calvary relief

Valjala church and Valjala stronghold

The St. Martins church of Valjala is considered the oldest rural church in Estonia. The conquest of Estonian territory was brought to an end in 1227 with a large campaign on the Island of Saaremaa where,

Valjala church

after the capture of the ancient stronghold of Valjala, a grandiose baptism was arranged. To commemorate this event a stone chapel at Valjala (about 1 km northwest of the former stronghold) was erected, marking the beginning of the history of Estonian sacred architecture. The chapel walls form the lower part of the present church choir. The construction of the stone church started in 1240. It was severely damaged during the St. George's Night uprising (1343–45) but was reconstructed.

The baptismal font of the Valjala church is one of the oldest pieces of carved stonework in Estonia. It is believed that the font was originally made for Haapsalu cathedral and only later brought to Saaremaa. The font is decorated with late Romanesque tendrils. Similar decor can be seen in Riga cathedral. The church was constructed both from local and Kaarma dolostone.

The Valjala stronghold is located on a flat natural hillock surrounded by a slightly oval-shaped ring wall. Its outer diameter is 120 metres in the southwest-northeast direction and the crosswise diameter is about 110 metres. The height of the walls inside the stronghold is 3–6 metres, outside – 5–8 metres. The Chronicle of Henry the Livonian describes this stronghold as "*castrum Waldia*", which was the strongest among other fortifications in Saaremaa. Here ended 20 years of battles against the invading crusader forces. The first act of the conquerors was to baptize the survivors. There is a limestone-lined water well on the northwestern margin of the inner yard that, according to the Chronicle of Henry the Livonian, was the source of the baptismal water. It should be noted that there were still many uprisings by islanders in the following years to wash off the baptismal water.

Valjala church

Valjala stronghold

Mihkli Farm Museum

Mihkli Farm Museum is located 3 kilometres from Kihelkonna village towards Kuressaare in western Saaremaa. This museum gives visitors an authentic view of a 19th century farm, including a complete set of buildings and all kinds of equipment needed to run a farm. Almost all things seen here have been made by people of six generations living at Mihkli during the past two centuries.

The Mihkli Farm Museum was established in 1959 when the last owner of the farm became the first employee of the new museum after having turned over the buildings and all everyday commodities to the Saaremaa Museum. The Mihkli farm is a typical western Saaremaa farm, where the dwelling-house and other buildings (barnhouse, wheel house, summer kitchen, smithy, sauna) border the central farmyard. The dwelling-house was presumably built in 1834 and the barn-house in 1840–1843. In 1846, the sauna was built in the orchard, its wooden parts and interior design dating from 1910. As the original windmill was destroyed by fire in 1994, a new windmill was erected a few hundred metres from the buildings in 2001.

Old storehouse

Folk party at the museum

Angla windmills

Windmills have always drawn particular attention on island landscapes. The most attractive windmills of Saaremaa are those at Angla, about 5 kilometres south of Leisi village in northern Saaremaa. All Angla village windmills were built together at the top of the gently-sloping hillock open to winds from all directions. There were nine windmills on this hill in 1925, five of which have been preserved.

The four remaining wooden windmills are typical of Saaremaa. These windmills could be turned with the help of an exterior wooden pole to catch the wind from any direction. The largest eight-sided wooden windmill at the site is of the Dutch type (although windmills in the Netherlands were commonly built of stone).

Places of geotourism interest in northern Saaremaa

ISLAND OF SAAREMAA – A PROSPECTIVE GEOPARK IN THE CENTRAL BALTIC AREA

The exploration and preservation of geological heritage aims not only at enhancing passive protection of nature monuments, but also addresses sustainable management of relevant regions, creating emloyment opportunities for local inhabitants without causing any damage to the surrounding environment. An outstanding initiative in this field is the Programme of Geoparks, in which the UNESCO Department of Earth Sciences, International Union of Geological Sciences, UNESCO's World Heritage Centre, as well as Man and the Biosphere (MAB) World Network of Biosphere joined forces to introduce, promote and protect the Earth's geological heritage in the best way.

With its aim of making natural heritage information available to as many people as possible and, at the same time, to promote regional economic activities, the Programme of Geoparks has found wide international support.

In June 2000, four nature reserves in Europe (Reserve Geologique de Haute-Provence, France; Natural History Museum of the Lesvos Petrified Forest, Greece; Geopark Gerolstein/Vulkaneifel, Germany, and Maestrazgo Cultural Park, Spain) formed the European Geoparks Network, now considerably expanded. However, geoparks have also been established elsewhere in the world – there are at least 20 in China.

Windmill at Angla

To be acknowledged by UNESCO, geoparks must accomplish the following:

• ensure the preservation of significant geosites for future generations;

• provide knowledge about the geological development of the Earth to the public at large and serve as a research basis for scientists;

• ensure sustainable development of the area.

Based on these criteria, Saaremaa Island is a prospective area for establishing a geopark, as outstanding natural phenomenon (Kaali meteorite craters, coastal cliffs abounding in fossils and island-specific landscapes – alvars and rocky islets) can be seen and studied. There are also numerous archaeological and cultural monuments (Kuressaare castle, windmills, old churches) concentrated in a relatively small area. Several measures have been taken to protect the local geological heritage, to teach nature sciences and to raise environmental consciousness of people in Saaremaa. One recent example is the opening of the Kaali Visitors' Center in 2005.

A proposal to found a new geopark must arise from the joint public interest of local municipalities and private enterprises, and be backed by the know-how and support of relevant international experts. The local authorities, however, should take the lead in working out and elaborating the plans for sustainable social and economic development. And Saaremaa is just the right place for a new geopark!

Saaremaa and Hiiumaa on the WWW:

Saaremaa: www.saaremaa.ee
en.wikipedia.org/wiki/Saaremaa (Wikipedia)
www.saaremaamuuseum.ee/eng (Saaremaa Museum)

Hiiumaa: www.hiiumaa.ee
en.wikipedia.org/wiki/Hiiu_County (Wikipedia)
www.hiiumaa.ee/tuletorn/english.php (Lighthouse Tour)
http://www.muuseum.hiiumaa.ee/?page=English (Museum of Hiiumaa)
turism.moonsund.ee/index.php?lang=en&style=en (Hiking in Hiiumaa)

Getting to Saaremaa and Hiiumaa islands:

by ferry: www.laevakompanii.ee/index.php?keel=2 (Saaremaa Shipping Company)

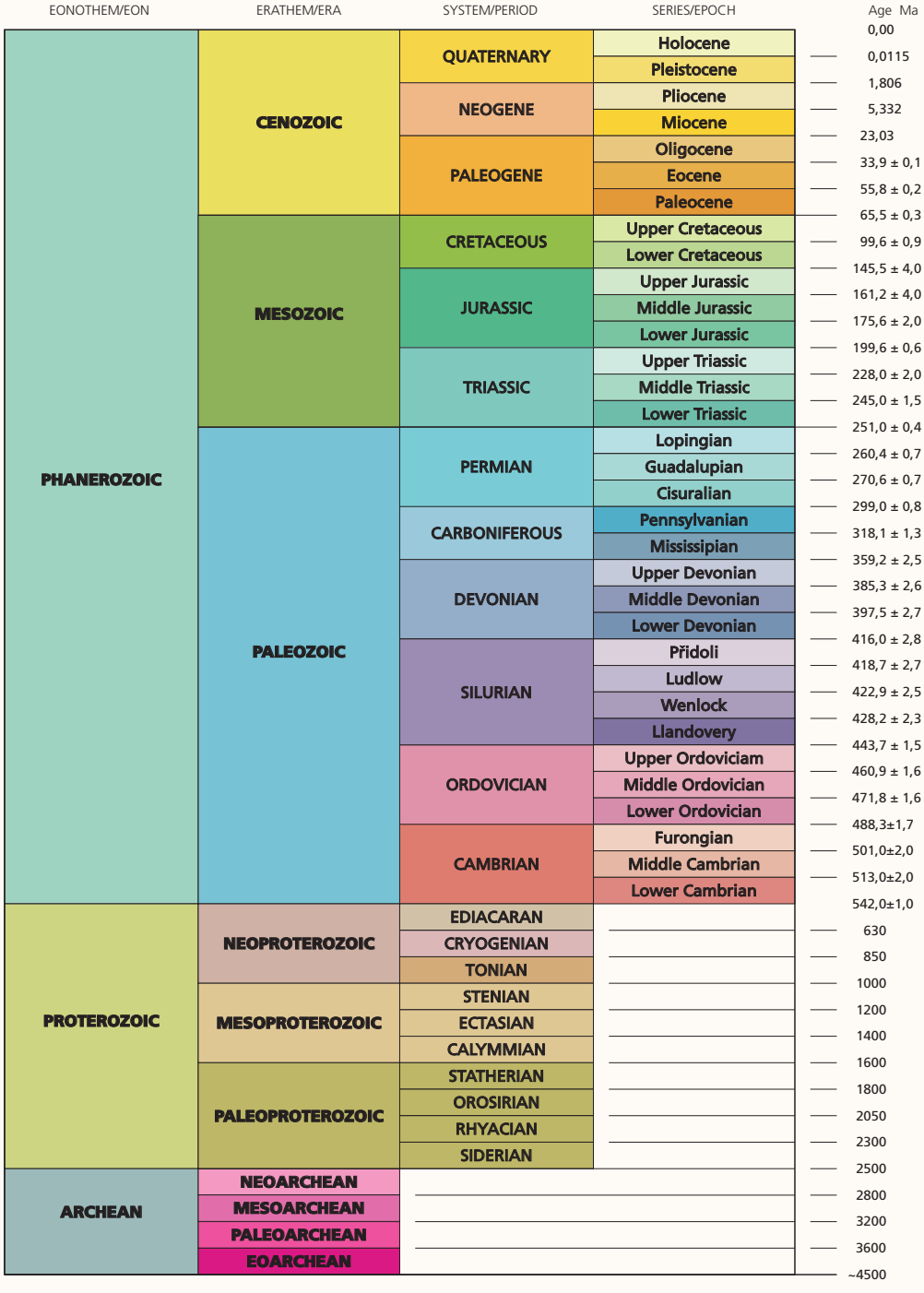
by bus: www.bussireisid.ee/index.html?MENU=&KEEL=en

by plane: www.eeke.ee (Kuressaare Airport)
www.tallinn-airport.ee/eng/kardlaairport/?articleID=1401 (Kärdla Airport)

Juniper shrubs at Kassari, Hiiumaa.
Photo: T. Bauert

Geological Time Scale

IUGS ICS Geological Time Scale 2004 (www.stratigraphy.org), adapted by Estonian Startigraphy Comission 2004 (www.gi.ee/ESK/)



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