

# The Baltic Klint beneath the central Baltic Sea and its comparison with the North Estonian Klint



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## ABSTRACT

Along its contact with the Baltic Shield, the margin of the East European Platform reveals a well-developed, flooded terraced relief. The most striking and consistent set of escarpments at the contact of the Lower Palaeozoic calcareous and terrigenous rocks, known as the Baltic Klint (BK), extends from northwest of Russia to the Swedish island of Öland. Marine seismic reflection profiling in 1990–2004 revealed the central Baltic Sea Klint (BSK) section in detail and enabled comparison of its geology/geomorphology with a classical klint-section onshore, namely the North Estonian Klint (NEK). The conception of the BK onshore, which is based on the land-sea separating terraced relief in northern Estonia, is not fully applicable beneath the sea. Therefore, we consider that the BSK includes the entire terraced Cambrian outcrop. We suggest the term “Baltic Klint Complex” to include the well-terraced margin of the Ordovician limestone outcrop, which is weakly developed in Estonia. Because of a steady lithological framework of the bedrock layers across the southern slope of the Fennoscandian Shield, the central BSK in the western and the NEK in the eastern part of the Baltic Homocline have largely identical morphologies. The North Estonian Ordovician limestone plateau with the calcareous crest of the BK extends across the central Baltic Sea, whereas morphological changes/variations along the Klint base occur due to the east-westerly lithostratigraphic/thickness changes in the siliciclastic Cambrian sequence. The verge of the NEK, located some 30–50 m above sea level, starts to drop in altitude as its east-westerly course turns to northeast-southwest in western Estonia. Further westwards, the BK shifts gradually into southerly deepening (0.1–0.2°) layers as its crest drops to c. 150 m below sea level (b.s.l.) near Gotska Sandön. This course change is accompanied by a considerable decrease in thickness of the platform sedimentary cover, as below the central Baltic Sea the stratal sequence is 150–250 m thinner than in northern Estonia. This has facilitated a deviation of the terraced relief-forming Cenozoic rivers traversing east-westerly across the southern slope of the Fennoscandian Shield and forming different morphostructures in its eastern and western parts. Thus, a low-lying central Baltic Sea depression with well-developed asymmetrical cuesta valleys and terraces occur in the western half of the Baltic Homocline. In its eastern part, however, the only explicitly shaped cuesta valley along the shield-platform boundary forms a narrow east-westerly branch/gulf of the Baltic Sea (Gulf of Finland). The well-terraced southern margin of this gulf runs along the contact of the outcropping terrigenous and calcareous rocks, rises above the sea and forms a complex landform known as the NEK.

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## 1. Introduction

In the local terminology, the term klint (older spellings glint/clint) is widely used for scarps in the sedimentary bedrock along and nearby the coastlines around the Baltic Sea (Raukas, 2005). Besides numerous solitary and differently oriented shorter cliffs at various stratigraphic levels, two heavily indented and lobed, arch-shaped klints at certain Early Palaeozoic levels extend east-westerly from Estonia across the floor of the central Baltic Sea. In the Gotska Sandön area, they bend southwards and run alongshore the islands off the Swedish east coast

(Fig. 1). Based on the age of the klint embedding rocks, the northern one is called the Ordovician Klint whereas its southern analogue between Saaremaa and Gotland is known as the Silurian Klint. However, the most common name for the klint that extends along the contact of the Ordovician calcareous and terrigenous rocks from Lake Ladoga in the northeast to the southern tip of Öland in the southwest is the Baltic Klint (BK).

Based on location, the c. 1600 km-long BK divides into three onshore sections (the Ingermanland, the North Estonian and the Öland) and the Baltic Sea Klint (BSK) section (Suuroja, 2008; Fig. 1). Compared to the mainland sections, particularly to the North Estonian Klint (NEK), the BSK is poorly studied; its nature and morphology, as well as connection to the onshore sections are only vaguely known.

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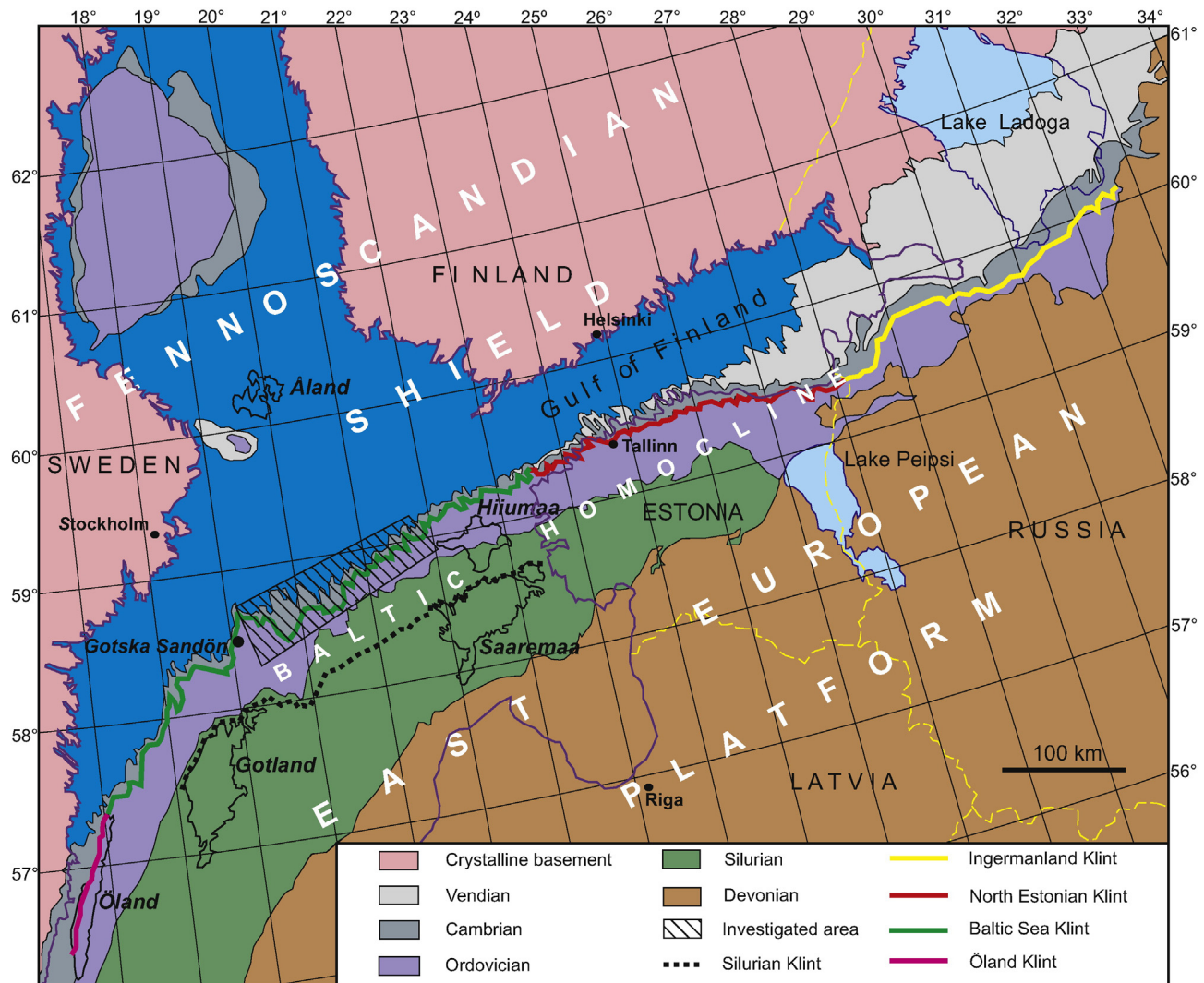


Fig. 1. Regional geological setting, with the location of the Baltic Klint and study area.

Up to the 1950s, the location and course of the BSK was gradually updated based on the successively improved nautical charts (e.g. Büchting, 1918; Fromm, 1943). Generalizing all accessible bathymetric data, Martinsson (1958) subdivided the BSK into different segments and described their height relationships with respect of the seafloor and various landforms (e.g. bedrock ridges, valleys, eskers and banks) surrounding and dissecting the Klint. He distinguished the segment between Hiiumaa and Gotska Sandön as the central BSK (Fig. 1).

At this time, it was not always possible to determine explicitly whether bathymetric alterations were due to changes in the bedrock surface or to thickness variations in the Quaternary sediments. Thus, in places, particularly in the case of the thick glaciofluvial sediments around Gotska Sandön, he remained suspicious about the exact course of the BSK. Only with introduction of continuous seismic reflection profiling in the early 1960s did details of the sub-bottom bedrock relief become available.

A great number of seismic lines, shot in 1964–1978 (Flodén, 1980) and in 1990–2004 by a team of Swedish–Estonian geologists (Tuuling and Flodén, 2009a) also crossed the BK. However, both studies were mainly focused on the correlation of the Palaeozoic rocks between Estonia and Sweden where the BK was treated only episodically as a key marker in interpreting the Klint-embedding Cambrian–Ordovician layers (Flodén, 1980; Flodén et al., 1994; Tuuling et al., 1995, 1997; Tuuling, 1998; Tuuling and Flodén, 2000a, 2007). Still, the submarine BK was broadly treated in discussing the bedrock structure and the

cuesta relief beneath the central Baltic Sea (Tuuling and Flodén, 2001; Tuuling et al., 2007).

Thus, relying on the interpretation of the high-resolution seismic profiles shot mainly in 1990–2004, in this paper all information published so far on the geology of the Palaeozoic sequence is used to describe and discuss the details of the BK geology beneath the central Baltic Sea. Its morphological, lithological and stratigraphic characteristics are juxtaposed with those of the NEK to discuss the connections between them, as well as the nature of the central BSK in the light of the regional geological and structural setting.

## 2. Geological setting

### 2.1. General structural and stratigraphic background

Being one of the most imposing geomorphologic features in the East European Lowland, the BK also marks an important structural boundary separating the Fennoscandian Shield from the East European Platform (Fig. 1). In detailed maps, however, there still exists a narrow strip of Neoproterozoic (Vendian) and Cambrian siliciclastic rocks north of the klint-line. Apart from its widest section in front of the Ingermanland Klint, this Vendian–Cambrian outcrop is largely submerged by the Baltic Sea.

On the southern slope of the Fennoscandian Shield, Vendian–Devonian sedimentary rocks overlie a peneplained, slightly south to

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